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Enhancing the Training of Mathematics and Science Teachers Program

Transforming the nature and delivery of mathematics and science secondary teacher education in Queensland

Final report, March 2017

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StepUp
Transforming mathematics & science teacher education in Queensland

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Step Up is one of five projects funded under the ETMST Program, in response to the 2012 report by former Australian Chief Scientist Professor Ian Chubb: *Maths, engineering and science in the national interest*.

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[1] The ETMST Program was implemented by the Australian Government Office for Learning and Teaching. The OLT ceased on 30 June 2016. The Australian Government Department of Education and Training continued to support the Program and funded project until completion.

List of acronyms used

AITSL	Australian Institute for Teaching and School Leadership
ETMST	Enhancing the Training of Mathematics and Science Teachers
CAP	collaborative action projects
STEAM	science, technology, engineering, arts and mathematics
STEM	science, technology, engineering and mathematics

Education terminology

Education terminology varies across institutions and jurisdictions. In this report, the following terms have been used:

action learning approach: an approach to solving real problems that involves taking action and reflecting upon the results, which helps improve the problem-solving process, as well as the solutions developed by the team.

authentic science: activities in which students are involved in problem-solving, experimentation, and inquiry that allows students to develop questions, learn scientific content, and engage in science as a social activity.

initial teacher education: pre-service teacher education.

initial teacher education student: a pre-service teacher; a prospective teacher (of mathematics and science).

nature of science: the values and assumptions inherent to the development of scientific knowledge (Lederman & Zeidler, 1987).

pedagogy: the method and practice of teaching, especially as an academic subject or theoretical concept.

professional experience: a core component of initial teacher education programs, providing pre-service teachers with an opportunity to link theory and practice in a school setting (Queensland Government, 2015).

Project intensive: forum where stakeholders are invited to present their ideas, reflect upon learnings and progress a project.

scientific inquiry: a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyse, and interpret data; proposing answers, explanations, and predictions; and communicating the results (National Research Council, 1996, p. 23).

step change: a sequence of stepped changes that lead to the intended outcomes.

student engagement: This project approaches student engagement in terms of recruitment and dissemination amongst critical stakeholders – pre-service teachers and STEM university students. Step Up draws on various student engagement theories to create strategies and evaluate benefits to students' learning and connectedness.

third space: (Zeichner, 2010, p. 89) a temporary learning community for collaborative self-study and professional learning where participants seek new experiences, approaches and roles in their teaching practice. The shared framework brings together key participants from higher education (teacher educators, scientists and pre-service teachers) and high schools (practising teachers and school students).

Executive summary

The Step Up project operated from late 2013 to early 2017 and was funded through the Enhancing the Training of Mathematics and Science Teachers (ETMST) Program. The ETMST Program was a response to the 2012 challenge by the Chief Scientist of Australia for improvements in the preparation of mathematics and science teachers. ETMST identified a complex and multifaceted challenge based around the notion of combining content and pedagogy so that mathematics and science are taught more like they are practised. The project was led by Queensland University of Technology in partnership with Australian Catholic University, Griffith University, James Cook University, The University of Queensland and the Queensland Department of Education and Training. The grant's focus was on pre-service, secondary mathematics and science teachers in Queensland.

Step Up sought to identify where significant change and impact can be made – going beyond traditional approaches that have involved providing more content, method and resources, and reconceiving what is possible through collaboration between practising scientists, mathematicians and teacher educators – to prepare the next generation of our nation's science and mathematics teachers.

Step Up initially focused on a number of ETMST's priorities. This included improving universities' collaborations between faculties, departments of science, mathematics and education; to deliver improvements in teacher education and greater number of graduating teachers. Step Up also developed curriculum arrangements that gave pre-service teachers a new vision of how mathematical and scientific content, thinking and pedagogy can work together; and how teachers can inspire knowledge creation. Step Up addressed these priorities through four major project elements: curriculum, accelerated student recruitment, partnerships and academic collaboration, and TeachConnect online community. These elements provided mechanisms other ETMST priorities were actioned, including working with employers, like state education departments, and building long-term relationships between universities and the teaching professionals.

In line with Step Up's aim to transform pre-service secondary mathematics and science teacher education, the project followed an action learning approach to implement educational reform. The action learning approach allowed this challenge to be addressed initially through a proof of concept stage which provided a structured way for opportunities to be identified and developed/actioned within each of the partner Institutions in the experimental phase. Lessons learned informed the planning of Step Up action research projects in the implementation phase and ongoing cross-disciplinary collaboration, where the facilitation of reflection leading to action was key. This resulted in six collaborative action projects (CAPs) developing out of the initial proof of concept stages. The CAPs (TeachConnect, Integrated STEM Teaching Pathways, STEM Studio, Practising Science with Pre-Service Teachers project (Practising Science), Pedagogy on Demand and STEAM Room) were designed in stages, with each stage informing the next. This was a purposeful move by the project leadership to ensure collaboration between team members that could lead to systemic change.

Step Up delivered four related innovative online resources that are available to the higher education sector. These resources created a professional platform that will support, facilitate and sustain the development of a learning community of emerging mathematics and science teachers actively engaged in an interdisciplinary, professional community of practice. This is the first step in shifting from isolated marginal innovations and represents new approaches to teacher preparation

that aims to change the attitudes of stakeholders with the potential for long-term systemic changes. Resources include:

- Practising Science instructional resources available for educational professionals
- TeachConnect, an online learning platform where pre-service teachers can propose and envision classroom experiences not governed by their supervising practicum teachers during professional experience
- Nature of STEM, which integrates aspects of several Step Up CAPs. The website intention is deepening pre-service teacher and in-service teacher conversations about how to think scientifically
- Pedagogy on Demand project resources, available on the K–12 learning management website Schoology.

Creating a professional online learning platform for mathematics and science pre-service teachers was a unique feature of Step Up. The goal to increase visibility and awareness amongst target students saw over 900 pre-service teachers and maths/science students involved in collaborative projects across the five institutions.

Step Up also provided emerging evidence of a current and future increase in numbers of mathematics and science teachers. Step Up's Integrated STEM Teaching Pathways CAP designed, developed and rolled out the Science/Mathematics Education Minor at James Cook University (2017), Queensland University of Technology (2015) and The University of Queensland (2017). This has contributed to a wider and more diverse pool of students entering the mathematics and science teacher pathway.

Step Up's Practising Science CAP provided evidence for collaborative course design and delivery, formalised in curriculum structures/processes, and has been embedded within the curriculum of mathematics and science pre-service teacher secondary courses at James Cook University and Queensland University of Technology. These innovative curricula have allowed pre-service teachers to design and implement inquiry-based scientific investigations.

A shared framework for operating across the consortium members led to strong foundations for systemic and cultural change. The Integrated STEM Teaching Pathways available for STEM majors allows students to transfer at the end of first year to a Bachelor of Education or articulate into a Masters of Teaching after completing their undergraduate degree. Flexibility to adapt the curriculum across institutional contexts is a key learning along with meeting Queensland College of Teachers accreditation requirements and addressed Australian Professional Standards for Teachers.

Continued partnerships to provide mechanisms for sustained resourcing and implementation (beyond the life of the project) have been established through Australian Research Council grants (two in progress) and successful Queensland Government Department of Education and Training funding ($100,000) between Queensland University of Technology and James Cook University. Examples of how partnerships have provided mechanisms for sustained resourcing and learning communities of emerging mathematics and science teachers actively engaged include the TeachConnect CAP which linked all Queensland universities and Queensland College of Teachers to secure external funding for ongoing development.

Table 1 defines outcomes aligned with each model approach (including collaborative action projects, student engagement and project design).

Table 1: Step Up project matrix of outcomes and model approaches

Project outcomes	**Model approaches**							
	Collaborative action projects						**Other**	
	Integrated STEM teaching Pathways	**Practising Science with PSTs**	**Pedagogy on Demand**	**TeachConnect**	**STEM Studio**	**STEAM Room project**	**Student engagement**	**Step Up project design**
Student outcomes								
Increase visibility and awareness amongst Step Up target students							✓	
Student awareness and uptake of networks	✓	✓	✓	✓	✓	✓	✓	
Increase numbers of students specialising in secondary mathematics and science teaching in areas of need	✓							
Teaching experiences available for mathematics and science students	✓				✓	✓	✓	
Strengthening pre-service teachers' mathematics/science knowledge and pedagogy		✓	✓		✓		✓	
Learning community of emerging mathematics and science teachers actively engaged in an interdisciplinary, professional community of practice		✓	✓	✓			✓	
Institutional outcomes								
A shared framework for operating across the consortium members	✓							✓
Documented course structures and articulations	✓							✓
Collaborative course design and delivery, formalised in curriculum structures/processes	✓	✓			✓			✓
Curriculum framework that involved mathematics and science and teacher education teams and stakeholders	✓	✓			✓			✓
Continued partnerships providing mechanisms for sustained resourcing and implementation (beyond the life of the project)				✓	✓			✓
Academic staff outcomes								
Participation of staff within and across universities in project activity	✓	✓	✓	✓	✓	✓	✓	✓
Key stakeholders to be aware of the project and the imperative that it sought to address	✓	✓	✓	✓	✓	✓	✓	✓
An expansion of networks of mathematics and science teacher education educators	✓	✓	✓	✓	✓	✓	✓	✓

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Chapter 1: Introduction

1.1 Context

A need was acknowledged for increased numbers of highly qualified mathematics and science teachers (Productivity Commission, 2012; OCS, 2012). Globally, nations are seeking mathematics and science secondary teachers capable of fostering a mathematically and scientifically literate populace to thrive with the everyday demands of 21st century life, be informed decision makers and provide an adequate supply of professionals trained in mathematics and science. Following a challenge issued by former Australian Chief Scientist Ian Chubb, the national Enhancing the Training of Mathematics and Science Teachers (ETMST) projects were designed to effect 'high quality, contemporary, engaging and equitable' educational opportunities for Australians through enhanced training of their future teachers (OCS, 2012, p. 6).

Although Step Up was part of this national initiative, the project was designed to reflect the unique needs of the Queensland context. The Queensland Department of Education has repeatedly raised concerns regarding the teaching of mathematics and science in secondary schools across the state (Office of Queensland Chief Scientist, 2014; Queensland Audit Office, 2014). Reports suggest Queensland National Assessment Program – Literacy and Numeracy (NAPLAN) scores are significantly lower than those of other states and territories (ACARA, 2013). In light of these and other concerns, with the importance of science, technology, engineering and mathematics (STEM) skills increasing into the future, the Queensland Government and Queensland universities are committed to lifting the standards and status of teaching within Queensland schools. It is within this climate that Step Up was situated.

1.2 Step Up

This project was funded for 3.5 years across five tertiary education institutions, led by Queensland University of Technology in partnership with Australian Catholic University, Griffith University, James Cook University, The University of Queensland and the Queensland Department of Education and Training. Step Up focused on the preparation of secondary mathematics and science teachers in Queensland. The project engaged external stakeholders (e.g. Queensland College of Teachers, Independent Schools Queensland, government schools, Science Teachers Association of Queensland and the State Library of Queensland) and stakeholders within the participating university environments (e.g. pre-service teachers and STEM students, Associate Deans of Learning and Teaching, teacher educators, STEM discipline experts, curriculum panels and administration).

Step Up aimed to effect step change in courses, partnerships, academic practice, and recruitment of mathematics and science students to teacher education in order to transform the nature and delivery of mathematics and science pre-service secondary teacher education in Queensland. Step Up further sought to develop transferable frameworks, resources, technologies and guides to inform the future nature and delivery of pre-service teacher education nationally.

Step Up initially focused on four of the nine ETMST priorities:

- **priority 1:** collaboration between faculties, schools or departments of science, mathematics and education that will produce teachers who have a contemporary and dynamic view of science that can inspire students

- **priority 2:** increasing the supply of graduates
- **priority 3:** curriculum arrangements that give pre-service teachers of mathematics and science a new vision of how mathematical and scientific content, thinking and pedagogy can work together
- **priority 5:** developing teachers' capabilities to engage secondary students in relevant and rigorous science and mathematics learning, including inculcating an understanding of how scientific and mathematical knowledge are created.

It is now evident that Step Up also contributes to knowledge and practice associated with:

- **priority 8:** with the support of employers, including state education departments, retraining suitably qualified professionals/teachers to expand the pool of teachers with a contemporary view of mathematics, science and pedagogy
- **priority 9:** encouraging mathematics, science and education faculties, schools or departments to build long-term relationships with teachers to ensure their knowledge and skills are kept up to date.

Step Up sought to address these priorities through four major project elements:

- **courses and curriculum** aligned with a shared curriculum framework, Australian Institute for Teaching and School Leadership (AITSL) standards and science threshold standards; grounded in mathematics and science disciplines; co-created by mathematics and science and teacher education academic communities; and delivered by inspirational teachers from multiple university sites
- **accelerated student recruitment** through marketing and promotion to mathematics and science students, mathematics and science academics championing mathematics and science teacher education career pathways, course structures that provide seamless opportunities to transition through mathematics and science undergraduate courses into mathematics and science teacher education and for mathematics and science teacher education students to integrate with mathematics and science disciplines
- **mathematics and science teacher education partnerships and academic collaborations** that focus on the long-term sustainability of Step Up outcomes and impact, promoting integration of stakeholders in the work of the project, designing and delivering curriculum materials, and producing resources and guides for use by other mathematics and science teacher education communities in Australian universities
- **TeachConnect (technology)** to provide a statewide platform for pre-service and emerging teacher access to online learning and peer support networks. In addition to supporting and extending the other elements, this element particularly seeks to support pre-service teachers' transition through practicum and into early career, supporting the establishment of a learning community of emerging mathematics and science teachers actively engaged in an interdisciplinary, professional community of practice.

These major elements provided mechanisms to initiate and sustain collaborative action to address the questions posed by the Chief Scientist of Australia in 2012 that subsequently underpinned the ETMST priorities. They are necessarily interrelated and have evolved over the life of the project, building upon working examples/precedents, reflecting upon the institutional and locational contexts within which the participating universities operate and growing through each project phase, as discussed throughout this report. Figure 1.1 overviews the step changes that underpinned the Step Up project; the step-change initiatives are discussed further in Chapter 4.

Figure 1.1: Step changes underpinning the Step Up project.

1.2.1 Major outcomes of Step Up

The major outcomes of this project were:

- a significant increase in the number of students specialising in secondary mathematics and science teaching in areas of need
- collaborative curriculum design and delivery, formalised in and or explicitly aligned with course structures and processes
- a learning community of emerging mathematics and science teachers actively engaged in an interdisciplinary, professional community of practice
- strong mathematics and science knowledge and pedagogy amongst mathematics and science teacher education students and graduates
- partnerships that provide mechanisms for sustained resourcing and implementation.

Chapter 2: Project design and implementation

2.1 Project design

The design of the Step Up project was underpinned by an action learning approach. Action learning can facilitate the development of new understandings by allowing team members to engage in collaborative reflection on their experiences to solve real-life, situated problems (Coghlan, 2012; Leonard & Marquardt, 2010). Garratt (2012) overviews four key elements of the action learning approach:

- a crucial institutional problem
- stakeholders willing to take risks to develop themselves and their institution
- authority to take action on the problem
- a system for learning reflectively.

In line with Step Up's aim to transform pre-service secondary mathematics and science teacher education, the project followed the action learning approach, illustrated in Figure 2.1, to implement educational reform. The ETMST program did not identify a single institutional problem, but rather a complex and multifaceted challenge based around the notion of combining content and pedagogy so that mathematics and science are taught more like they are practised.

Figure 2.1: Action learning cycle.

The action learning approach allowed this challenge to be addressed through a proof of concept stage, which provided a structured way for opportunities to be identified and developed/actioned within each of the partner Institutions in the experimental phase. The proof of concept provided a platform for a mix of ideas/prototypes to be tested – from quick and easy wins to more challenging, transformative ideas. Some of these initiatives did not succeed in delivering initial expectations. Lessons learned informed the planning of Step Up action research projects and ongoing cross-disciplinary collaboration, where the facilitation of reflection leading to action was key. This resulted in six collaborative action projects (CAPs) developing out of the initial proof of concept stages (Figure 2.2).

Step Up activities were underpinned by the integration of robust and intentional approaches to learning design, curriculum design and assessment informed by previous Australian Government Office for Learning and Teaching and Australian Learning and Teaching Council projects and innovative international models like Science and Mathematics Teacher Imperative (Mathematics Teacher Education Partnership, 2014). Step Up project members engaged in rigorous and

collaborative reflection in formal settings (e.g. during project intensives and forums in June and November each year, where a guided reflective process was used) and informal settings (e.g. as the CAPs developed) to address the challenges involved in achieving project outcomes. This collaborative reflection contributed towards the development of a shared vision across faculties and institutions over the life of the project. Due to the nature of action learning, this plan evolved throughout the project, to ensure outcomes were reached. This evolving, dynamic approach has been discussed by Coghlan (2012, p. 16): 'Action learning operates in the realm of practical knowing, where concern is for the practical and where situations are dynamic and are never identical or replicable. It focuses on what a particular organizational system needs in the present for the future.'

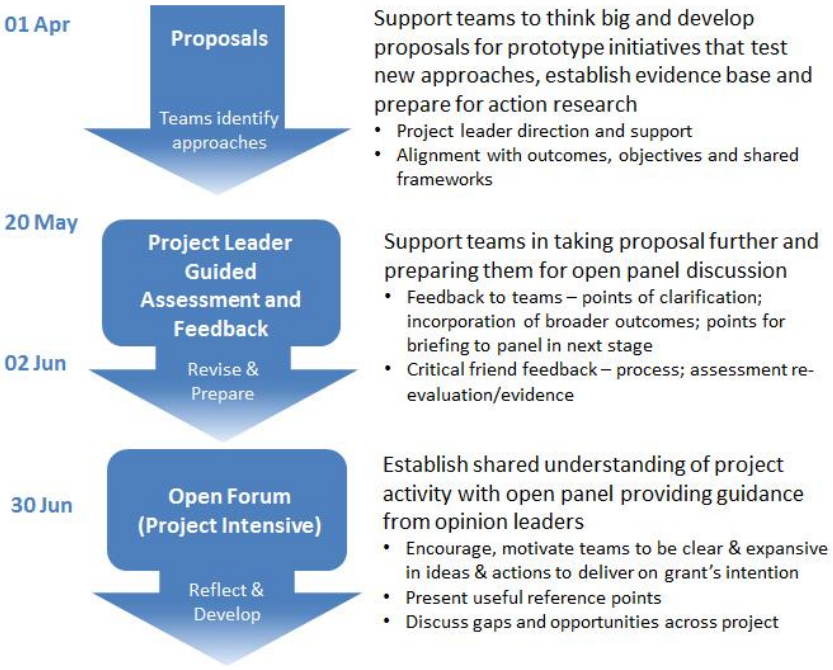


Figure 2.2: Proof of concept to collaborative action projects process.

The CAPs were designed in stages, with each stage informing the next, as illustrated in Figures 2.2 and 2.3. This was a purposeful move by the project leadership to build social capital, identify and support champions for change within the project team and build systemic change. A bottom-up approach enabled participants to identify actions aligned with the grant intent and project outcomes, tapping into areas of interest/passion for action. This also gave due consideration to local processes, systems and structures for leveraging change. Step Up members were required to unpack the challenge of how teacher education can combine content and pedagogy so that mathematics and science are taught more like they are practised. Once the challenge was unpacked, the stakeholders collaborated about how the challenge would be addressed. These plans were then put into action and reflected upon by teams.

By taking these new learnings forward, the groups re-evaluated the challenge and implemented the learnings into the next cycle. Although the action learning approach appears to involve a sequence of established stages, in reality the action learning stages were recursive, non-linear and dependent upon the interactions between project team members and their ability to implement structural and sustainable changes. The recursive nature of the approach involved collaborative rethinking, regrouping, and reimagining and refocusing on the ETMST challenges within the context of teams' specific circumstances.

The actioning learning approach underpinned the four phases of the Step Up project plan, from 2013 to 2016, as illustrated in Figure 2.3.

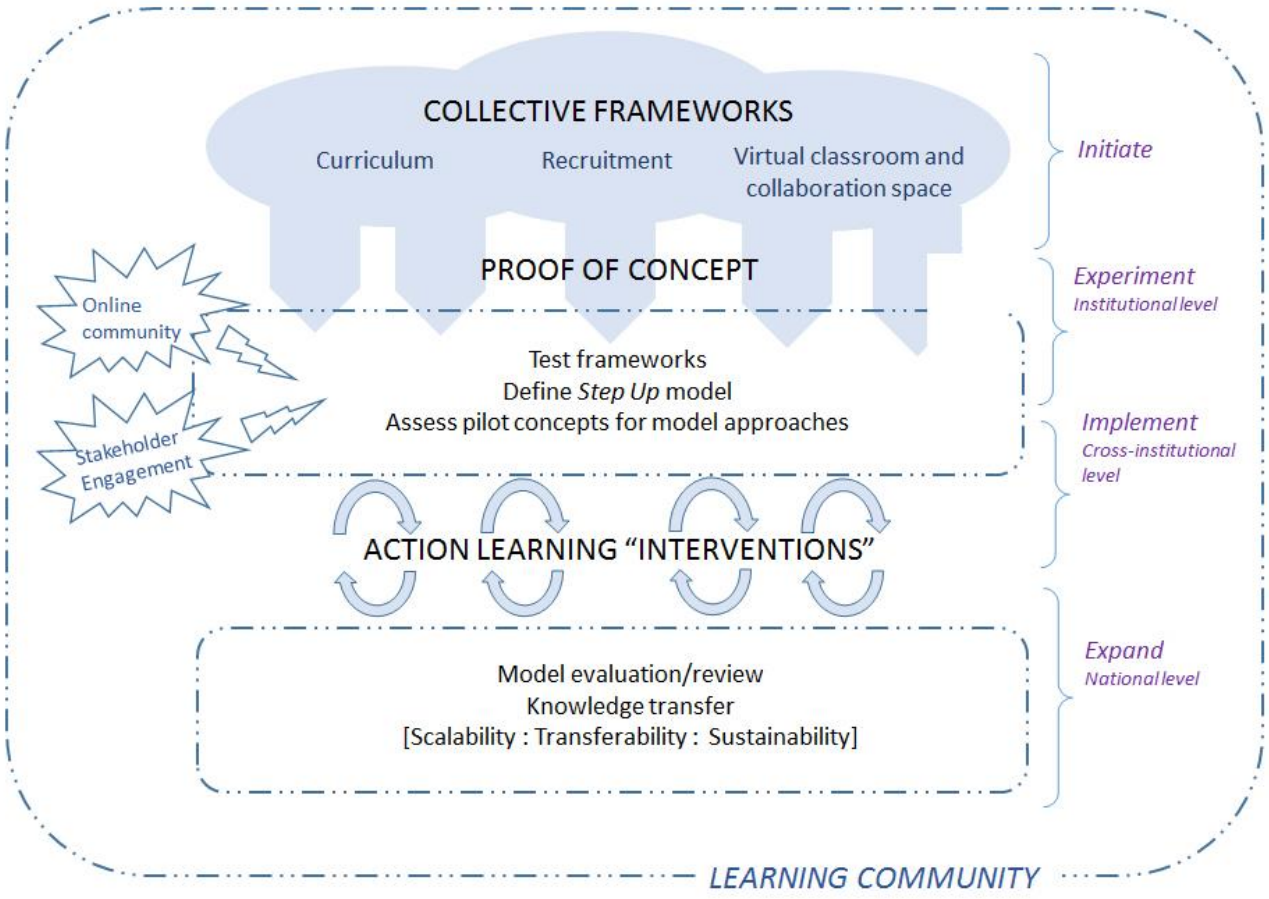


Figure 2.3: Phases of the original project plan.

2.1.1 Initiation phase (September 2013 – March 2014)

The initiation phase established the project delivery arrangements, project plan and governance framework. Within the initial three months, the first project intensive was held with as many participating academics as possible as a means of initiating collaborations and collective frameworks. (Chapter 5 examines dissemination locates the project intensive in the dissemination timeline.) This intensive provided the mechanism for all participants to be engaged directly in the development of the project logic and outcomes statement, ensuring collective understanding of the deliverables, including anticipated short- to long-term outcomes. In this phase, project team members were introduced, and cross-institutional and cross-faculty connections were encouraged. In addition to the project intensive and targeted group meetings, such as Curriculum Framework Think Tank, an online community space and shared Google drive were established for sharing ideas, news, documentation and resources.

2.1.2 Experiment phase (March–December 2014)

Following the initiation phase, in which the limited nature of existing working relationships across faculties was recognised, the experiment phase activated cross-disciplinary collaboration at an institutional level through promoting, supporting and trialling prototype activities, known as the proof of concept project, as indicated in Figure 2.2. Support for proof of concept projects included

the allocation of seed funding. During this phase institutional teams planned, implemented and evaluated their proof of concept projects. Teams were encouraged to be as innovative as possible within a single semester action learning cycle. Proof of concept projects were submitted to a reference panel for decision and direction. The proof of concept project proposals informed a critical friend review, which was shared across the project, supporting formative and summative project evaluation. The Step Up critical friend examined the proof of concept projects objectively, providing critique and asking provocative questions (Costa & Kallick, 1993). Project intensives were held in the middle and at the end of the year to expand thinking about what was possible within the project scope and to enable challenges and learnings to be shared cross-institutionally, paving the way for the next phase.

2.1.3 Implementation phase (January–December 2015)

Drawing upon a second round of reference panel and critical friend feedback, academics identified collective areas of interest to implement cross-institutional, cross-faculty CAPs (see Appendix B for an overview of the six CAPs). The intention was to develop these as model approaches that could be trialled across a minimum of two institutions with a view to future transferability. During this phase, members were expected to design, implement and evaluate their CAPs, building upon the collaborations, shared understandings and learnings that came from the proof of concept process. The reference panel and critical friend review provided transparency and rigour in the assessment and allocation of further project resources to support CAP implementation. They fed into project intensives which also provided mechanisms to identify learnings and implications to inform further action. These processes were useful to steer teams towards a cohesive view of Step Up and its potential impact.

2.1.4 Expansion phase (January–December 2016)

The fourth phase commenced in January 2016 and is currently ongoing. The original aim was to expand the CAPs to a national level and undertake model evaluation and review. Although the CAPs have not yet been shared on a national level, a meta-level analysis of the five ETMST projects, conducted by the external evaluators at the University of the Sunshine Coast and Phillips KPA, has informed national discussions about key learnings from the Step Up project. An ongoing aim of all phases was to continue to capture the key learnings and ensure they are scalable, transferable and sustainable.

2.1.5 Medium-term and long-term impact (January 2017 and subsequent years)

Step Up was designed cognisant of desired medium-term and long-term impacts and outcomes (Appendix D). Project team members will continue dissemination of Step Up outputs and further support changes across Australia in the preparation of mathematics and science teachers.

To stimulate ongoing efforts to demonstrate leadership and innovation in STEM Education, the Step Up project provided additional funding support to five cross disciplinary projects ($5000 per project) that were collaboratively designed across Faculties of Education, Science, Engineering and Health with the intention of expansion of existing networks of mathematics and science teacher educators and developing and activating these networks into emerging communities of practice.

Step Up project members contributed significantly to the June 9th, 2017 National Dissemination Workshop titled" Crossing the Bridge: New Frameworks for STEM teacher education.

2.2 Theoretical/conceptual framework

Step Up was underpinned by nine interrelated theoretical perspectives, shown in Table 2.1.

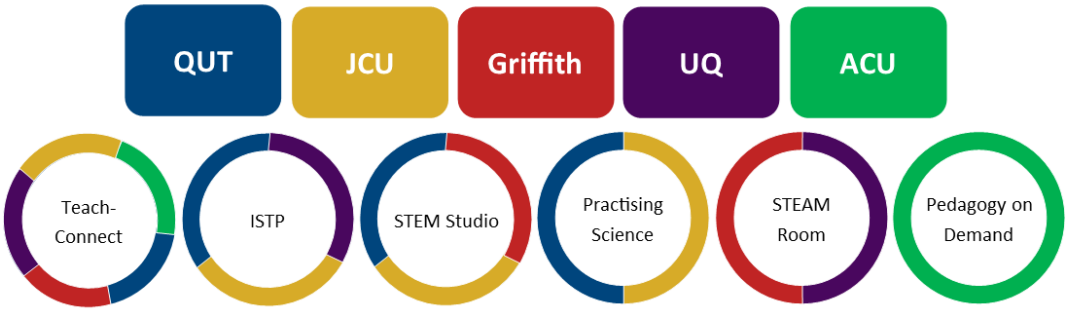
Table 2.1: Elements of the theoretical/conceptual framework

Informing perspectives	Evidence base	How did this lead to the agenda for Step Up?
Teacher development is ongoing	Coble, 2012	The project acknowledges the development of mathematics and science pre-service teachers must be conceived as part of an extended process that commences well before initial teacher education and extends until retirement.
Evidence-based framework for action	Mathematics Teacher Education Partnership, 2014; Presley, et al., 2012; Redd, et al., 2012	Adapting a similar framework to the Science and Mathematics Teacher Imperative, the core components of leadership, policy and infrastructure; recruitment, selection and admission; content, pedagogy and clinical practice; beginning teacher support; and teacher and school development informed Step Up.
Acknowledgement that effective reform needs both structural and cultural change	Fullan & Miles, 1992; Roxa, Olsson, & Martensson, 2008	The systems containing and regulating pre-service teacher education and places of employment must accept and support changes. This cannot occur without overall cultural change across all levels to support structural change in pre-service teacher education programs. It is important to acknowledge that understanding and accepting the principles underpinning effective pre-service teacher education is contested. The project proposes that mathematics and science pre-service teacher education should be the responsibility of both education and science faculties.
Sustainability	Silvius, van den Brink, & Köhler, 2012	Step Up acknowledges that approaches need to be able to be continued and expanded upon after the end of the life of the project (e.g. be socially viable, economically feasible, economically durable, lasting).
Nature of science	Lederman, 1992; Lederman & Zeidler, 1987	The nature of science, including the disciplinary values, stance, identity, mindset and behaviour of scientists and mathematicians, informed Step Up CAPs.
Differences in STEM cognition	Alamolhodaei, 2001; Bermúdez, 2014; Dietrich, 2004	Step Up recognises the nature and forms of cognition, including creativity and divergent thinking.
Teaching science as it is practised	Dewey, 1910 (as cited in National Research Council, 2000); Moore, 1993; National Research Council 2000; Schwab, 1962.	This perspective underpinned the ETMST project. It involved recognition of scientists' and mathematicians' ways of thinking, including risk taking and tolerance of failure. Step Up focused on open-ended, student-selected mathematics and science inquiry in the classroom, rather than pre-determined 'recipe science' approaches.

Informing perspectives	Evidence base	How did this lead to the agenda for Step Up?
Informal learning	Jamieson, et al., 2000; Keppell, Souter, & Riddle, 2011	Step Up appreciated the nature and value of informal learning as it occurs outside the classroom, lecture room or laboratory, including online or in community settings.
Community of practice	Akerson, Cullen, & Hanson, 2009	The effectiveness of support for learning and professional development in a group of people who share a profession informed the collaborative design.

Chapter 3: Project impacts and outcomes

Step Up aimed to reach project deliverables as governed by the logic statement. As discussed in Section 2.1, project deliverables were achieved through collaborative delivery of six CAPs (see CAP case studies in Appendix C for further details). Figure 3.1 overviews the joint design and delivery, indicating the extent of true collaboration between the five institutions, as illustrated by the colour coding and placement of each CAP.



ACU, Australian Catholic University. Griffith, Griffith University. JCU, James Cook University. QUT, Queensland University of Technology. UQ, The University of Queensland.

Figure 3.1: Cross-institutional collaborative action projects.

This chapter discusses the medium- and long-term project impacts and outcomes (see Appendix D for Step Up project logic). The impacts and outcomes are presented in terms of the three key stakeholders: students, institutions and academic staff. The chapter concludes with a consideration of the factors critical to the success of Step Up.

3.1 Student impacts and outcomes

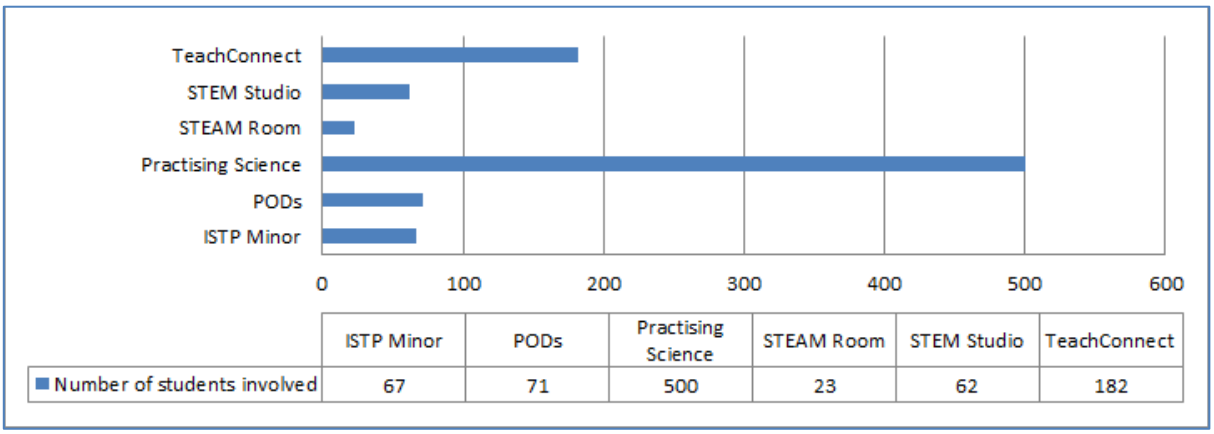
During the Experiment phase, the Step Up Student Engagement team worked collaboratively across the five institutions to *increase visibility and awareness amongst Step Up target students* to facilitate *student awareness and uptake of networks*. In this context students are defined as both mathematics and science pre-service teachers and mathematics and science students. The overarching purpose of the engagement strategy was noted in interviews:

> *We created opportunities for students to really go to these national platforms [e.g. CONASTA, STEM Fest]… we wanted to have a strategy for communication so that we'd be sharing their insights and they would be championing Step Up. It's not just about us, but championing pre-service teachers who don't really have a profile in the professional space.*

Creating a professional platform for mathematics and science pre-service teachers was a unique feature of Step Up. Diverse student engagement activities were designed to support successful transition into teaching careers, foster networks and enable project dissemination. Over the past three years, more than 170 pre-service teachers were involved in 19 engagement activities (including workshops, conferences and special STEM events).

The Step Up CAPs have engaged numerous students across the five institutions (Figure 3.2). The STEM Studio involved 35 mathematics and science pre-service secondary teachers at Queensland University of Technology, 7 mathematics and science pre-service secondary teachers at James Cook University and 20 mathematics and science pre-service secondary teachers at Griffith University. More than 717 participants have joined TeachConnect and there are currently 182 active users. The

Practising Science resources have been implemented with 40 mathematics and science pre-service secondary teachers at James Cook University, and approximately 460 at Queensland University of Technology. The Australian Catholic University team conducted focus groups to review the Pedagogy on Demand with 71 pre-service teachers enrolled in graduate diploma courses at Australian Catholic University, Griffith University and Queensland University of Technology. Twenty-three University of Queensland mathematics and science pre-service secondary teachers developed and led three STEAM Room activities. To date, 96 mathematics and science students have enrolled in the Integrated STEM Teaching Pathways minor at James Cook University and Queensland University of Technology. For some CAPs, engagement numbers are necessarily small due to their intensive qualities and trial phases of implementation.



ISTP, Integrated STEM Teaching Pathways. POD, Pedagogy on Demand.

Figure 3.2: Number of students involved in CAPs.

Step Up has provided emerging evidence of a current and future increase in numbers of mathematics and science teachers. The Integrated STEM Teaching pathways project has developed the Science/Mathematics Education Minor in order to allow for a wider and more diverse pool of students entering the mathematics and science teacher pathway, thus leading to increased numbers of students specialising in secondary mathematics and science teaching in areas of need. The Science/Mathematics Education Minor provides an authentic introduction and pathway into the secondary mathematics and science teaching profession with the minor designed to 'hook' science, mathematics and engineering students into considering mathematics and science teaching as a viable career option. Implementation of the minor commenced in 2015 at Queensland University of Technology and the first students will complete the minor in mid-2017. The first unit of the minor at has been run twice, with 24 students in 2015, 30 students in 2016 and 30 enrolled in 2017. To date, one student has transferred from engineering to Bachelor of Education (mathematics and science secondary) after completing the first unit of Science/Mathematics Education Minor and two completed the Minor in mid 2017 with one enrolling into MTeach. It is anticipated that an initial increase in Queensland University of Technology student numbers in general will be evident from 2019.

The minor at James Cook University will start in 2017 and has been designed to precede and articulate into the new Master of Learning and Teaching (Secondary). It is anticipated that an increase in student numbers will be evident by 2020. The development of new course structures is in progress at The University of Queensland, with changes to Bachelor of Science tabled and the minor available for Bachelor of Mathematics students. In future iterations of the STEM Studio, it is anticipated that teaching experiences will be available for mathematics and science students as a capstone experience for the Science/Mathematics Education Minor. Through collaboration of

approaches, the Integrated STEM Teaching Pathways project and the STEM Studio will combine to provide these opportunities.

The STEM Studio has provided opportunities for pre-service teachers to go beyond knowledge, understanding and skills, to influence their attitudes, dispositions, values and understanding of the nature of science. Critically, the STEM Studio provides numerous opportunities for guided reflection, as discussed by one of the pre-service teachers:

> *The current curriculum does not teach hands-on teaching strategies accompanied by feedback and reflection (especially as an external student) – again this appears to me to be the most critical part of learning to be a teacher which is not covered in my current course.*

Preliminary data (pre- and post-testing) of participants suggests potential positive changes in pre-service teacher self-efficacy after teaching in the STEM Studio, especially in the areas of effective instruction, motivating students and coping with change in the classroom. Influencing the mindsets of future teachers is critical to overcoming doubts and fears about their capability and confidence to teach in STEM areas. This will be further explored through qualitative analysis of existing data that focuses on collaboration between participants, professional identity, support mechanisms, teaching practices and connections between the STEM Studio and mathematics and science pre-service secondary teacher education courses.

The Practising Science with Pre-service Teachers project (Practising Science) has been embedded within the curriculum of mathematics and science pre-service secondary courses at James Cook University and Queensland University of Technology. The innovative curriculum has allowed pre-service teachers to design and implement scientific investigations. Evidence from a validated measure, the Teaching Science as Inquiry survey, suggests that involvement in this project may assist in strengthening pre-service teachers' mathematics/science knowledge and pedagogy. Figure 3.3 presents some of the survey data regarding pre-service teacher mathematics and science knowledge and pedagogy.

Anecdotally, a member of the Practising Science team reflected on an external student's appreciation of the new assessment:

> *She very much appreciated the way that we've approached the assessment for this year by immersing her in that experience where she had to do an EEI [extended experimental investigation], at home as an external pre-service teacher and then to reflect on that experience as a student, to put themselves in the shoes of a Year 11 or Year 12 student, and what that experience meant for them as a teacher. She commented on how that's such an innovative approach to doing an assessment and how it actually embedded her in the actual science inquiry process.*

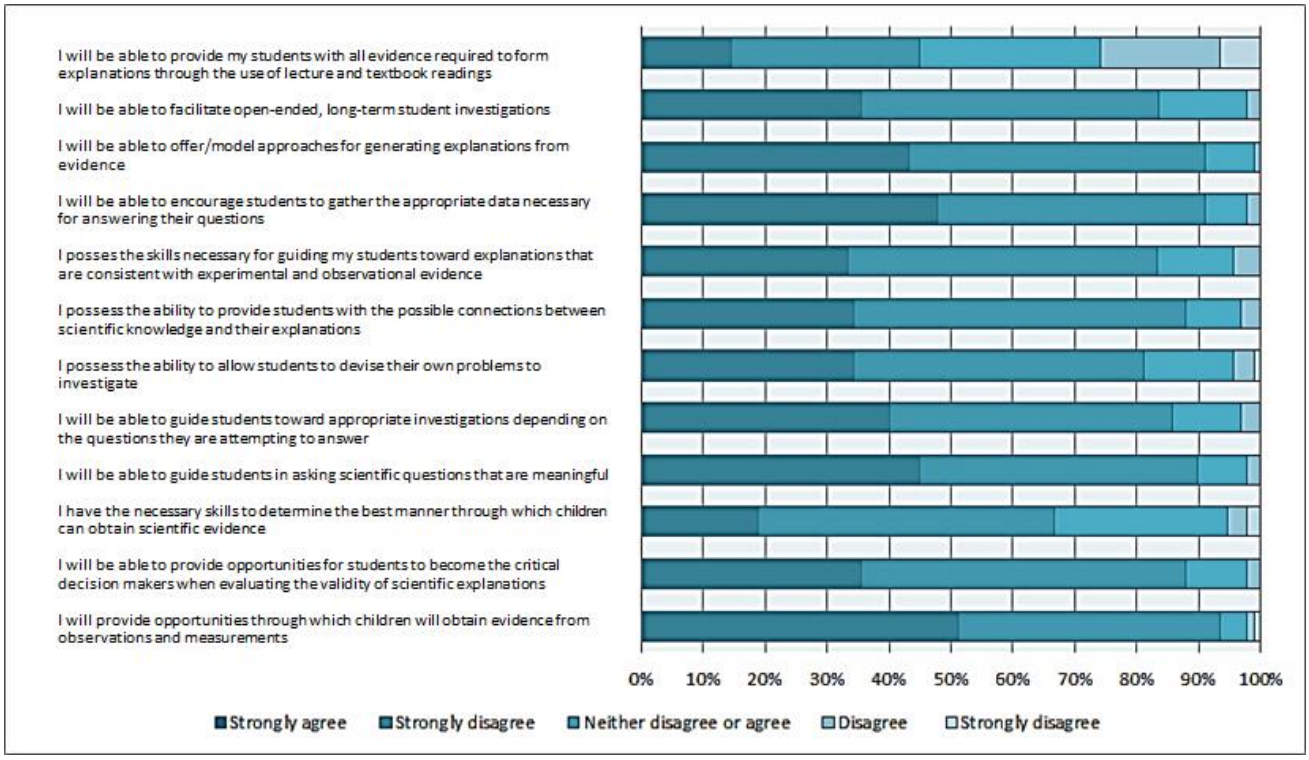


Figure 3.3: Teaching Science as Inquiry survey – selected questionnaire items.

A legacy of the Step Up CAPs is the development of four related innovative online resources that are available to the higher education sector. These resources created a professional platform for mathematics and science pre-service teachers that will support, facilitate and sustain the development of a learning community of emerging mathematics and science teachers actively engaged in an interdisciplinary, professional community of practice. First, Step Up has developed a webpage that will make the Practising Science instructional resources publically available. The Department of Education Queensland has expressed interest in including the link to the Practising Science website on their science education resources webpage. Second, an online space at TeachConnect allows pre-service teachers to propose and envision classroom experiences that are not governed by their supervising practicum teachers during professional experience. In the same way, early-career teachers are able to unpack student learning experiences with experienced scientific practitioners. Third, Nature of STEM website will integrate aspects of several Step Up CAPs. It includes the videos developed by the Practising Science project with the intention of deepening pre-service teacher and in-service teacher conversations about how to think scientifically. Finally, the resources developed by the Pedagogy on Demand project are available on the K–12 learning management website Schoology. This team reflected on this strategic decision during the interview process:

> *What we actually want to see is a resource that pre-service teachers can touch base with when they do prac, when they're in first year of teaching … So we don't want this locked away in a University learning management system … we actually want it in an open system that they can continue to access.*

The retention of beginning teachers on transition into the workforce is a global issue. Up to 25 per cent of beginning teachers leave the profession within the first five years (Department of Education Science and Training, 2003; Queensland Audit Office, 2014), due to issues including lack of workplace support and unrealistic expectations of the profession (e.g. Boser, 2000). Step Up

provides mechanisms to support increased retention on transition; however, limitations exist regarding provision of tangible evidence due to the life of the funded project.

Lack of workplace support, identified as a potential issue, has been partly addressed with the TeachConnect platform. Connecting pre-service teachers with mentors, including in-service teachers and mathematics and science discipline experts, TeachConnect provides a platform of ongoing support as pre-service teachers transition into the workforce. This platform is available to all pre-service teachers within Queensland, with plans to roll this initiative out nationally and potentially internationally.

Unrealistic expectations of the profession can influence teachers' job satisfaction and subsequent attrition or retention. Providing pre-service teachers with practical classroom experiences, as afforded in STEM Studio, supports pre-service teachers in understanding classroom requirements, implementing lessons and developing confidence in themselves as teachers. These crucial elements of the STEM Studio represent authentic aspects of classroom experiences and may help rectify the disjoint between expectations and reality. The importance of the STEM Studio was discussed by a Graduate Diploma pre-service teacher during the post interview:

> *I think for me personally probably it was about self-confidence and just the reassurance that knowing the content is one thing but you need to be able to communicate it effectively to students, I think the Studio experience just really cemented it for me. I realised that, wow, I can do this, this is great!*

There is potential to increase retention on transition and support students with strong content and pedagogical skills. Practising Science provides students with skills to guide and engage high school students in designing and conducting science inquiry projects, as well as providing requisite knowledge in scientific research design. These principles have been implemented at two partner institutions, evidenced within curriculum documents and teaching resources.

3.2 Institutional (curriculum) impacts and outcomes

A shared framework for operating across the consortium members is a key outcome for any collaborative project. Successful achievement of this deliverable is required to form strong foundations for systemic and cultural change. A shared framework must encompass a shared language, a shared vision, and a plan for ongoing links across faculties and between institutions.

Step Up evidenced this outcome through initial and continued stakeholder involvement. Initial discussions regarding the project trajectory involved 10 academics across STEM and 14 academics within education. These discussions involved the five partner institutions and numerous external stakeholders. A key success factor for this outcome was involving members in the design of the project, ensuring a shared framework was established. As noted by several of the academic participants, 'the most successful academic engagement was the project intensives, getting them all in the same room at the same time' and, 'I think also the nature of this particular project, from my perspective, is it was working towards something concrete, it was very clear that the actions and the pathways, there's a clear product'.

As a foundation for Step Up, the shared framework was revisited throughout project milestones to maintain the shared vision important for success.

Insight for systemic change can be drawn from documented course structures and articulations from Step Up. Several of the CAPs worked on embedding activities developed by the projects within

curriculum to enact change. For example, the Integrated STEM Teaching Pathways included minor subjects available for STEM majors, with students being able to transfer at the end of first year or enter a Masters of Teaching after completing their undergraduate degree. This embedded change ensures ongoing sustainability of the Step Up outcomes and provides further evidence of the institutional impact of Step Up.

Several CAPs provide evidence for collaborative course design and delivery, formalised in curriculum structures/processes. Practising Science developed a curriculum in consultation with educators and scientists across multiple institutions. Details of implementation differ at each institution in line with local needs or requirements based on existing education course structures, and time constraints at the time of implementation. Flexibility to adapt the curriculum to various contexts is a key learning from Step Up, which can inform future collaborative projects involving cross-institutional links. At Queensland University of Technology and James Cook University, the principles of practising science have been implemented into curriculum and course resources. Resources are available on the Step Up website.

The STEM Studio provided a different pathway for this outcome as it was developed outside of the formal curriculum through cross-faculty and cross-institutional collaboration. Unlike the CAPs that started within the curriculum, a critical factor to STEM Studio's sustainability is that it now needs to be accepted and seen to add value to the existing curriculum. As stated by one participant, '*once we refined the model and how it runs and everything else, then we're going to turn it into a course which will sit inside our current teacher preparation programs*'.

In addition, the Integrated STEM Teaching Pathways team at the lead institution worked with both the Education, Science and Engineering faculties to provide a minor whereby both science and education academics taught in the units. These units and changes are evidenced through course documents and documents provided to students. This had a flow-on effect for academic staff within these units, leading to a key learning from the project, as evidenced in reflective comments by one participant: 'As a result of seeing [name removed] teach, and I'm not a school teacher and I don't come from education, but I try to teach in a different manner than standing out in front and transmitting knowledge'.

Several partner institutions implemented variations of a curriculum framework that involved mathematics and science and teacher education teams and stakeholders. Initially, Step Up aimed to present a shared curriculum across institutions. However, due to the complexities of university contexts, the challenge of accreditation and differing university priorities, this was unable to come to fruition. However, institutions were able to draw upon common principles across frameworks and implement these within their own context. In addition, they were able to draw out significant learnings from the process, which further formed the higher education sector. For instance, the importance of external collaborators, mutual respect and trust across the sector and an understanding of administration procedures were essential for involving mathematics and science and teacher education teams and stakeholders in a curriculum framework. As stated by mathematics and science and teacher education teams:

> *This project can speak more broadly because they've had a go at seeing whether or not these ideas have merit, in different contexts, under different pressure, in different systems, facing different structures and so I think the learning that can come from that is more substantive …*
>
> *It's the principles that have been derived through the work of each of the institutions that will be transferable …*

> *I think there were lots of advantages to working across institutions, particularly in developing the principles that underpin the third space notion, which was then developed, across each of the different institutional partners to respond to the context that we were working within. Without that cross-institutional collaboration the principles that underpin each context wouldn't have been developed. It would have been something that I was developing here that was particular to my needs, as the other institutions would have had as well. Whereas now I think with the principles that we have been able to derive from our collaborative work, we have something that is transferable.*

Preliminary evidence provided for continued partnerships providing mechanisms for sustained resourcing and implementation (beyond the life of the project) suggests Step Up will be successful in this endeavour. Through Step Up, partnerships have been established outside of the project (e.g. Australian Research Council grants, journal publications, book chapters). These partnerships highlight the continuing relationships between institutions, faculties and external stakeholders, and the commitment to the goals of Step Up. For instance, one institution Griffith University has secured funding to continue to run STEM Studio beyond the life of the project. This mechanism ensures a future for this initiative. In addition, STEM Studio members indicated they would continue to work together to implement the studio even after the conclusion of the Step Up. Making a submission for Australian Research Council Linkage Projects and other research funding provides a mechanism that may support future project work. Further, TeachConnect linked with all university partner institutions and secured external funding from the Queensland College of Teachers to continue working. These are just a few examples of the way partnerships will continue to provide mechanisms for sustained resourcing and implementation. For many academics on the Step Up team, sustainability has become a focus of planning:

Evidence of continued partnerships can also been seen through the established networks as a result of Step Up and the shared vision being seen as important to continue:

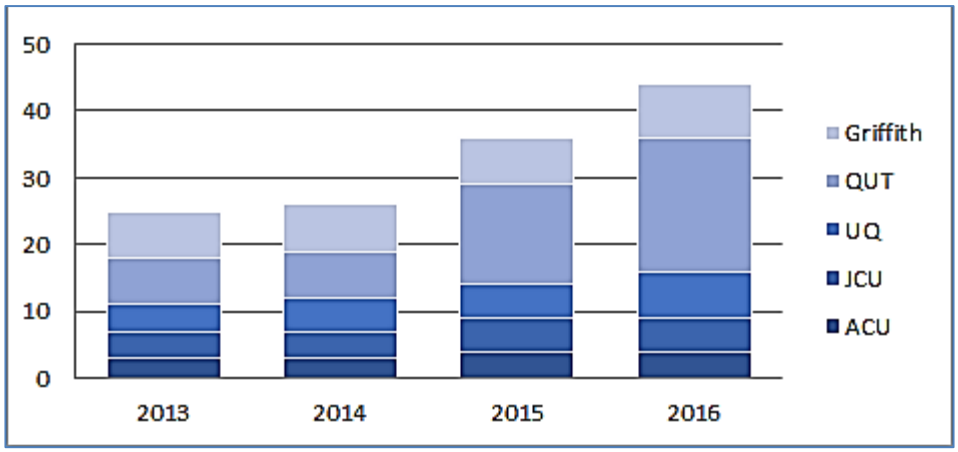
> *It's introduced us to other people from other universities that we didn't know before. People in science, out of other faculties, in other universities and we have developed a very positive mindset towards what we're trying to do.*

As evidenced, teams within Step Up will continue to work together for systemic and cultural change (Appendix D and Appendix E). Step Up is on track to achieve its long-term outcomes, including for the dissemination of the Queensland model, nationally. Steps have been put in place to ensure ongoing success. This is further evidenced in Chapter 5.

3.3 Academic staff impacts and outcomes

Step Up was successful in acquiring the participation of staff within and across universities in project activity, as illustrated in Figure 3.4. At conception, five partner universities developed the proposal for Step Up. In 2013–14 there were 26 project participants across partner institutions, 36 in 2015 and 44 in 2016. Within the experimental phase, 26 staff were involved in project activity. As phases extended and morphed, for the CAPs, the STEAM Room saw two academics from two institutions, STEM Studio saw seven academics from three institutions, Pedagogy on Demand saw two academics from one institution, Integrated Pathways had seven academics from three institutions, Practising Science had three academics from two institutions and TeachConnect

existed across all institutions including external partners, and was driven by one academic and a Queensland University of Technology learning designer.



ACU, Australian Catholic University. Griffith, Griffith University. JCU, James Cook University. QUT, Queensland University of Technology. UQ, The University of Queensland.

Figure 3.4: Number of academics involved in Step Up across institutions.

Project intensives, newsletters, email communication, social media (i.e. Google Plus for internal communication, Twitter for external communication) and networking events were organised to assist key stakeholders to be aware of the project and the imperative that it sought to address. Stakeholders indicated their awareness of the project by connecting through the various channels/events (Appendix G) as well as through active involvement in the intensives (Appendix F), proof of concepts and CAPs. The outcomes of the CAPs and the long-term impact statements (Appendix E) provide evidence that the imperative that Step Up sought to address was understood. It was, however, these intensives that participants found very beneficial:

> *The whole forum was actually brilliant in terms of getting teachers together, getting government people together, getting university people together, getting students together.*

Evidence that Step Up was successful in advancing an expansion of networks of mathematics and science teacher education Educators was noted, in part, through interdisciplinary teams planning and delivering CAPs across institutions. Step Up provided a catalyst for connecting individuals otherwise unlikely to work together. As evidenced by participants:

> *There has actually been some good collaborations that have been cross institutional … If Step Up hadn't occurred – that wouldn't have happened normally.*

> *Instead of having one point of contact, I have four in the science and engineering faculty, and subsequent to this, I'm now working with another staff member in another faculty who is interested in inquiry in their own university science instruction.*

When further evidencing this outcome, information can be drawn from each CAP regarding the number of scientists and educators working together. For example, Integrated STEM Teaching Pathways connected approximately eight scientists and five teacher educators. STEM Studio was actively involved in connecting participants, as evidenced in Figure 3.5. Information provided by participants suggests these networks are continuing to shape STEM teacher education outside of Step Up, expanding the networks:

As a consequence of this particular project … a couple of academics across disciplines have been able to conduct commercial research with the Queensland Department of Education and Training in the STEM area and also work with the QLD Museum in the STEM area. It's hoped that we will develop an ARC Linkage with them in the next round.

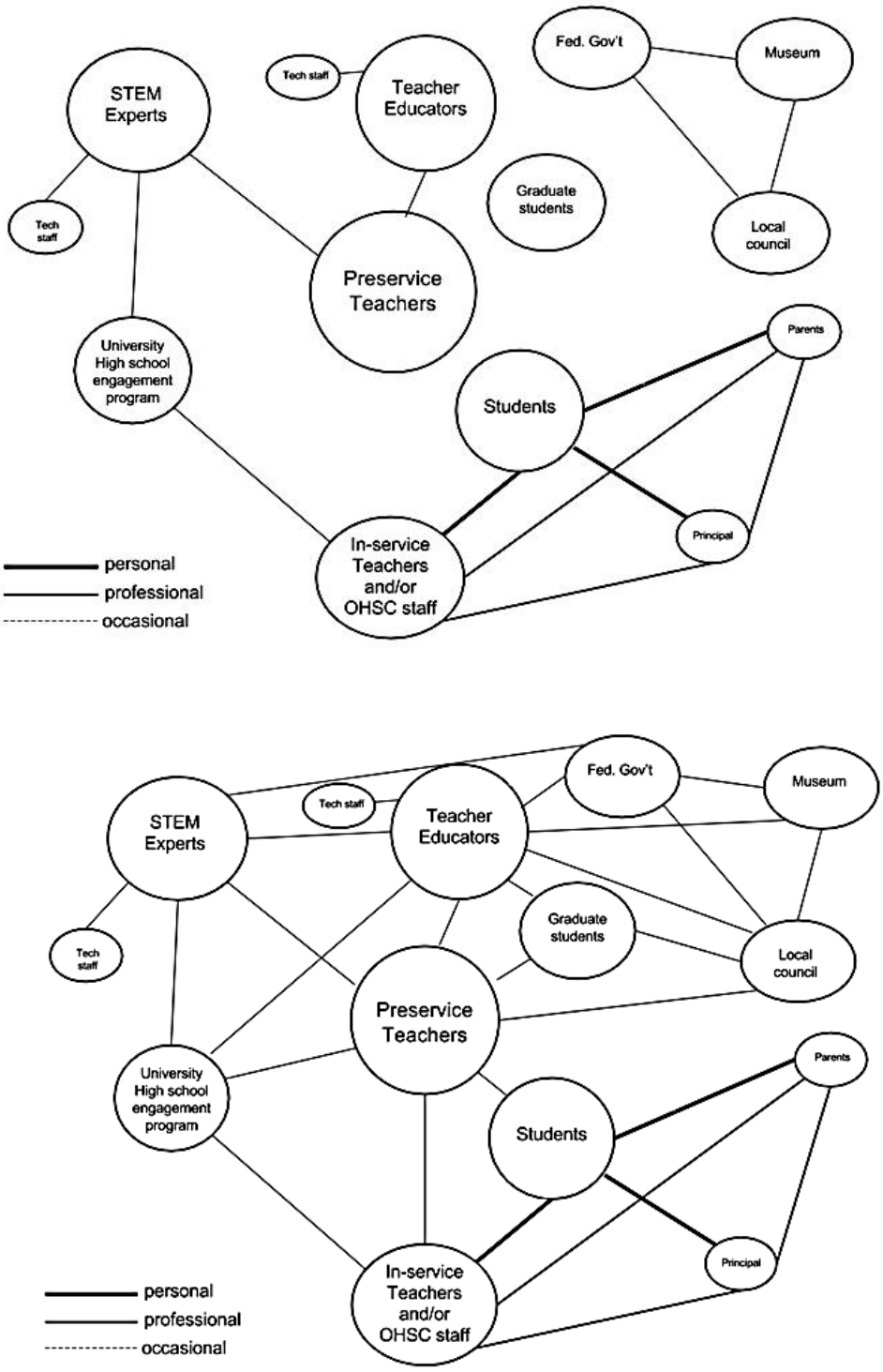


Figure 3.5: Connections developed before (upper) and after (lower) STEM Studio for Griffith University, James Cook University and Queensland Institute of Technology.

3.4 Factors critical to the success of the project approach

3.4.1 Champions at every level

Markham (1998) identified that champions influence others towards project success. Step Up echoed this, with several participants identifying champions as critical for success, deciding, 'a lot of change in society in general comes from these champions, the few very key people who are very committed' and 'all of the projects within Step Up have had some champion in them who's really driven it'.

Indeed, one participant suggested it was due to champions that institutional change can occur:

> *To get change you need a champion. If you don't have the champion change isn't going to happen. So it's actually providing a forum but also providing the strategic initiative, the strategic support if you like, for that champion to then take it through their institution. So I think that's where you start to get institutional change.*

Interestingly, one academic participant posed a significant thought for the ongoing sustainability of the project, suggesting that a champion is required past the initial implementation phase, which is an important learning for future projects:

> *It usually takes a person who really believes in it and at the right level. Then it also takes enough people so that there is some redundancy in the system at the operational level to take care of it, not just for the next two years but for the next five years. Then after that maybe for the next 10 years. It can fall down if the person who operationally cares for it and knows how it all works isn't there.*

3.4.2 Cross-faculty and cross-institutional respect

San Martín-Rodríguez, et al. (2005) recognised that mutual respect is important for successful collaborations. This respect can lead to a decrease in the competitive nature of the business climate, which enables the sharing of resources and learnings, and the strengthening of cross-institutional and cross-faculty links. As evidenced by an interviewee at an institutional level, 'we've probably got much less competitive commercially … you know, not going to tell you what we're doing, keeping our cards close to our chest – I think we're much happier to share practice and ideas and so on'.

Through the Step Up project approach, four elements for successful collaboration emerged, as identified at an institutional level by an education academic:

> *The whole experience really brought to the forefront the importance of probably four elements of institutional capital between faculties. That's funding, workload, trust and recognition for your work. … So these are quite sensitive issues. I found they were the common ones that came up in any discussion about cross-faculty relationships. … Managing those is part & parcel to the success of a project like this.*

By identifying these four elements of success, challenges can be overcome:

> *I felt as though the effort – it tended to be scattered sometimes, just because everybody had their pet project. Whether or not that actually fitted the brief or not was – but also that's probably inevitable. People are going to put energy into things that they're passionate about.*

3.4.3 Step Up as a catalyst for change

Step Up can be considered a trigger for several unintended outcomes brought to the table by academic staff across the project through existing relationships and networks. These outcomes, not considered part of Step Up originally, clearly aligned with priorities 8 and 9 and are significant to enact change within the sector. To discount changes of a large, high-profile project due to the scope of the project would be remiss. Outcomes provided by participants across the project that they credited to Step Up include:

- updating of pedagogy for academic staff in STEM faculty
- foundation science courses for all undergraduate teachers
- updated resources, content knowledge and pedagogy for undergraduate teachers specialising in early childhood and/or primary
- School curriculum development for Queensland Curriculum and Assessment Authority by academic staff involved in Step Up
- benchmarking of university science teacher education curriculum across Queensland
- new relationships between universities and schools
- stronger relationships between universities and schools
- high school students being exposed to new pedagogy and resources
- profiling education research across other faculties
- linking with existing programs such as Mentoring of Beginning teachers.
- skills development for pre-service teachers exploring creative tools and links between STEM and arts education (STEAM)
- increased profile of STEM education amongst university leadership.

In part, academic interviewees suggested Step Up contributed towards these originally unintended outcomes: 'The fact that … having a high profile project draws your attention to certain things' and 'this project had brought profile and resource and brain space to think, and interactions with good, smart people means that it bubbles up the priority list'.

Chapter 4: Step-change initiatives

Step change refers to a significant change in policy or attitude, above what is usually able to be achieved. Step Up has provided initiatives that assist with enabling step change within the secondary mathematics and science pre-service teacher landscape. Three areas have been influenced by Step Up CAPs:

- **collaborative cross-faculty arrangements:** collaborative initiatives in course design and delivery
- **integrating content and pedagogy to reflect the experience of authentic science:** preparing teachers who have a contemporary and dynamic view of science and who are capable of bringing authentic science into the classroom
- **developing the professional identity of STEM teachers:** creating, extending and enhancing professional learning and support networks for undergraduates and teachers.

4.1 Collaborative cross-faculty curriculum arrangements

Priority 1 of the ETMST Program aims to increase collaboration between faculties of Science, Mathematics and Education to expose pre-service teacher education students to contemporary science and mathematics, whilst at the same time providing models of how mathematical and scientific content, thinking and pedagogy can, in part, be a product of collaboration. Priority 2 of the ETMST Program is to increase the supply of graduates.

Embodying these priorities, the Integrated STEM Teaching Pathways project provides a case study of success in this area (Case Study 1, Appendix C).

Case Study 1: Integrated STEM Teaching Pathways

The ongoing Integrated STEM Teaching Pathways project involved the development of the Science and Mathematics Education Minor. The minor was developed through a collaborative approach between Education and Science faculties at Queensland University of Technology, James Cook University and The University of Queensland. Academic staff from both faculties collaboratively designed and taught the minor units. With authentic content deliberately tied to pedagogy, this pathway has value. The sharing of resources and minor structure has occurred across universities. Evidence gathered from the three institutions indicates that the collaborative course design and delivery, formalised in curriculum structures and processes, have been successful. To date, 96 students have enrolled in the Integrated STEM Teaching Pathways minor at James Cook University and Queensland University of Technology. The development of the minor is in progress at The University of Queensland, with anticipated changes for the Bachelor of Science. The principles underpinning the minor framework have been shared across the three Queensland universities; however, the design is flexible enough to adapt to various contexts and academic expertise, allowing it to be rolled out differently across institutions.

At James Cook University, for example, the scope and sequence of these subjects, as constitutive of an Education minor with a Bachelor of Science, might provide an exemplar for consideration at a national level. The sequence draws students through a series of teaching, learning and assessment experiences that develop desirable graduate attributes in Bachelor of Science students, and that expose them to facets of the education field. In doing so, students are provided with a taste of Education. Those students who undertake a minor in Education will be credited points towards the completion the Master of Learning and Teaching (Secondary), allowing them to gain teacher accreditation, and opening up a new career option for Bachelor of Science students.

The implementation of a minor has significant real-world impact that can lead to step change. A survey undertaken as part of Step Up suggested interest from STEM undergraduate students towards units and minors in education (Figure 4.1). The survey suggested 76 per cent of respondents would consider taking a unit in mathematics/science teacher education, and 69 per cent would have considered a minor in mathematics/science education. Several students who took the minor indicated their understandings of teachers had shifted and their employability prospects heightened. It is important to note that students indicated they would be more motivated to take a minor if it led to credit in a teaching qualification.

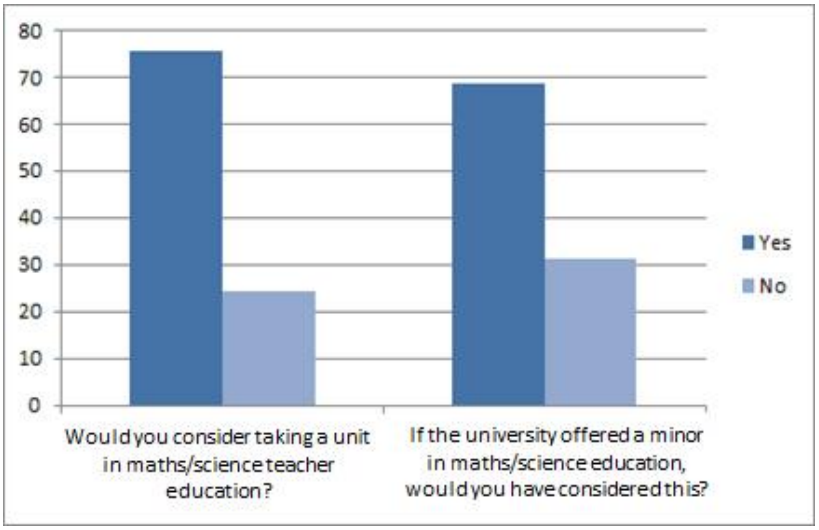


Figure 4.1: Percentage of STEM undergraduate students at Queensland University of Technology who would consider a pathway into teaching.

4.2 Integrating content and pedagogy to reflect the experience of authentic science

According to Tytler (2007), science education in Australia is facing two key challenges. First, many teachers require a more contemporary view about the nature of science and the work of scientists. Second, Tytler argues that science should be taught in a manner that gives students more agency and focuses on the possible co-construction of scientific knowledge. The challenge of preparing teachers who have a contemporary view of science and who are capable of bringing authentic science into the classroom has generated a range of responses from the CAP teams.

The Step Up project facilitated collaboration and dialogue between relevant experts to develop authentic experiences that integrated STEM content and pedagogy. The CAPs were underpinned by

the aim of creating authentic learning experiences for mathematics and science pre-service secondary teachers. Pedagogy on Demand (Case Study 2, Appendix C) and Practising Science (Case Study 3, Appendix C) are exemplars of how scientific content knowledge and pedagogy can be integrated in mathematics and science teacher education courses to reflect a contemporary and authentic view of science.

Case study 2: Pedagogy on Demand

Many students and teachers see authentic science as requiring one to be in a science laboratory doing experiments and using specialised equipment. In mathematics, students adopt a mechanistic view, seeing it primarily about completing tasks by finding the right formula (e.g. Young-Loveridge, et al., 2006). Although science and mathematics are valued by students, there is little opportunity in regular classes to see how it can be applied to everyday life. Providing students with opportunities to experience how science really is enacted – i.e. authentic science – has been advocated as an important means to allow students to know and learn about science (e.g. Van Eijck & Roth, 2009). Science and mathematics permeate most aspects of life and it is through exploring the mathematics and science of everyday phenomena that students derive interest and potentially long-term sustained involvement in these domains. The extensive research on what engages students validates the approach adopted by Pedagogy on Demand where science and mathematics are contextualised around sport, for instance. Concepts defined in the national curriculum (content) and inquiry oriented pedagogical practices involving greater student-centred learning opportunities are central to the CAP. Discussions with sports scientists have highlighted those real-world experiences and applications of science and mathematics in sport that have impacted the design of Pedagogy on Demand resource.

Case Study 3: Practising Science

The instructional sequence involved pre-service teachers applying existing knowledge of science, while learning new knowledge about scientific research design, to develop and implement their own scientific investigations. The approach is also an integral part of the assessment in those units where all pre-service teachers are required to design, conduct and reflect on their scientific investigations and pedagogy. Through the Practising Science project, videos of scientists explaining how they design and conduct scientific research, and how they apply thought processes like analogical reasoning, distributed reasoning and unexpected outcomes, enhanced the curriculum further and enabled a flipped-classroom approach to instruction to be explored. Other resources such as readings and examples from scientific literature also served to scaffold the pre-service teachers' instruction and completion of the science inquiry assessment task in the Education courses from participating universities.

As discussed by one of the Practising Science pre-service teachers:

> *Scientific inquiry engages students in a process of learning ... They feel like they own the knowledge they create, whereas if you are just giving it to them quite often it's just like water off a duck's back. They don't own the knowledge, they're not engaged by it so they just – it goes in one ear and out the other.*

This quote highlights the pre-service teacher's contemporary views about the interconnected relationship between scientific knowledge and pedagogy. Further, the Practising Science videos provide an authentic means to discuss the work of scientists in various contexts (such as manipulative experimental inquiry, correlational inquiry and observational inquiry).

4.3 Developing the professional identity of STEM teachers

The development of a strong professional identity is related to beginning teachers' resilience, retention and effectiveness in the classroom (Mansfield, Beltman & Price, 2014). There is a need to develop the professional identity of STEM teachers. With issues such as teacher burnout and small pools of qualified STEM secondary teachers plaguing the sector, it is important to create, extend and enhance professional learning, and implement and sustain support networks. This challenge generated innovative approaches from the CAPs.

4.3.1 Interdisciplinary professional networks

Priority 9 of the ETMST Program is to encourage Mathematics, Science and Education faculties to build long-term relationships with teachers. The facilitation of collaboration and ongoing relationships between pre-service teachers, teacher educators and mathematics and science discipline experts can be seen as a success factor for Step Up, as demonstrated by the STEM Studio (Case Study 6, Appendix C).

Case study 6: STEM Studio

Through individual support and mentoring, the STEM Studio provided mathematics and science pre-service secondary teachers with the opportunity to explore their emerging professional identities. This was enabled through feedback from the practising teachers, teacher educators, mathematics and science discipline experts, other pre-service teachers and their own personal reflections. The pre-service teachers' interactions were explored, and analysed to identify 'critical moments' of teaching that related to their understanding of their identity as a STEM teacher. These interactions were discussed on a mentor-to-peer and peer-to-peer basis, helping pre-service teachers to observe and critique their teaching and its impact on the learning experiences of students in the classroom. For example, one pre-service teacher reflected on the critical moment they felt confident to shift away from a focus on content knowledge:

> *I have shifted my focus from 'I need to teach this' to 'Do the students understand what I'm teaching?' I feel more comfortable extending activities and discussion if it benefits the students and less worried about getting through all the content in one lesson.*

4.3.2 Supporting early-career mathematics and science teachers

Priority 8 of the ETMST Program involves the provision of support for mathematics and science teachers to ensure they have a contemporary view of mathematics, science and pedagogy. This priority acknowledges that in-service teachers also require ongoing support. TeachConnect (Case Study 7, Appendix C) provides support for teachers at every stage of their career, from first-year pre-service teachers to experienced mentor teachers. This support is underpinned by the notion that teacher development is an ongoing process that commences well before formal teacher training and extends until retirement (Coble, 2012).

Case study 7: TeachConnect

TeachConnect is an exemplar of an innovative strategy that uses an online platform and engagement strategy to link pre-service teachers and teaching graduates to a community and to mentors in their discipline and profession, providing a sense of professional belonging (Kelly, et al., 2016). The development of an online professional network, will help to ensure that beginning teachers do not feel isolated in their school environments, regardless of their geographic location or employment status, and that their professional identity will continue to evolve as they feel a sense of competence and confidence through ongoing interaction with mathematics and science mentors (Kelly, Clará, & Kickbusch, 2015).

The Queensland College of Teachers has agreed to invest $90,000 in TeachConnect over the next three years and is looking at ways in which the platform can contribute to the gathering of evidence for AITSL's Professional Standards for Teachers, particularly 6 and 7, which address professional engagement. As an online interdisciplinary professional network, TeachConnect can support mathematics and science teachers' ongoing interactions with science professionals, increase their awareness of professional development opportunities and conferences and promote dialogue around inquiry-based learning, as exemplified by discussion around the Nature of STEM.

Chapter 5: Dissemination of project outcomes, and impact

Through the project design and dissemination, Step Up has worked within and beyond the project to recognise and enable agents of (practice) change and advocates of change (champions). The second group is particularly important in providing important systemic/organisational support to change agents. See Appendix F for an overview of dissemination objectives, activities, timeline and outcomes.

Step Up dissemination activities have:

- identified and engaged stakeholders as active participants in design and implementation of model approaches
- supported or improved alignment with other parts of the education system as needed
- achieved collaboration that could support sustainability of project outcomes beyond the life of the grant funding
- achieved advocacy and support, informing other related elements of the system/sector and building positive momentum for and around change in practice.

For dissemination for action to be successful and sustained, establishment and development of effective working relationships was critical – underpinned by mutually beneficial outcomes, which were identified and tackled in meaningful ways together. The greatest successes for Step Up have come when, in identifying areas for shared action, parties have achieved the high-level challenge posed by the ETMST program and the shared desire to improve education outcomes to identify points where specific priorities intersect, particularly:

- organisational and budget priorities (e.g. key political imperatives, corporate review outcomes)
- profiling opportunities (e.g. media opportunities)
- professional interests/drivers (e.g. individual performance goals, career development for individual stakeholders/partners).

For example, backed by Step's Up national profile and project funding, James Cook University was able to initiate co-funded activities with regional bodies (businesses, local school communities and non-government organisations). These activities aligned Step Up practice changes with local interests and priorities. As observed by JCU participants, 'Now because it's been successful, people are interested in keeping those partnerships alive … that space is now available for pre-service teachers to practise innovative pedagogy in and they're keen to have us continue to do that.' Also, the proven relationships and profile have paved the way for approaches to be sustained through other funding sources: 'The reef education is sustainable because Council now gives schools $2,000 a year for this purpose.'

TeachConnect illustrates how focused dissemination strategies can achieve statewide practice change. Pre-existing relationships between individuals enabled Step Up activity to be aligned with the Queensland College of Teachers' interest in supporting emerging teachers to remain in the profession. Queensland College of Teachers' backing of TeachConnect was arguably a critical factor in achieving take-up by every Queensland University in its pilot phase. Further, alignment with the Mentoring Beginning Teachers initiative ensured that mentor training built upon the learnings of this successfully established program. The TeachConnect team is now working in partnership with university professional experience coordinators to explicitly connect the platform to assessment

and students' portfolio of standards. Following the initial success of the project, Queensland College of Teachers has given in-principle commitment to extend the partnership, with three years of additional support funding.

This partnership also facilitated shared media coverage as well as interest from the Queensland Minister for Education, who profiled Step Up in her opening address at the 2016 Peter Doherty Awards for STEM Education (the premier science teaching awards and recognition forum in Queensland).

Dissemination was key to overcoming the initial challenge of perceived inflexibilities in education curriculum change – by trialling innovative learning experiences through student engagement in extra or co-curricular activities. For instance, Step Up offered sponsored opportunities for pre-service teachers to participate in high-profile STEM education events to develop their professional identity and as peer leaders. Through these opportunities, the value of extended professional experience was made more visible to pre-service teachers, which in turn increased interest in and take-up of Step Up co-curricular activities such as the STEM Studio. Appendix F and G documents the project dissemination timeline and channels used to support dissemination across the project.

It has been important at all stages of the Step Up project to consult with pre-service teachers and student groups through focus groups, interviews and through events and communication channels. Such engagement efforts have informed project research and CAP development, events and evaluation, and strategically fostered ongoing professional networks.

Step Up's dissemination activities and outcomes have focused intentionally on practice change at a Queensland level. The Step Up project team has engaged in national dissemination to achieve a broader context, to build upon the learnings from related programs and maximise the potential for transferability (Appendix F). The Step Up team has also led discussions at a national level– a highlight has been the ETMST national forum on 30th September 2016 at the Australian Conference on Science and Mathematics Education (ACSME). Through this forum, Step Up was able to bring university leaders, program evaluators and participants from the five ETMST projects together to identify the big ideas, key opportunities, challenges and directions, informed by the projects' collective findings. These discussions have paved the way for further change within Queensland (informing transition planning after the project funding ceases for ongoing research collaboration amongst the Step Up universities) and assisting with the planning for the June 30, 2017 national dissemination workshop.

Participation in the 9th June 2017 national dissemination workshop with The Council of Australian Deans of Science and Education will be an important opportunity to further the impact of Step Up and the ETMST program generally.

5.1 Channels to support dissemination

Channels were actively used to support communication and dissemination across the project and by project participants (Appendix G), including:

- **project website:** to provide entry into the project and points of contact to connect with activities/people and enable follow up from events, and to share relevant updates from pre-service teachers and the sector via the Step Up blog
- **media:** to profile outcomes and engage positively in the public dialogue/debate regarding secondary mathematics and science education in Queensland
- **social media:** Twitter to build profile connected with events/media in the sector as background for stakeholder engagement, LinkedIn to support pre-service teacher

engagement activities prior to TeachConnect. Step Up also connected with student groups and professional associations to share news and opportunities via extensive existing Facebook and Twitter networks

- **Google+ community:** from establishment phase, intended as a mechanism to support exchange/sharing across the project and with key stakeholders
- **Google Drive:** from establishment, to share consistent project documentation; to enable different levels of information to be shared for steering, implementation and project support functions
- **e-newsletter:** to share regularly project updates and event invitations with project stakeholders and subscribers, pre-service and in-service teachers, academics, professional associations and government bodies.

The project office employed a professional communication function to strategically plan, implement, monitor and review communication efforts. From early in the project, it became clear that participants had varying experience with different communication platforms/tools. A key aspect has been to develop and support (including through training/coaching) active use of the above channels and enable content to be provided in a timely way from a range of key stakeholders (e.g. pre-service teacher blogs, activity updates, event details and experiences, relevant sector news). In line with the project lifecycle, this function has supported communication in a phased approach – from design to transition of communication beyond the life of the grant.

5.2 Project learnings

- Early, targeted and ongoing engagement of external partners is crucial to build trust and shared outcomes that enable the further resourcing and support needed to sustain change beyond the project funding period.
- A shared framework for operating across institutions is a key outcome for any collaborative project.
- External partners such as decision makers or leaders at a sector level (e.g. accrediting bodies) can facilitate/expedite cross-institutional buy-in to action.
- The ability to find the match between the urgency of priorities and the time needed to enact change has been crucial to establishing involvement and/or partnership. These factors have been found to apply to all stakeholders, at all levels, whether internal or external to higher education.
- Although formal engagement with key stakeholders across the sector is important for awareness and understanding, the most productive, action-oriented collaborations, in the short to medium term, are extensions of formerly established professional and inter-personal connections. These connections effectively fast-track the relationship-building process and provide a foundation of trust that can otherwise take years to establish.
- A significant challenge to enabling cross-institutional communication and collaboration through online platforms/channels is that different institutions and individuals have different preferences. Regardless of the level of training and reinforcement provided, if the platform selected is not supported or commonly used in an institution, there is little likelihood of uptake as part of day-to-day business/practice.
- Aligning regular, intensive, face-to-face dissemination activity with project funding drives collective project design and delivery as well as the development of cross-project relationships, which are crucial to cohesion and collective problem solving.
- Dissemination was key to overcoming the initial challenge of perceived inflexibilities in curriculum change.

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Appendices

Appendix A: Certification by Senior Deputy Vice-Chancellor Academic (Professor Carol Dickenson)

I certify that all parts of the final report for this Enhancing the Training of Mathematics and Science Teachers grant provide an accurate representation of the implementation, impact and findings of the project, and that the report is of publishable quality.

Name: ……..…….....Date: ……..……

Appendix B: Collaborative Action Project overview

Collaborative Action Project	Institutions involved
STEM Studio: *A collaborative space for pre-service teachers to work with an in-service teacher, discipline expert and teacher educator to design and deliver trans-disciplinary STEM education in an authentic, supportive and non-assessed environment.*	Queensland University of Technology – lead Griffith University James Cook University
TeachConnect: *An online platform to connect and support teachers as they transition across all career stages from pre-service professional experience, through early career and into service. TeachConnect offers private mentor circles, a community knowledge forum and live chat. The platform also assists user to gather evidence that they are meeting the AITSL Professional Standards for Teachers.*	Queensland University of Technology – lead Queensland College of Teachers – major partner Across all Qld universities
Pedagogy on Demand: *A suite of pedagogical resources on topics of interest to secondary students that will support pre-service secondary teachers to design and implement engaging and worthwhile STEM activities.*	Australian Catholic University – lead Trialled at Griffith University
STEAM Room: *By combining the Arts (A) with Science, Technology, Engineering and Mathematics (STEM), the STEAM Room enables pre-service teachers to engage in classroom, school and community contexts in this space.*	The University of Queensland – lead Griffith University
Practising Science with Pre-service Teachers (Inquiry Project): *This project delivers a learning experience that assists pre-service teachers to understand and teach science in the same way that scientists practise research. Scientists and educators across multiple universities collaborated to create a series of videos that highlight a number of different scientific inquiry methods and how they can be used in the classroom.*	Queensland University of Technology – lead James Cook University
Integrated STEM Teaching Pathways: *A multi-university approach to creating new pathways into teaching for Queensland science, mathematics, engineering and technology students through avenues such as the Science and Mathematics Education Minor.*	Queensland University of Technology – lead James Cook University The University of Queensland

AITSL, Australian Institute for Teaching and School Leadership. STEM, science, technology, engineering and mathematics.

Appendix C: Case Studies 1 to 7

Case Study 1: Integrated STEM Teaching Pathways

Purpose

Encouraging **STEM students** to enter mathematics and science teaching degrees through innovative transition pathways.

The Science and Mathematics Education Minor (ScMEd Minor) was developed through collaboration between education and science faculties and a cross-institutional team from QUT, JCU and UQ.

The Minor provides an **authentic introduction and pathway**, designed to "hook" undergraduate science, mathematics and engineering students into considering secondary school teaching as a viable career option, rather than a fallback option.

Features

- Emphasise the contemporary, multi-disciplinary nature of the work of scientists
- Work to provide a more authentic understanding of science and teaching careers
- Explore communication of scientific outcomes for educational purposes - general public, children and young people.
- Bring science and education students together in multi-disciplinary teams, culminating in a capstone learning experience.
- Articulate with postgraduate teacher education qualifications
- Pave the way for collaboration in related course developments (eg science units in Bachelor of Education)

Impact

- Teaching experiences available for mathematics and science students (Figure 1)
- Student awareness and uptake
- Increasing number of students specialising in mathematics and science teaching
- Contribution to renewed curriculum frameworks
- Platform for continued collaborative course design and delivery
- Curriculum change that can sustain changes in Learning and Teaching practice beyond the life of the grant/project.

"Having alternative career pathways is important to me. I have gained the capacity to be a skilled lecturer, tutor or teacher in the future. The Science and Maths Minor gave me a deepened knowledge of the ways people learn and understand."

Bachelor of Engineering/CRB040 student, 2015

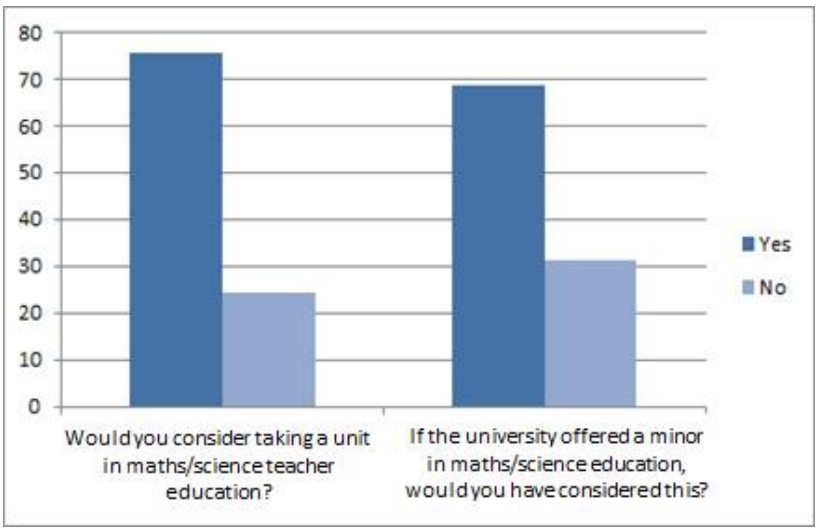


Figure 1: Percentage of STEM undergraduate students at Queensland University of Technology who would consider a pathway into teaching.

Outputs

Queensland University of Technology **Science and Mathematics Education Minor (ScMEd Minor)** Available to: Science, Engineering and Mathematics students
Four subjects on offer are: 1. CRB040: Learning Science through Teaching 2. SEB200: Communicating Science/Maths to Diverse Audiences 3. CRB204: Maths Curriculum Studies 1 OR CRB215: Science Curriculum Studies 1 4. SEB300: Application Capstone
2015 The first unit of the Minor (CRB040) at QUT run with 24 students
2016 CRB040 run again with 29 students, SEB200 run for the first time with 15 students
2017 CRB040 run again with 30 students enrolled, SEB200 run again with 15 students First students due to complete the Minor by mid-2017. Minor available to IT students
James Cook University **Education Minor (EdMiCom)** Available to: Science and Education students. Designed to articulate with the new Master of Learning and Teaching (Secondary).
Four subjects on offer are: 1. ED2610: The Nature of Inquiry: From Theory to Practice 2. ED3610: Professional Communication Practices 3. ED3620: Professional Practice: Assessment & Evaluation 4. ED4620: Developing Your Professional Identity through Service Learning

2015/2016
Subject development template developed and implemented, which was found to facilitate cross-disciplinary collaboration in subject development – with consideration of QCT accreditation requirements and Australian Professional Standards for Teachers.

University of Queensland
Education Minor
Available to: Science and Education students. UQ have implemented course structure changes to enable an education minor to be implemented in future.

Next Steps

- Continued implementation of approved course developments
- National dissemination
- Targeting increased uptake of minor
- Tracking articulations into mathematics or science teacher education from pathway programs

Case Study 2: Pedagogy on Demand: A Virtual Classroom to Support STEM Education

ACU
AUSTRALIAN CATHOLIC UNIVERSITY

Purpose

To create an innovative resource and pedagogy for teacher educators that supports pre-service teachers in designing inspirational teaching and learning experiences in STEM (Chubb, 2012).

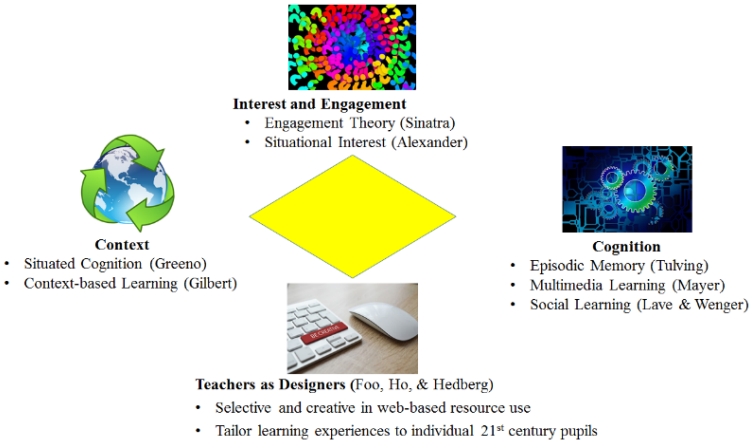
Goals

The creation of a collection of resources that:

- interests and engages 21st century pupils;
- addresses the mandated curriculum;
- capitalises on technology;
- highlights the role of "teachers as designers";
- uses a freely accessible e-learning management system, Schoology, for professional dialogue about teaching and learning (i.e., podchats); and
- provides access to resource pods and archived podchats beyond formal use in a teacher education program.

Design Concept

Theoretical Framework



Impact

This project creates a third space bridging university coursework and professional practice. By incorporating multimedia vignettes of diverse teaching practices, it provides the opportunity for rich and productive discussions connecting theory and practice.

Outputs

Product – Resource Pods

Information for Lecturers: Using Pods (https://app.schoology.com/course/794380711/materials) – Requires login password

- Mathematics in Sports: Years 7 to 10
- Science in Sports: Years 7 to 10
- Mathematics in Cryptography: Years 7 to 10
- Science in Cryptography: Years 7 to 10
- Science of Space Tourism: Years 7 to 10

Papers

Diezmann, C. M., & Watters, J.J. (2016, October). *Using resource pods to re-envision pre-service teacher education in mathematics and science*. Paper presented at the 4th International STEM in Education Conference, Beijing Normal University, Beijing, China.

Diezmann, C. M., & Watters, J.J. (2015, August). *Designing pods of resources for preservice teachers within a virtual classroom.* Paper presented at the 11th European Science Educators Research Association Conference, Helsinki, Finland.

Watters, J.J., & Diezmann, C. M. (2016, October). *A multimedia third space to enhance pre-service teacher evaluation.* Paper presented at the 4th International STEM in Education Conference, Beijing Normal University, Beijing, China.

Watters, J.J., & Diezmann, C. M. (2016, August). *Pedagogy on Demand: Evaluating a multimedia resource to support preservice teachers understanding of classroom teaching*. Paper presented at the European Educational Research Association Conference, Leading Education: The Distinct Contributions of Educational Researchers, University College Dublin, Dublin, Ireland.

Next Steps

1. Recording and archiving podchats.
2. Evaluating the uptake and effectiveness of the resource pods and podchats during coursework.
3. Disseminating and encouraging implementation of the resource pods and podchats in STEM teacher education.
4. Monitoring the impact of resource pods and podchats that enables Pedagogy On Demand in professional practice (24/7 mobile access).
5. Publishing findings in high quality international journals.

Case Study 3: Practising Science (Engaging Students in Scientific Inquiry)

Queensland University of Technology

JAMES COOK UNIVERSITY AUSTRALIA

Purpose

- Addressing the need to increase the quality of pre-service teachers (PSTs), this project helps educators refine their understanding and improve their confidence working with scientific research design, types of scientific thinking, and in engaging students with inquiry across various content areas – moving beyond recipe-based science.
- QUT and JCU teacher education courses trialled the Engaging Students in Scientific Inquiry resources in 2016, with 40 PSTs at JCU and approximately 460 at QUT.
- Science and education academics have worked together to create these unique professional learning resources, which will be made freely available to all teacher educators via the Step Up website.

Features

- ETMST priority 5 – The resources support PSTs to better understand scientific research design and thinking, and to develop their capabilities in engaging students to learn how knowledge is created.
- ETMST priority 1 – Education academics collaborated with scientists across two universities, to create resources to unpack real-world scientific research, as well as learning activities and other resources.
- ETMST priority 3 – *Engaging Students with Scientific Inquiry* resources have been integrated within QUT and JCU teacher education curriculum.

Outputs

An engaging suite of professional learning resources:

- 7 accessible videos focusing on real-world scientific research:
  - Correlational inquiry and medical research – Dr James Davis, QUT
  - Manipulative experimental inquiry
    - Ecological sciences – Dr Jennifer Firn, QUT
    - Chemistry and biofuels – Jana Adamovska, QUT
  - Descriptive / observational inquiry and astrophysics – Dr Stephen Hughes, QUT
  - Distributive reasoning – Johnston Davidson, Australian Institute of Marine Science
  - Analogical reasoning – Jason Doyle, Australian Institute of Marine Science
  - The role of unexpected findings – Dr Paul Muir, Museum of Tropical Queensland.
- 5 videos explaining different types of research design – comparative, correlational, descriptive / observational, manipulative experimental, and perturbation studies.
- A series of learning activities for each area of research design, to scaffold PST instruction and assessment.

- A summary of research and links to videos.
- All resources are showcased online, with introductory videos from Dr Alberto Bellocchi and Dr Tanya Doyle, at www.stepup.edu.au/inquiry

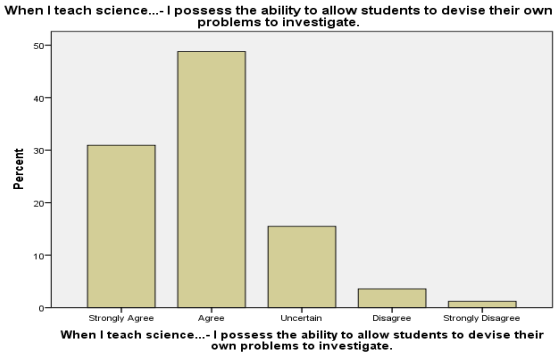
The outputs have been formalised within QUT and JCU curriculum with unit plan documentation, assessment documents and Blackboard sites.

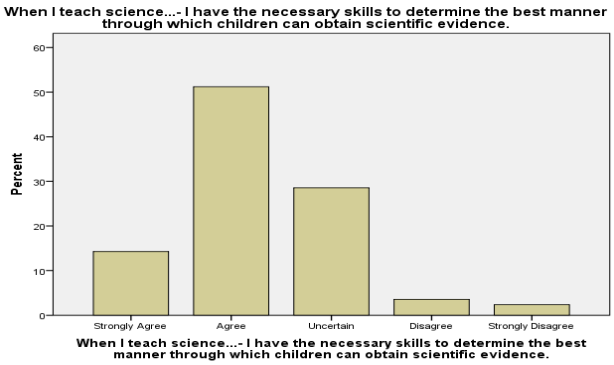
"Scientific inquiry engages students in a process of learning...They feel like they own the knowledge they create, whereas if you are just giving it to them quite often it's just like water off a duck's back. They're not engaged by it so they just -it goes in one ear and out the other."(participating PST)

Impact

Step Up Outcome 1 – The the *Engaging Students in Scientific Inquiry* resources have been introduced within QUT and JCU teacher education courses. This intervention exemplifies a collaborative course and curriculum innovation that has been formalised in university processes.

Step Up Outcome 4 – the resources strengthen science and maths knowledge and pedagogy amongst participating MSTed students. This has been demonstrated through a validated TSI Survey:





By improving PSTs' skills and confidence with scientific inquiry, this project may contribute to higher retention of science teachers in the workforce by reducing the impact of emotions such as fear on their experiences with planning and conducting investigations with school students.

Next Steps

- Continued implementation in curriculum delivery at QUT and JCU
- Online promotion of dedicated legacy web space by project leaders and partners
- Extension/Transfer - *Engaging Students with Scientific Inquiry* resources shared with Griffith University and will be disseminated nationally
- Resources to be accessed widely by pre-service teachers as well as in-service teachers and teacher educators
- Benefits for PSTs further evaluated by project leaders – via validated survey.

Case Study 4: Student Engagement

Purpose

Step Up professional learning opportunities encourage pre-service teachers to:

- develop their **networks and professional connectedness** with peers, in-service teachers and STEM professionals
- hone **new skills for STEM education,** complementing their university coursework and professional experience placements
- **increase their confidence** and readiness for a STEM teaching career

Student engagement was integral to the Step Up project and key to the implementation and sustainability of many of the collaboration action projects.

Step Up provided multiple student engagement opportunities for pre-service teachers across **all five partner universities** including networking events, professional development workshops and scholarships.

Features

ETMST priority 2 - effective engagement supports graduate supply, by helping recruit students through targeted communications and events, and to develop their skills and confidence for resilience and workforce retention.

ETMST priority 1, 3 & 4 - through student engagement activities, Step Up works with pre-service teachers to explore new ways mathematical and scientific content, thinking and pedagogy can work together.

Outputs

Pre-service Teacher Engagement Strategic Framework Report

Attitudinal research conducted on Step Up participants including interviews (2016) and online surveys (2015,2016) as well as feedback gathered for each Step Up activity.

Step Up Professional Learning Activities

79 pre-service teachers engaged in over 12 events in 2015 and 95 at 7 events in 2016. The top five student benefits included:

1. Learning practical applications of the curriculum
2. Developing more tools for teaching toolkit
3. Strengthening pedagogical skills
4. Gaining more STEM teaching resources
5. Improving classroom readiness *(2015 survey data)*

Impact

Student awareness and uptake of STEM resources and networks, meeting the needs of new maths/science teachers

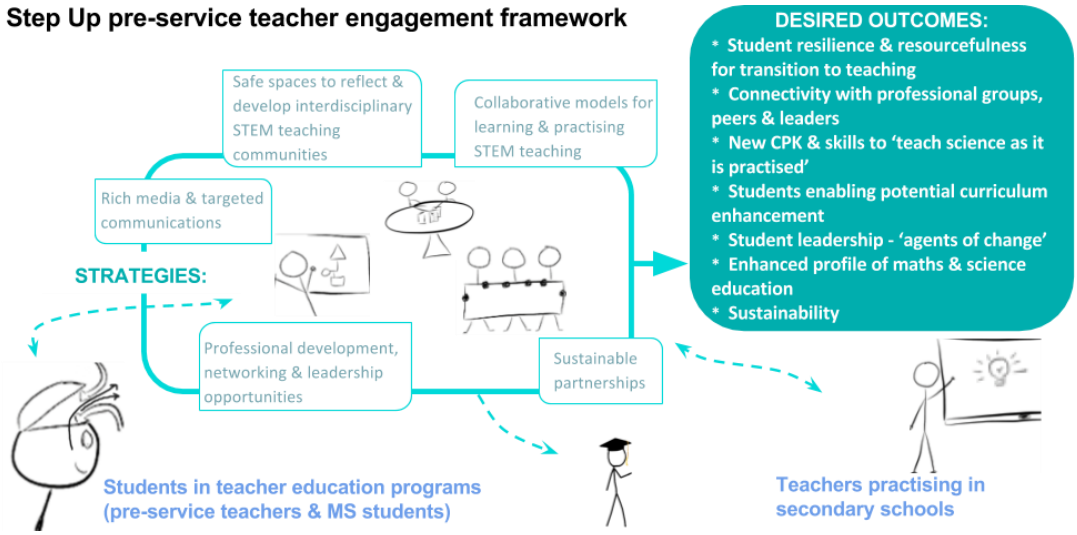
Over 2015-16, 174 pre-service teachers were directly supported/assisted by Step Up to take part in 19 diverse professional learning opportunities, along with 525 participants in various Step Up collaboration action projects .

Strong maths/science knowledge and pedagogy amongst pre-service teachers

Pre-service teachers gained insights into how maths/ science content, thinking and pedagogy can work together - to 'teach science as it is practised'. For e.g. STEM Studio participants worked together, with peers, STEM discipline experts, in-service teachers and a learning designer, to explore innovative ways to teach STEM, reflect and receive feedback, as well as mutually engage in peer-based learning.

Evidence base for strategies to improve teacher retention

Student feedback and targeted evaluation of each of Step Up's activities informed a Pre-Service Teacher Engagement Strategic Framework. Results indicated that extra-curricular professional learning activities helped pre-service teachers to feel more strongly prepared to enter their teaching careers - Agree 63.16%, Strongly agree 23.86%. *(2015 survey data).*



Next Steps

Step Up Alumni Group

To build on the student engagement started during the Step Up project, a proposal to initiate a 2017 Step Up Alumni group is being developed. The group will be for pre-service and early career teachers to further support transition and provide:

- Resource sharing
- Networking opportunities
- Professional development
- Mentoring
- Leadership
- Access to STEM professionals

Case Study 5: STEAM Room

Purpose

The STEAM Room was envisioned as a **science, technology, arts and mathematics** (STEAM) literacy and learning venture staffed by pre-service teachers in a community setting. Through informal or 'pop-up' programs it aimed to build wider science-maths fluency in the community, and **enrich and encourage innovation in pre-service teacher learning**. In addition, teacher professional development workshops, featuring the latest pedagogy, introduced new ways of teaching science and maths in the classroom to an audience of pre- and in-service teachers.

Features

- Design thinking teacher professional development for pre-service and in-service teachers.
- Collaboration with science and maths in-service teachers and teacher educators
- informal STEAM teaching opportunities in the community (delivery of workshops)

Outputs

STEAM teaching modules and assessment

- Delivered in Education, University of Queensland, Chris Campbell, 2015

Informal STEAM teaching opportunities

- One day hands-on science activities at the Queensland Museum

Design thinking professional development workshops

- One day workshop at Queensland University of Technology
- One day workshop at Annandale College, Townsville

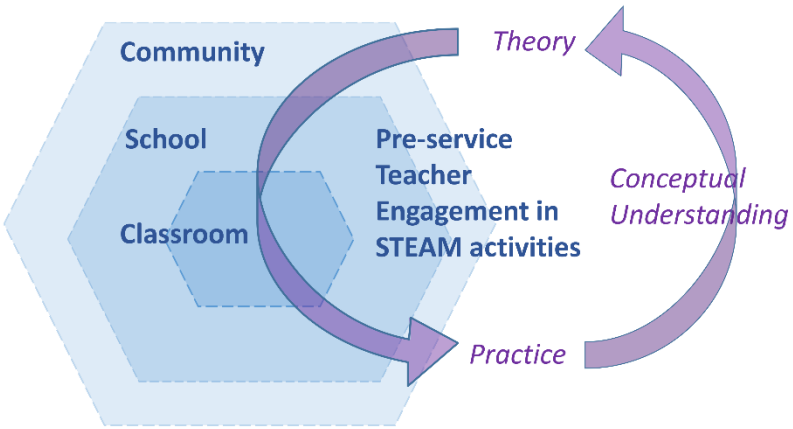
Queensland Smithsonian Fellowship

- Project leader awarded Queensland-Smithsonian Fellowship to work at the Centre for Learning and Digital Access for 13 weeks in 2016.

Impact

Impact of pre-service teachers engaging with STEAM across learning environments.

- Pre-service teacher engagement
- Perceptions on knowledge, and confidence
- Pre-service teacher reflections on their teaching experiences



Next Steps

Phase 1: Project leader attending The Smithsonian Center for Learning and Digital Access (SCALDA) to investigate and evaluate their online training sessions recently created for American science teachers. She will work alongside science educators to evaluate the potential for a similar system to be utilised in Australia, essentially moving the STEAM Room online - 2016.

Phase 2: The results of theis investigation and evaluation will be brought back to Queensland for dissemination across Queensland universities. Training may be offered for academics, teachers and pre-service teachers in online digital resources – 2017.

'Technology provides great platforms for collaboration in knowledge creation where teachers can share and enrich teaching materials. Perhaps most importantly, technology can support new pedagogies that focus on learners as active participants with tools for inquiry-based pedagogies and collaborative workspaces.'

Case Study 6: STEM Studio

Queensland University of Technology

Griffith UNIVERSITY

JAMES COOK UNIVERSITY AUSTRALIA

Purpose

The STEM Studio has demonstrated the potential impact that professional learning within a community of practice can have on enhancing initial teacher education. Key to the STEM Studio was the collaboration between key participants from higher education (teacher educators, scientists and pre-service teachers) and high schools (principals, practising teachers and school students).

The STEM Studio has contributed to change in higher education practices through:

- Development of an effective framework for cross-faculty collaboration and working across higher education, high school systems and industry.
- Development of cross faculty relationships leading to collaborative course design and delivery, formalised in curriculum structures/processes
- New ways to support the integration of content and pedagogy through authentic inquiry based experiences supported by discipline experts and mentored by teacher educators.
- Providing opportunities for PSTs to increase self-efficacy and develop their own professional teacher identity.

Features

Different models of the STEM Studio have been trialled at multiple institutions across Queensland, Australia, including Queensland University of Technology (QUT), James Cook University (JCU) and Griffith University (GU) (Figure 1).

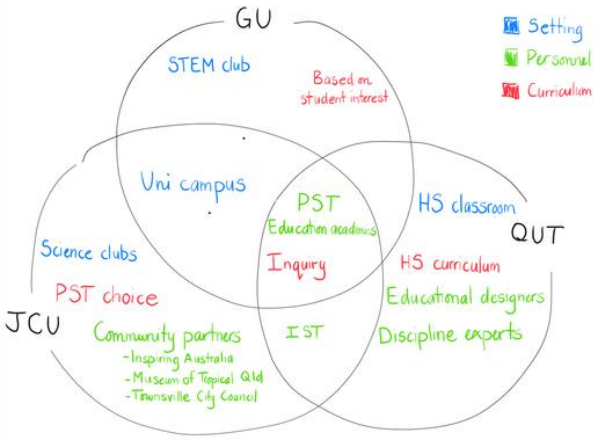


Figure 1: Common features of STEM Studio model at 3 different sites

Common to each model are the STEM Studio interactions between disciplinary experts, mentor practising teachers and novice PST's in the exploratory third space. In this space participants encourage pre-service teachers (PST) to rethink their disciplinary knowledge, discourse practice and assumptions in learning from each other in design and delivery of innovative STEM curricula. The STEM Studio provides a safe non-assessed authentic and supportive environment for pre-service teachers to connect theory and practice and trial new teaching approaches. Across the three institutions, the STEM Studio has involved 6 high schools from south-east Queensland, experienced and innovative teachers in STEM education (14), STEM experts (18), museum educator (1), teacher educators (4), PSTs (47) and over 450 high school students Figure 2.

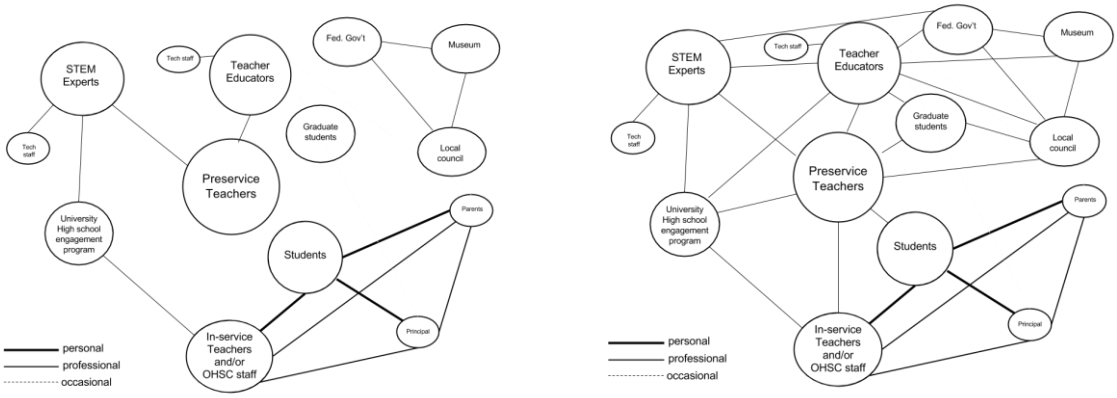


Figure 2: Visual construct of connections developed pre (left) and post (right) STEM Studio across the 3 institutions.

Outputs

- STEM Studio has developed a framework for collaboration across higher education, high school systems and industry partners in a third space.
- STEM Inquiry Process model
- Resources developed by PST's
- Griffith STEAM studio model will be used to design a course for future on inquiry in the STEM fields, with a particular focus on training pre-service teachers to be able to run STEM clubs in their future schools.
- Conceptualising the STEAM field as fields of inquiry has allowed those at Griffith to unify the fields under one common process, with variations in response to the nature of the student project.

Impact

A learning community of emerging mathematics and science teachers actively engaged in an inter-disciplinary, professional community of practice

The STEM Studio provided a rich environment for Student engagement and PST's building networks. PST's that undertook the STEM Studio:

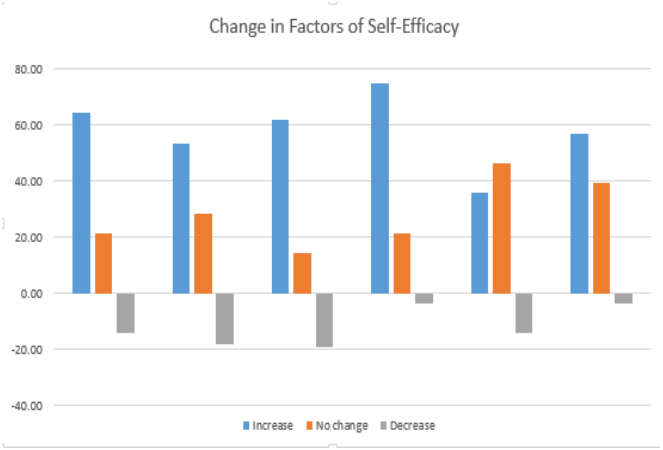
- Remained in contact with peers through a Facebook group
- Remained in contact with the schools (incl. 4 students offered prac at that school)
- Subsequently took part in other student engagement opportunities (88%) including professional development.

Connecting maths/science content with pedagogy, values and principles

The support network created by the STEM Studio (STEM experts, teacher educators and in-service teachers) helped pre-service teachers connect content and pedagogy and influenced their scientific thinking process. PST's were encouraged to think more deeply about their lesson plans and were more invested in educational outcomes.

Developing the professional identity of STEM teachers

Preliminary data showed positive changes in PST self-efficacy (pre and post testing) after teaching in the STEM Studio especially in the areas of effective instruction, motivating students and coping with change in the classroom. Influencing the mindsets of future teachers is critical to overcome doubts and fears about their capability and confidence to teach in the STEM areas (Figure 3). This will be further explored through qualitative analysis focusing on collaboration between participants, professional identity, support mechanisms, teaching practices and connections between the STEM Studio and ITE course.



1. Provide effective instruction (64%)
2. Adapt instruction to individual needs (54%)
3. Motivate students (62%)
4. Maintain discipline in the classroom (75%)
5. Cooperate with colleagues and parents (36%)
6. Cope with change in the classroom (57%)

Measured using the Teacher Self-Efficacy Scale (Skaalvick & Skaalvick, 2010).

Figure 3: Changes in self efficacy based on before and after responses to Self-Efficacy survey

Next Steps

- Ongoing discussion around transition of the learnings of how STEM Studio model could translate into the Bachelor of Education degree. The STEM Studio involves academics who teach directly into PST courses. Involvement in the project has deepened their understanding of the challenges faced by ISTs and PSTs as they attempt to improve their mathematics and science pedagogical content knowledge and teaching practices to prepare them for classrooms of the future.
- The STEM Studio adds value to the pre-service teacher pipeline and compliments other Step Up initiatives by providing a space to trial/practise learnings from these programs whilst collaborating with scientists, teacher educators, industry and in-service teachers in an authentic classroom environment.

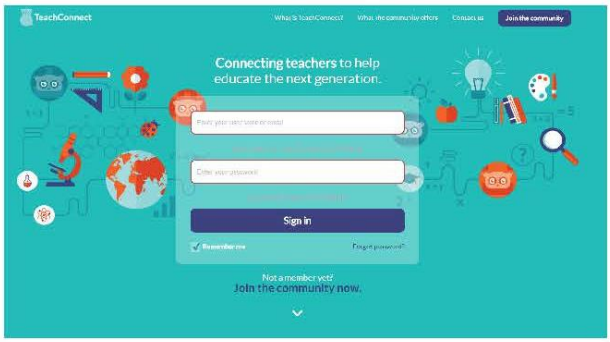
Case Study 7: TeachConnect

TeachConnect is a large scale collaboration involving pre-service science and mathematics teachers from all over Queensland (9 universities) and developed in collaboration with the Queensland College of Teachers, with expertise from scores of experienced teachers.

What is TeachConnect? www.teachconnect.edu.au

Technology: a platform for all devices

Access TeachConnect on mobiles, tables and laptops for access anywhere anytime.



Engagement: pre-service and in-service

Strategy for embedding TeachConnect into university programs and gaining broad involvement from in-service teachers at all levels.

A design challenge

Through design-based research TeachConnect addresses the challenge of: how can we design the best possible online support for beginning teachers?

How does it help teachers?

Mentors

Teacher mentors and subject experts have joined the platform and participated in online and in-person seminars. Teachers engage with mentors through messages, chat and circles.

Community knowledge

The larger the network, the more the expertise. In TeachConnect knowledge is re-used, growing every year as teachers build up a knowledge-base around all aspects of the profession.

Specialised knowledge

External sites and multi-media bringing teachers into subject-specific discussions.

Appendix D: Step Up project logic

INPUTS	ACTIVITIES	OUTPUTS	IMPACTS/OUTCOMES		
Key resources (human and other) to support the project; identify how the resources will produce the project outputs	Main things the project will do to achieve its objectives	Significant and observable/tangible outputs. Identify people reached	**Short term (<2 years)** What has happened as a direct result of the activities and outputs?	**Medium term (2–5 years)** What results are emerging from the initial outcomes?	**Long term (5+ years)** What results should follow from the project overall?
Project leadership Critical friend and external progress review/guidance Academic leaders to design and deliver pilots; integrate activities Project management and project support Senior professional learning and teaching support Research assistance Dedicated project office space Physical collaborative forums Regular governance meetings	**Curriculum** Review mathematics and science curriculum to incorporate teaching pedagogy and experience Develop Step Up curriculum framework for pre-service mathematics and science teacher education Establish TeachConnect to enable access to networks, support and resources **Pathways** Develop pathways and programs for mathematics and science students to become secondary mathematics and science teachers **Recruitment** Develop and implement student recruitment and engagement strategy **Stakeholders** Build engagement of key stakeholders Engage with accrediting bodies **Evidence base** Build evidence base around teacher quality, trends, the role of universities and strategies to address **Dissemination** Develop and implement strategy (primarily statewide focus) Advocate a collective view of secondary maths science teacher education requirements across Queensland	Statewide online learning and peer support networks (TeachConnect) Ongoing engagement and events for pre-service teachers, in-service teachers and schools Step Up communication and collaborative platforms New frameworks, innovative resources, guides and tools, including curriculum documentation Research and evaluation	Shared framework for operating across the consortium members Key stakeholders aware of project and the imperative that it is seeking to address Participation of staff within and across universities in project activity	1. Documented course structures and articulations (mathematics and science students in participating unis) 2. Strong maths/science knowledge and pedagogy amongst mathematics and science teacher education students 3. Increased visibility and awareness amongst Step Up target students 4. Teaching experiences available for mathematics and science students 5. Student awareness and uptake of networks 6. Double number of applications to transfer to mathematics and science secondary education 7. Triple number of students specialising in secondary mathematics and science teaching in areas of need 8. Expansion of networks of mathematics and science teacher education educators – active interdisciplinary community of practice 9. Curriculum framework (mathematics and science and teacher education teaching teams, stakeholders) community of practice 10. Collaborative course design and delivery, formalised in curriculum structures/processes	11. Increased retention on transition 12. Increased number of students specialising in secondary maths–science teaching 13. A learning community of emerging mathematics and science teachers actively engaged in an interdisciplinary, professional community of practice 14. Partnerships that provide mechanisms for sustained resourcing and implementation (beyond the life of the project) 15. Queensland model disseminated nationally

Appendix E: Collaborative Action Projects medium- to long-term impacts and outcomes

		IMPACTS/OUTCOMES														
		Medium term (2–5 years)									Long term (5+ years)					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Collaborative Action Projects	Integrated Pathways	✓			✓	✓	✓	✓			✓		✓		✓	✓
	Pedagogy on Demand		✓						✓							✓
	Practising Science	✓	✓	✓							✓				✓	✓
	STEAM Room		✓	✓		✓			✓					✓		
	STEM Studio		✓		✓	✓			✓	✓	✓	✓		✓	✓	
	TeachConnect			✓		✓					✓	✓		✓	✓	✓

Appendix F: Project dissemination timeline

Dissemination objectives	Example activities	Outcomes and products of dissemination
Initiate (Sept. 2013 – Mar. 2014): Shared frameworks and project logic		
- Establish new relationships across the project - Review project approach and feasibility - Establish shared understanding and commitment - Find points of shared interest and action - Identify critical success factors	- 14–15 Oct 2013. Project leaders intensive - 14–15 Nov 2013. Project intensive - Nov. 2013. Vice Chancellor's update - 3 Feb. 2014. Curriculum think tank - Mar. – May 2014. University stakeholder workshops – virtual classroom business needs analysis - Key stakeholder meetings – Chief Scientist, Queensland College of Teachers, Queensland Government Department of Education and Training - Regular meetings with sponsor, executive deans, project leaders	- Project logic and outcomes statement - Success criteria and frameworks - Understanding key agencies' policy drivers and priorities - Identified opportunities for change, potential prototype activities - Project plan, governance model and risk management plan - Project collaboration platform - Draft curriculum framework - Business analysis report – Step Up technology
Experiment (Apr. – Dec. 2014): Early trials, collaborating across disciplines at institutional level		
- Refocus on intent of program/grant - Advance thinking around what is possible within scope - Provide external feedback and advice as focal point for extending approaches - Maximise collective awareness - Engage partners in proof of concept activity design and delivery - Align with policy and strategy priorities of key agencies in sector	- 22 Apr. Queensland University of Technology Step Up workshop with stakeholders - 20 May to 2 Jun. Project leaders group proof of concept assessment and feedback - May critical friend review - 27 Jun. Project intensive including external panel review - Intensive follow-up workshops – reflections, implications and proposed project strategies - Contribution to ETMST meta-analysis - 20 Aug. STEM Education conference (invited to present) - 26 Sept. Joint stakeholder forum with IMSITE project - 22–24 Nov. Project Intensive - 24 Nov. Stakeholder engagement forum, STEM Education: Inspiring Minds for the Future? (host) - Key stakeholder meetings – Queensland College of Teachers, Queensland Government Department of Education and Training, Queensland Museum, State Library - Regular meetings with sponsor, executive deans, project leaders and university teams	- Proof of concept proposals - Independent critical panel feedback on proposals - Proposal assessment methodology - Allocation of seed funding (up to $2000 per activity) - Alignment of project office support - Critical friend review document - High schools engaged as partners - Broad stakeholder awareness - Active cross-faculty working partnerships - Step Up directions informed by stakeholder inputs (critical attributes for future science teachers)
Implement (Jan. – Dec. 2015): Apply the learnings from institutional prototype (proof of concept) trials to the development of CAPs		
- Steer development of modal approaches tested in a range of contexts (CAPs)	- External review of proposals - Jun. Critical friend assessment of CAPs against project evaluation questions	- Panel feedback document - Allocation of additional support resourcing to cross-institutional

Dissemination objectives	Example activities	Outcomes and products of dissemination
- Boost resourcing to targeted areas of collaborative activity for maximised outcomes - Action learning to inform future implementation plans for collaborative projects - Engage partners in CAPs - Keep abreast of policy and strategy shifts at national and state level	- Cross-institutional think tank - 19 Nov. Queensland Government Department of Education and Training STEM cross-sector reference group meeting (invitation to attend) - Dec. Critical friend assessment of value, impact, collaboration, dissemination and sustainability - Participation in ETMST project conferences/forums including Macquarie University, Southern Cross University and the University of Melbourne - Continued stakeholder engagement through CAP participation - University team workshops (two rounds)	project teams (equivalent to six months, 50% postdoc.) - *Step Up collaborative action teams: Progress, challenges, issues and opportunities – towards the next 18 months* (critical friend progress review report) - Step Up intensive outcomes report - Step Up rationale and roadmap - *Step Up Collaborative action projects: towards the final stage* report (critical friend progress review report)
Extend (Jan. – Dec. 2016): Capture key impacts/learnings and establish transition plans		
- Support /lead national engagement in preparation for major policy think tank in 2017 - Identify key ideas, learnings and recommendations for sector change/impact - Identify critical aspects of collaboration across STEM and teacher education that are critical for future practice	- Videoconference Step Up – Review of CAPs, external feedback and discussion - Coordination of series of ETMST Project leader meetings (Jun–Dec) - 30 Sept. ETMST National Forum, in association with Australian Conference of Maths and Science Education - 21,22 Nov Step Up project intensive - Participation in ReMSTEP project conference - Continued stakeholder engagement through participation in CAPs	- CAP case studies - *National Forum – Enhancing the training of mathematics and science teachers – outcomes and directions* document - Dissemination plans for each CAP from 2017 - Preliminary transition plans for Step Up at university level from 2017 - Emergent ideas for transforming pre-service teacher education from Step Up - Formation of working group to take collective dissemination plans forward from 2017

AITSL, Australian Institute for Teaching and School Leadership. CAPs, collaborative action projects. IMSITE, Inspiring Mathematics and Science in Teacher Education. ReMSTEP, reconceptualising mathematics and science teacher education programs. STEM, science, technology, engineering and mathematics.

Appendix G: Channels to support communication and dissemination across the project

Snapshot examples

26% increased student uptake of networks via participation in Step Up professional development activities (from 35 students in 2014 to 135 students in 2016).

Increased awareness of Step Up and its purpose within and across partner universities (Step Up newsletter distribution list – 2016: 15% Griffith University, 45% Queensland University of Technology, 5% University of Queensland, 2% Australian Catholic University, 10% James Cook University and 23% Other).

92% of students reported that their attitudes towards teaching were positively affected by their participation in Step Up professional development activities (results from 2015 Step Up student engagement survey).

Establishment of **successful collaborations** with key external partners beneficial to ongoing enhancement of initial teacher education (e.g. Questacon, Queensland Museum, ASTA, STAQ, Moreton Bay STEMFest, Queensland University of Technology STEM High School Engagement, The Cube, Design Minds - State Library Queensland).

ASTA, Australian Science Teachers Association. STAQ, Science Teachers Association of Queensland. STEM, science, technology, mathematics and engineering.

Supporting communications

Highlight activities/outputs	Outcomes/results
Objective 1: Support Step Up relationship development and management through relevant and effective communication.	
Established **project website** featuring project background (including contact points), student blog, news, events and Twitter feed.	4981 website users in 2016 including 27.3% return visitors. Contributions to website from pre-service teachers, teacher educators and project teams. Peak engagement generated by blogs written by pre-service teachers about their involvement in Step Up activities.
Distributed project updates (includes opportunities and events) via **monthly e-newsletters**.	Over 426 people subscribed to the Step Up mailing list (45% pre-service teachers, 25% in-service teachers, 15% sector, 10% project team, 5% Other). 29.4% open rate (14.1% above industry average) with 9.4% click-through rate (8.3% above industry average).
Collaboration via **Google Plus** and **Google Drive docs.**	52 users of Google Shared drive. 67 members of the Google plus public community with average of two sector news posting/week.
Established **Twitter** presence featuring tweets from key sector conferences and pre-service teacher activities.	415 engaged twitter followers from over 998 tweets. Top tweet written by pre-service teacher sponsored by Step Up to attend sector conference which achieved 111 engagements. 1.5% average tweet engagement rate (0.5% above industry average).
Media highlighting Step Up key external relationships beneficial to ongoing enhancement of initial teacher education.	Ten online and six print articles in a range of community and sector publications highlighting partnerships with ● Australian Science Teachers Association ● Queensland Museum ● Moreton Bay STEM Fest ● Queensland College of Teachers ● Design Minds, State Library Queensland.
Objective 2: Support student engagement strategy with targeted communication.	

Academic champion selected from each university partner to facilitate communication of Step Up news and opportunities for pre-service teachers.	Pre-service teachers rated communication as most effective when sent from academic/professional contacts and peers. They heeded recommendations about professional development opportunities most from lecturers/tutors and student peers (rated equally high at 4.17 out of 5) (results from 2015 Step Up student engagement survey). Students from University of Queensland, Queensland University of Technology, Griffith University, University of Southern Queensland and James Cook University involved in Step Up professional development activities, 2014–2016.
Communication of opportunities and events via **e-newsletters, emails, blackboard posts, lecture presentations, Twitter, Facebook groups, flyers, O-week stalls and student-led education clubs.**	Increase in pre-service teacher participation in Step Up professional development activities over three years (35 students 2014, 110 students 2015, 135 students 2016). Students reported that their attitudes towards teaching were positively affected by their participation in Step Up professional development activities (92%)[1]. Interest shown via pre-service teachers in a Step Up alumni group focused on professional development activities, networking and social support.
Targeted communications highlighting the value of professional development and networking to pre-service teachers through **student sponsorship** and **avenues for word of mouth.**	70% increase in the number of pre-service teachers attending STAQ/CONASTA conferences. Pre-service teachers have gained positions on professional teaching bodies and assisted with organisation of events for other beginning teachers. STAQ/CONASTA organisations have now recognised the need for pre-service teacher professional development and networking and have added a dedicated pre-service teacher workshop line to their conferences. 68% of students reported that they would recommend their peers get involved in Step Up professional development activities (results from 2015 Step Up student engagement survey).
Objective 3: Establish communication and channels to support medium- and long-term impact/outcomes of the project and beyond the life of the project.	
Re-development of the Step Up website to reflect the outcomes of the project and **provide resources for the sector**.	Key stakeholders aware of Step Up success stories. Successful collaborations highlighted. Resources to provide basis for other universities to build on the work of Step Up in initial teacher education.

Step Up awareness through physical presence at **national professional and research conferences** - display materials, flyers, sponsorship, presentations.	Cross-institutional teams presented Step Up outcomes at national sector conferences (e.g. National STEM Education Conference 2016, CONASTA 2016 (Queensland University of Technology, James Cook University and Griffith University) and AARE 2015 (University of Queensland and Queensland University of Technology).
Collective dissemination of Step Up model approaches to national audience.	Development of a collective book of project research approaches, findings, outcomes and recommendations is underway.
Nominated for **awards and successful grant applications** to increase recognition and awareness of approaches.	Team member acknowledged with a Vice Chancellor's Award for Excellence (TeachConnect). Nomination for international Wharton Reimagine Education award.

AARE, Australian Association for Research in Education. CONASTA, Conference of the Australian Science Teachers Association. STAQ, Science Teachers Association of Queensland. STEM, science, technology, mathematics and engineering.

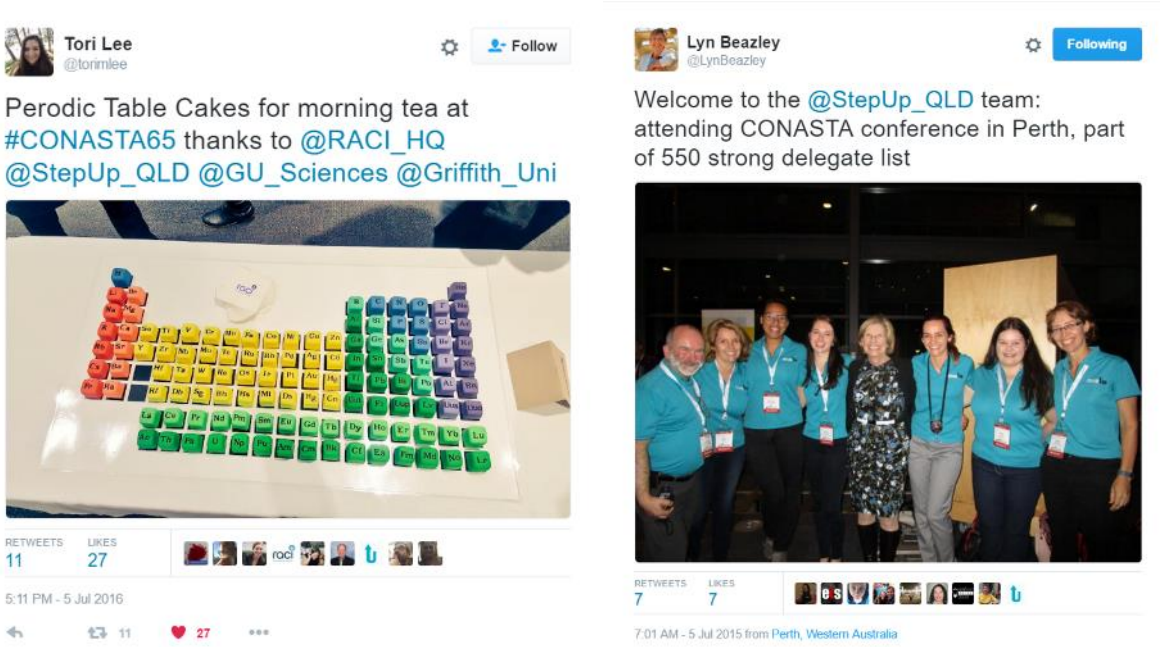
Step Up Twitter breakdown

415 followers

- 25 to 34: 49%
- Queensland: 53%
- Male 31%, female 69%

Top tweets

111 engagements, 11 retweets, 27 likes, 88 engagements, 7 retweets, 7 likes



Twitter followers included:

Step Up	Griffith University Queensland University of Technology University of Queensland Scientists and education academics Pre-service teachers
Sector	The Conversation Education Questacon Museum of Tropical Queensland World Science Festival Brisbane Queensland Museum Digital Queensland Queensland Science The Edge Queensland College of Teachers Queensland Curriculum and Assessment Authority Schools

Influencers	Tarnya Smith, Queensland Member of Parliament Ken Silburn, 2015 recipient - Prime Minister's Prize for Excellence in Science Teaching in Secondary Schools Dave Burgess, American educator and speaker Kathy Harris, Independent Schools Queensland Bronwyn Harch, Institute for Future Environments Director, Queensland University of Technology Natasha Bita, Journalist, *The Daily Telegraph* Karen Whelan, Assistant Dean Learning and Teaching, Queensland University of Technology Stuart Palmer, Deakin University and ETMST's ReMSTEP project. Sarah Chapman, Global Tropical Futures Project Martin Sillence, Curriculum Leader, Science, QUT Margaret Petty, Head of Department, Creative Industries, QUT

ReMSTEP, Reconceptualising mathematics and science teacher education program.

Step Up media publications

Print

01/06/2015 *The Australian*, National Affairs, Education
How to inspire kids? It's not rocket science

Highlighted STEM Studio model approach and collaboration between STEM and Education academics to increase interest in science

09/11/2015 *The Courier Mail*, Brisbane
Mentoring system gives new teachers a leg up

In partnership with Queensland College of Teachers, article highlighted TeachConnect and importance of mentoring to support beginning teachers

08/12/2015 *The Courier Mail*, *Qweekend* magazine, Brisbane
The year's leaders in arts, science , sport, technology, fashion, food, education and ideas

Nick Kelly featured as Queensland cultural leader for his work as co-founder of TeachConnect

July 2015 *QUT Links Alumni Magazine*, Issue 2 (readership: Australia & International)
Students Step Up to STEM

Collaboration of scientists with current and future teachers to explore different teaching approaches via STEM Studio

May 2015 *Queensland Science Teacher* (Science Teachers Association of Queensland), Volume 41, Issue 2 (readership: QLD teachers)*The changing face of science teacher education in Queensland*, by Julia Davies

The value of extra-curricular professional development in pre-service teacher education

March 2016 *The Gap SHS* newsletter (readership: students/general community)
Science faculty review

Student participation in STEM Studio at The Gap SHS

Online

01/6/15 *QUT News* (readership: QUT community, media)
QUT 'steps up' to showcase science teaching and spark students' curiosity

02/7/15 *QUT News* (readership: QUT community, media)
QUT soon-to-be science teachers using real world challenges to promote science

16/09/15 *QUT News* (readership: QUT community, media)
Secondary students swapping sport for science workshops

27/01/16 The Educator online (readership: sector, in-service and pre-service teachers)
Five reasons why I am excited to study teaching in 2016

The value of professional development for pre-service teachers featuring STEM Studio

01/12/14 ASTA website (readership: sector, in-service and pre-service teachers)
Congratulations to the three recipients of the Step Up/ASTA Initiative Award

Blog post featuring three pre-service teachers from Step Up partner universities awarded a scholarship to attend ASTA Summer camp

18/07/15 Design Minds website, The Queensland State Library (readership: general community)
Step Up STEAM Room Project: Pre-service teachers in the Community, by Chris Campbell

18/07/15 Design Minds website, The Queensland State Library (readership: general community)
Full STEAM ahead for Queensland schools, by Andrew Sands

10/9/15 Design Minds website, The State Library (readership: general community)
*Insight into Design Thinking Worksho*p, by Pahia Cooper

10/9/15 Design Minds website, The Queensland State Library (readership: general community)
Inspire: Current and future Queensland teachers Step Up to design thinking in Townsville, by Natalie Wright

30/08/16 Queensland STEM education network website (readership: STEM education sector)
Northside STEM Challenge: Robots open students' eyes to the future

Other

30/10/15 Speech by The Hon. Kate Jones, Minister for Education launching TeachConnect. Delivered at the Queensland College of Teachers Excellence in Teaching Awards Celebration held on UNESCO World Teacher Day.

*http://www.roymorgan.com/industries/media/readership/newspaper-readership

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EDUCATION

How to inspire kids? It's not rocket science

Caitlin Davidson, 14, and Finn Merrick, 13, of The Gap State High School in Brisbane with associate professor Nick Davis-Poynter at QUT. Picture: Lyndon Mechielsen.

The Australian | 12:00AM June 1, 2015 Save

NATASHA BITA
National correspondent Brisbane @natasha_bita

Star bioengineers and astrophysicists are recruiting teenagers to study maths and science, as industry demands more science-savvy workers.

Queensland University of Technology is using its top international researchers to inspire high school students to study science, technology, engineering and maths.

Year 9 students can visit QUT's state-of-the-art laboratories to meet the scientists and take part in experiments.

Finn Merrick, 13, of The Gap State High School with QUT biofuels expert Tom Rainey and science teacher Amanda Ross.

Students Step Up to STEM

Some of Australia's top scientists are joining forces with current and future teachers at QUT to explore different teaching approaches for inspiring more students to study science and mathematics.

The Step Up program, led by Professor Les Dawes, is developing high-quality secondary school teachers who can impart their passion for science, technology, engineering and maths (STEM) to the next generation.

The program utilises the STEM Studio, where scientists and teachers work together with school students to develop learning activities that will engage children.

Faculty Review: SCIENCE

The Science faculty is focused on nurturing our students' curiosity and developing their critical thinking and creative skills so that they can explore the world of scientific discovery and challenge themselves to investigate the world around them. The students learn to observe, investigate and work collaboratively to make predictions and solve problems. Students develop an understanding of why science is important and how it relates to their lives and its importance in society. They are supported in developing their scientific knowledge, understandings and skills to make informed decisions about local, national and global issues and to participate, if they so wish, in science-related careers.

This year our Year 7 students have been introduced to a laboratory environment and focused on developing basic experimental skills. Throughout the year they will be examining the interactions of organisms in the environment and investigating the impacts of human activities on these systems. They will also investigate basic physics through simple machines and be introduced to the concept of Extended Experimental Investigations with their Beanstalk Story.

Our Year 8 students have been developing and refining their laboratory skills in order to develop their own investigations which explore chemical reactions. Throughout the year students will be investigating different energy transformations and exploring energy have developed to a level of proficiency to allow them to investigate chemical reactions involved in a hiker's portable hot meal pack. Students will continue to build on their knowledge of atoms and energy transformation to investigate electricity as well as the behaviour of light, heat and sound. They will also explore the interconnectivity of life, examining the human body, the natural environment and the concepts of change and sustainability.

Year 10 is the last year that science is a compulsory core subject and the course builds on students' previous knowledge students willing to take risks, challenge themselves academically and engage in Higher Order Thinking skills while making genuine links across multiple disciplines. The Gap High's partnership with QUT's Step-Up program has seen our STEM students access scientific researchers and QUT's STEM Studio laboratory facilities. Such experiences cannot usually be provided at the school level. Students have not only met the challenges courageously, but also displayed a commitment to academic excellence.

At the Year 11 and 12 level, the Science

News

Northside STEM challenge: Robots open students' eyes to the future

23 August 2016

High school students on Brisbane's northside have celebrated the end of an eight-week robot-building journey with a community showcase of their robots at Murrumba State Secondary College.

Last week's showcase was the culmination of the Moreton Bay STEM Fest, which involved 240 students from across the Moreton Bay region.

Mentoring system gives new teachers a leg up

BRITTANY VONOW

QUEENSLAND universities have banded together to boost the confidence of graduate teachers, offering support to those who are struggling in the classroom.

Initially focusing on those teaching science and maths, where the largest shortages exist, Queensland's eight universities, as well as the Queensland College of Teachers and the Office of Learning and Teaching, have developed the TeachConnect mentoring system to create a network between experienced teachers and those coming into the profession.

University of Southern Queensland research fellow Nick Kelly said when graduates leave university, they lose their support network – at the exact time they face the challenges of being a first-year teacher.

"So now ... we're establishing a community of teachers across Queensland ready to go and support each other," he said.

Mr Kelly said recent studies had found one in five new teachers did not have a mentor, with those on part-time or contract work particularly affected.

"This system has been set up for pre-service teachers, no matter their situation, whether they are employed casually or have had six months off before going into the workforce," he said.

Until 2016, the program will focus on secondary maths and science teachers.

An Australian Council for Educational Research report released this year found Queensland faced a critical shortage of maths and physics teachers, as most are male and almost half of them are approaching retirement.