

# ETMST Programme final report: ReMSTEP

## **Enhancing the Training of Mathematics and Science Teachers** Reconceptualising Mathematics and Science Teacher Education Programs [ReMSTEP]

Final report 28<sup>th</sup> February 2017

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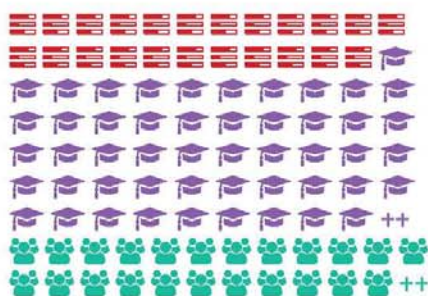
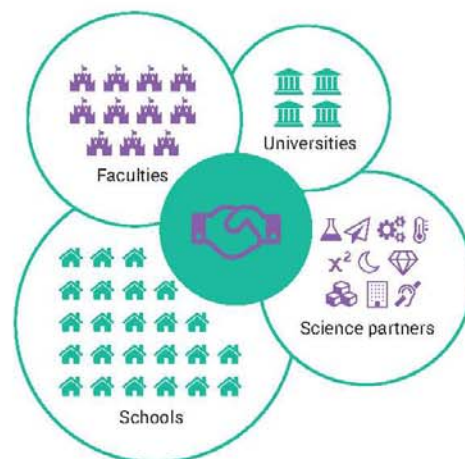
## List of acronyms used

AITSL	Australian Institute for Teaching and School Leadership
ARC	Australian Research Council
ASELL	Advancing Science by Enhancing Learning in the Laboratory
ASMPP	Australian Mathematics & Science Partnership Program
BSc	Bachelor of Science
BTeach	Bachelor of Teaching
ETMST	Enhancing the Training of Mathematics and Science Teachers
GTAC	The Gene Technology Access Centre
GTP	Growing Tall Poppies
IFM	Institute for Frontier Materials
ITE	Initial teacher education
LLA	Laboratory Learning Activities
MSS	Monash Science Squad
MTeach	Master of Teaching
NESB	Non-English Speaking Background
OECD	Organisation for Economic Co-operation and Development
OLT	Office for Learning and Teaching
PISA	Programme for International Student Assessment
PST	Pre-service teacher
QUT	Queensland University of Technology
SES	Socioeconomic Status
STAV	Science Teachers Association of Victoria
STEM	Science, Technology, Engineering and Mathematics
UoM	University of Melbourne
UTAS	University of Tasmania
VCE	Victorian Certificate of Education
VSSEC	Victorian Space Science Education Centre

# Achievements statement



ReMSTEP formed **collaborative partnerships** between **11 faculties** across **4 universities**, who collaborated with **10 external science partners** and **24 primary and secondary schools**.



These took the form of **23 new education programs or enhancements** that impacted **2182 pre-service teachers** over 3 years and enabled interactions with over **200 scientists, mathematicians and academics**.

## ReMSTEP has contributed to the ETMST goals through:

New study options developed in collaboration with science and mathematics departments and researchers

- delivering a cohort of graduate teachers better equipped to integrate mathematical and science practice into their classroom pedagogy.

Units of study for Science and Mathematics students

- workplace experience giving high calibre science and maths students exposure to teaching as a career

Additional Experiences for pre-service teachers designed and delivered in collaboration with specialist centres

- providing opportunities for pre-service teachers to enrich their content knowledge and develop learning resources alongside practising scientists and mathematicians.

Exemplars and resources

- resources, collaboration models and innovative pedagogies developed through the ReMSTEP activities will be shared with the education community.

Core to all ReMSTEP activity is collaboration across faculties, universities and specialist science and maths centres, and the exploration of ways of linking pre-service teachers to practising scientists and mathematicians, in order to represent the creativity and drive of scientific and mathematical thinking for these future teachers.

## THE ReMSTEP PARTNERS



This will:

Change the **MINDSETS** and **THINKING** of both students and teachers

# Executive summary

## ReMSTEP Project context

At the time of the project launch in 2014, and it continues to be true today<sup>a</sup>, there was increasing concern in Australia at the decreasing student performance and participation in mathematics and science at a time when capabilities in these disciplines are increasingly important for the supply of STEM (Science, Technology, Engineering and Mathematics) professionals, for scientific and mathematical competency in the workplace generally and for individuals' capacity to participate fully in contemporary society.

Part of the reason for this decline is held to be the failure of teacher-centred pedagogies focused on delivery of resolved and abstracted knowledge to engage students. This is compounded by a growing shortfall of trained secondary mathematics and science teachers and primary generalist teachers capable of deeper level engagement with disciplinary ideas and practices. We share the vision articulated in this initiative that approaches to teaching and learning that involve students in aspects of contemporary sciences as a set of exciting and socially relevant practices, rather than resolved knowledge products, provides an opportunity to turn this situation around.

## Aim of the ReMSTEP project

ReMSTEP established a network of four leading universities dedicated to developing new teacher education approaches that align contemporary practices in the sciences with innovative and engaging approaches to teaching and learning. The four partner institutions have:

- a variety of teacher education course structures that provides the opportunity to test these approaches in a diverse range of contexts,
- a history of collaboration between the education and mathematics/science faculties that provides the foundation for this proposal,
- a track record of collaboration between the education team members on pedagogical research, and
- approaches to mathematics and science teacher education that develop teachers' capabilities and dispositions to represent these practices in their classrooms.

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<sup>a</sup> *TIMSS 2015: a first look at Australia's results*. Available at:  
[http://research.acer.edu.au/cgi/viewcontent.cgi?article=1000&context=timss\\_2015](http://research.acer.edu.au/cgi/viewcontent.cgi?article=1000&context=timss_2015)

## Project approach

ReMSTEP has introduced new approaches to mathematics and science teacher education, which were developed within a range of existing courses, coupled with supporting resources and revitalised, evidence-based approaches to mathematics and science teacher education that develop teachers' capabilities and dispositions to represent these practices in their classrooms. Rather than implementing a singular and purpose-built course structure, this project created appropriate conditions for simultaneous developmental activity across diverse teacher education programs and sites of mathematical and scientific practice. A range of collaborative activities were initiated, including:

- New courses, subjects and content have been introduced into university teacher education programs.
- A variety of collaborative activities between university education, science and mathematics departments have been established.
- Partnerships strengthened with external mathematics and science organisations.
- A network of academics, pre-service and in-service teachers, teacher educators and scientists has been created.
- The dissemination of findings through a variety of mechanisms, including the ReMSTEP website [[www.ReMSTEP.org.au](http://www.ReMSTEP.org.au)] and two annual ReMSTEP conferences in November of 2015 and 2016.

## Project outputs

Project outputs take the form of a variety of new educational programs or enhancements, collectively referred to as 'project activities', which are situated within the innovations detailed in Chapter 3 of the main report. Deeper and more lasting outcomes include changes to practice, courses, resources, understanding, attitudes and collaboration which have sustainability beyond the life of the project (see below).

## Project outcomes

The outcomes of the project include:

1. Evidence-based development of approaches to mathematics and science education and teacher education that link contemporary practices in the sciences to evidence-based, inquiry-based, problem solving pedagogies.
2. A cohort of graduate primary and secondary teachers better-equipped to integrate not just an awareness of contemporary mathematics and science concepts but aspects of actual mathematical and scientific practice into their classroom pedagogy.

3. Comprehensively documented innovative pedagogies that are specific to the teaching and communication of cutting edge mathematical and scientific practices, implemented across a variety of education contexts and sites.
4. Re-conceptualised subjects and science and mathematics educational activities that exemplify scientific practices, together with an evidence-based framework supported by public access resources to support collaborative work between specialist mathematics and science teacher educators and research mathematicians and scientists. These will be made widely available through a web-mediated environment.
5. Innovative and effective teacher education practices that can be articulated and disseminated as ‘exemplifications of meaningful collaboration’ between the mathematics and science research communities and educators.
6. Key principles around which effective dissemination of these approaches can inform the practice of other universities in connecting the sciences and teacher education together with communication principles and practices that can support public understanding of contemporary scientific practices and ideas.
7. An established network of science, mathematics and education researchers, supported with an online environment, dedicated to connecting contemporary science and mathematics and associated pedagogies in a variety of educational contexts.

## **Project impact**

Evaluative data have shown that the ReMSTEP project has been fruitful and successful in a variety of aspects, including:

- An established network of key agencies involved in science and science teacher education.
- Observed changes in pre-service teacher’s (PSTs<sup>b</sup>) attitudes towards scientists and science teaching and learning.
- Improved capacity of both PSTs in integrating contemporary science and mathematics practice into the curriculum.
- Sustainable collaborations and partnerships have been developed among different faculties of higher education institutions, science and technology research centres, and local primary and secondary schools.
- The project provided new study options and additional experiences to engage PSTs with cutting-edge science and mathematics practices. Specifically, this project

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<sup>b</sup> Please note that the term ‘pre-service teacher’ (PST) and ‘Initial teacher education student’ (ITE) are used throughout this document. These terms are equivalent.



achieved significant results in changing PSTs' knowledge, attitude and capacity in relation to mathematics and science teaching.

- Undergraduate science and mathematics students were motivated to consider taking up one of the available pathways to teaching as a career.

## **Key findings, implications and recommendations**

The evaluative data show that cross-faculty engagement in science teacher education has been identified as one of the strongest outcomes of ReMSTEP. Strong networks have been established between science/maths and education academic staff. Academics from different faculties met on a regular basis to share expert knowledge, collaborate and develop resources across the diverse activities. Ongoing collaborative arrangements have been established in planning and maintaining teacher education courses and activities. At some point, this outcome would need to become formalised (i.e, cultural shift) in respective faculties to ensure sustainability.

The ReMSTEP project offered an opportunity for undergraduate science and mathematics students to engage with schools in order to build a recruitment pipeline of high potential mathematics and science teachers. As a result of the activities that focused on this cohort of tertiary students, undergraduate science and mathematics students were motivated to consider taking up one of the available pathways to teaching as a career.

Another major achievement of ReMSTEP was to assist pre-service teachers to change their stereotypes of science and mathematics teaching and develop their capacities to integrate contemporary science and/or mathematics into the school curriculum. Being exposed to cutting-edge mathematics and science research and practice allowed PSTs to develop new perspectives on the contemporary practice of science and mathematics, growing confidence in teaching difficult concepts, and updating their subject knowledge. There is evidence that these rewarding experiences will be transformed into school contexts and ultimately benefit school students.

Our initial recommendations, based on the evidence we have gathered in the course of the project, are:

- There is a need to include a focus on contemporary mathematics and science for primary level PSTs, where the research shows initial experiences and attitudes are formed that impact subsequently in secondary and tertiary education participation and achievement.
- To incorporate into teacher education courses opportunities for students to explore ideas and achieve success in contemporary science and mathematics learning experiences that are linked to real world challenges.

- The evidence shows the benefits of including interactions between PSTs and contemporary science and mathematics professionals and their practices, and a key aspect of their teacher education experience.
- There is a need to capitalise on the ReMSTEP work by developing school activities in science and mathematics that represent contemporary practice in these disciplines
- To follow-up ReMSTEP activities with longitudinal research that tracks the outcomes of the project into the long-term career impact of the pre-service teachers who participated in the education programs, and their wider influence and impact in schools.

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# Chapter 1: Project Context

## 1.1 Introduction

As noted in the executive summary, there are well recognised problems with student participation and achievement in mathematics and science and with the teaching of these subjects that are shared internationally. Of particular concern are widespread shortages of suitable secondary mathematics and science teachers and the teaching of mathematics and science in primary schools, lower levels of student participation in mathematics and science at senior secondary and tertiary levels and declining student performance on some national and international measures of achievement in these subjects.

There are a number of interrelated phenomena that form a self-perpetuating cycle contributing to this situation. As project director Stephen Dinham has noted<sup>1</sup>:

- Students of science and mathematics see these subjects as lacking relevance to their future lives, and fail to appreciate the creative and engaging nature of contemporary scientific and mathematical practices and the importance of these ways of thinking in a variety of contemporary concerns, and a variety of occupations.
- Many primary teachers report a lack of competence and confidence in teaching mathematics and science, not having taken the higher levels of these subjects in senior secondary school or in some cases not studying mathematics and/or science at this level.<sup>2</sup>
- Primary students can develop negative attitudes and mindsets about their ability in these subjects. Early experiences of struggle or ‘failure’, especially in mathematics, can powerfully predict and constrain future engagement and achievement and act as a barrier to learning. Students can see their ability and indeed identity as fixed.<sup>3</sup>
- Primary students in Australia perform relatively more poorly on international measures of achievement in mathematics and science than their secondary counterparts with a general pattern of decline.<sup>4</sup>
- There is substantial evidence that dispositions towards science and mathematics decline across the secondary school years. This is linked for science with perceived lack of relevance and lack of opportunity to engage with ideas in personally relevant ways.<sup>5</sup>
- There is increasing concern that school science and mathematics curricula do not adequately reflect contemporary practices within the discipline.<sup>6</sup>
- There are shortages of suitably trained secondary mathematics and science teachers. PISA data has revealed that ‘around 30 per cent of 15 year old Australian students were enrolled in schools whose leaders reported that a lack of qualified mathematics teachers was hindering instruction. The figure for science teachers was around 24

per cent. Conversely, the OECD average for mathematics and science was about 18 per cent for each.<sup>7</sup> This situation is worse in government schools, low SES schools and regional and remote schools. Some schools tick all these boxes. Some students will not encounter a trained mathematics or science teacher until the latter years of secondary schooling, if at all.

- Participation in the higher more 'difficult' levels of mathematics and science at senior secondary level is declining.
- Participation in undergraduate university mathematics and science courses is also declining; with some departments of mathematics shrinking or closing.<sup>8</sup>
- There are shortages of initial teacher education (ITE) candidates in secondary mathematics and science, especially physics and chemistry.
- Some ITE primary candidates struggle with mathematics and science because of their background, some have not taken mathematics or science through to Year 12 level or if so, at a low level, and have developed negative mindsets and attitudes towards these subjects.<sup>9</sup>

The above represents a powerful cycle that cannot be allowed to continue and must be broken. However because of the cycle's complex, interrelated and self-reinforcing nature, there are no 'quick fixes'. It requires a response that isn't just about providing for the needs of industry but of the need for a more scientifically literate and capable population.

Changing the thinking of teachers and students of mathematics and science lies at the heart of what ETMST (Enhancing the Training of Mathematics and Science Teachers) and ReMSTEP (part of ETMST) are attempting to achieve through exploring multiple models for engaging ITE candidates actively and legitimately in a variety of professional practices. One key to this change in thinking is to engage students – both school and ITE - in activities that capture the contemporary relevance and excitement of scientific and mathematical practices across a range of endeavours. ReMSTEP is premised on the notion that this 'turn to practice' will enable the school subjects of mathematics and science to better represent contemporary professional ways of thinking and working in STEM.



## Chapter 2: Project Approach

### 2.1 Details of the Project

The intended project outcomes and rationale of the ReMSTEP project were stated in the initial proposal (2013) as follows:

This project established a network between four leading universities dedicated to developing new initial teacher education that aligns contemporary practices in the sciences with innovative and engaging approaches to teaching and learning. The four universities - Melbourne, Monash, La Trobe and Deakin – have:

- a) a variety of teacher education course structures that provide the opportunity to test these approaches in a diverse range of contexts,
- b) a history of collaboration between the education and mathematics/science faculties that provide the foundation for this proposal, and
- c) a track record of collaboration between the education team members on pedagogical research.

The project supported the extension of these collaborations to break new ground in development of:

- a) approaches to teaching and learning that exemplify contemporary scientific and mathematical practices,
- b) a framework to guide these approaches,
- c) effective approaches to collaboration between science and education academics that can support this, and
- d) approaches to dissemination and cooperation that provide maximum impact in the field.

*Please refer to the executive summary [p.8] to see the key outcomes of the project.*

In terms of dissemination, it was intended from the start that any information, findings or resources of ReMSTEP be made available to any interested parties in the interest of achieving maximum impact. An active website was established early in the project (see [ReMSTEP.org.au](http://ReMSTEP.org.au)). Dissemination also occurred through the two annual sharing conferences held in 2015 and 2016 and at conferences for the five overall ETMST projects. Various reports to the funding body, the ETMST appointed evaluators and this report also formed part of the dissemination strategy. There is also a book commissioned by the Australian Council for Education Research that is in progress at the time of writing.

## 2.2 The Innovations

As the ReMSTEP project was never envisaged as a single project but rather was conceptualised and enacted as a series of interrelated activities devised to meet the overarching goals of both ReMSTEP and the ETMST program, we have grouped these activities designed to achieve the project outcomes under a series of broad innovations set out in the original ReMSTEP proposal. Some activities are confined to a single university, although activities of the same type occurred at other universities, whilst others were spread across a number of universities. Some activities contributed to more than one innovation.

There were some changes to the intended innovations as the ReMSTEP project proceeded from the proposal stage to implementation and ultimately completion, with the following seven innovations being the final version:

1. Contemporary science and mathematics integrated in initial teacher education units of study.
2. Undergraduate mathematics and science students engaging with schools.
3. Mathematics and Science teaching specialisations within ITE primary programs.
4. Specialist science and technology centre collaborations.
5. Opportunities for students to interact with scientists in world-class research environments.
6. Building on existing ITE candidate expertise in mathematics and science.
7. Building a recruitment pipeline of high potential mathematics and science teachers.

Further details on the activities that comprise these innovations are outlined in Chapter 3<sup>c</sup>.

## 2.3 Integrating Cutting-edge Practices and Pedagogy

The ReMSTEP project proposal was built upon the concept of integrating ‘real’ cutting-edge mathematics and science with initial teacher education, both primary and secondary. Every teacher education program must anticipate two communities of learner: pre-service teachers and the students they will teach. In this project, the challenge was to integrate a vision of mathematics and science as dynamic communities of research practice in a way that can be reproduced through classroom activity.

### A focus on practice rather than knowledge

A long-standing critique of school science pedagogy is its passive, transmissive nature focused on the resolved conceptual products of science, which misrepresents the excitement and dynamism of the living practice. Joseph Schwab argued that students should be educated in what he called the syntactical as opposed to the substantive structure of the discipline: the way science ideas are posed, experiments are performed, and how data are

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<sup>c</sup> It will be seen that innovations 6 and 7 are more long term outcomes of innovations 1 to 5.

converted into scientific knowledge<sup>10</sup>. This is echoed in the inclusion of epistemic knowledge – about the nature of scientific knowledge building – in the recent 2015 PISA scientific literacy assessment (2016).

It is also consistent with current understandings of science as a discursive practice involving a range of multi-modal literacies that should form the basis of any science education. In mathematics there is an equivalent advocacy for greater emphasis on problem solving and mathematical modelling. In both cases, traditional mathematics and science teacher education have tended to perpetuate a focus on conceptual products or instrumental processes at the expense of experiences with the way contemporary scientists and mathematicians work in key areas. From the point of view of contemporary scientists, current science education misrepresents contemporary practice in the field<sup>11</sup>.

This project thus focused on the very important work of representing scientific and mathematical cutting edge practices in pedagogies as part of a reconceptualised teacher education, to inspire prospective teachers and through them students, as to the nature of scientific and mathematical practices as ways of working and thinking that can contribute to resolving major contemporary issues. A significant issue with engaging students in mathematics and science is their exposure to models of people involved in the area with whom students can identify as consonant with their own future identity development, and possible career pathways. This project generated compelling examples of scientists' and mathematicians' work, consistent with this need to generate understandings of the nature of work in the sciences.

### **Inquiry, problem solving, modelling, context**

The focus on cutting edge science practices is consistent with and supported by current advocacy for school science and mathematics of inquiry and problem solving pedagogies, modelling, and the contextual siting of representational work. The approach taken in linking cutting edge practice and pedagogy makes particular use of an innovative, guided inquiry pedagogy that has been developed and validated over a number of ARC projects<sup>12</sup> and has been shown to lead to quality learning and reasoning, and student engagement<sup>13</sup>. The pedagogy captures the imaginative, often visual processes of knowledge building in science and mathematics. Visualisation and modelling are key literacy competencies in science and mathematics, increasingly supported by digital tools in contemporary practice in the sciences.

Learning mathematics and science is also about connecting ideas to each other. The types of actions in which students must engage to build integrated and flexible knowledge networks include connecting, representing, identifying, describing, interpreting, sorting, applying, designing, planning, checking, imagining, explaining, justifying, comparing, contrasting, inferring, deducing and proving. In all of these, the role of language is central. Jay Lemke has said, "To learn science is to learn to speak science" and mathematical literacy similarly requires proficiency in technical language and in reasoning and argumentation<sup>14</sup>. The

promotion of such proficiencies requires innovative approaches to induct prospective teachers to these new forms of practice.

Another key feature of the approach was the central role of context. Contexts have often been thought of as essential in providing relevance of science to students, or as meaningful conceptual anchors or in developing scientific and mathematical literacy. Corrigan and her colleagues have been developing a frame for rethinking the use of contexts in science education that centres not only on the conceptual aspects of science (the individual concepts and big ideas often seen as the products of science) but also on the attributes of contexts, (which are part of the processes and practices of science)<sup>15</sup>. Engaging students in different contexts with an emphasis on making sense of such content using scientific ways of thinking and acting, provides learners of sciences with the opportunities to not only develop their understanding of the products of science, but also the processes and practices that are necessary to engage with in science.

While the focus of the approaches to teaching and learning is on the engagement in quality learning for pre-service teachers and tertiary science students, in an important sense these are proxies for pedagogies of engagement for school students, since it was intended that what was exemplified for pre-service teachers will both involve, and be translatable into school classroom practices. An important aspect of the project was the exploration of how to render sophisticated mathematics and science practices and ideas educationally translatable for different levels of schooling – from primary through to tertiary. The project has involved, through the different innovations, working with pre-service teachers and science/mathematics students to explore how best to generate scientific and mathematical practices for classrooms across the primary-secondary-tertiary levels.

### **Linking pre-service teachers and education academics with the science and mathematical community**

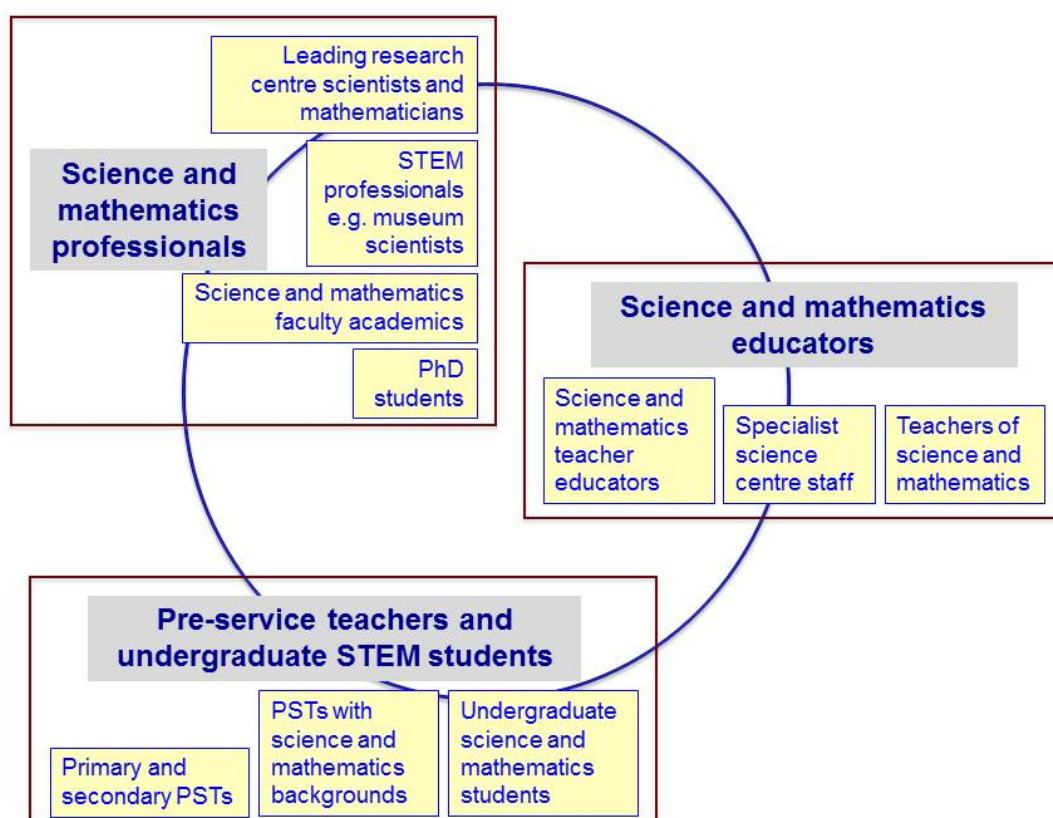
The key vision underpinning ReMSTEP has been the exposure of pre-service science and mathematics teachers to contemporary practices and perspectives in these disciplines, through collaborative practices between the teacher education and scientific and mathematics professional communities. The key aim has been to enhance PSTs' knowledge and dispositions towards these school subjects and introduce ways of teaching and learning that better engage students. The key means through which this was done was to explore, within teacher education courses, a range of productive ways of linking PSTs with contemporary practice.

A central concern driving ReMSTEP has therefore been the exploration of different, effective and sustainable ways of linking educators and PSTs with a variety of professional scientists and mathematicians and/or their practice, in order to enhance PST experience of contemporary practice in these disciplines, and through this their subject and pedagogical knowledge and dispositions. ReMSTEP has thus had a focus on practical inquiry into these

links and their effects, and the types of knowledge and productive teaching and learning approaches that can ensue.

Central to this inquiry has been the seven innovations, each of which has explored different connections with contemporary practices of science and mathematics. Figure 1 represents the different groups of educators and scientists and mathematicians, and PSTs and students, whose interactions have constituted REMSTEP. The partnerships between university science and mathematics teacher educators, and university science and mathematics academics and researchers, have been central to driving these innovative arrangements.

**Figure 1: Generalised model of the ReMSTEP community interactions**



The different innovations have thus involved different combinations and types of students, science and mathematics professionals, and educators, in exploring productive ways of representing contemporary STEM practices and their pedagogical implications. Innovation 1 for instance involved academics from the education and science faculties, and research staff, collaborating to develop and deliver courses to pre-service teachers and undergraduate science and mathematics students. Innovation 5 involved a range of models whereby PSTs, sometimes with special expertise, interacted directly with research scientists, science and education academics or PhD science students to interpret their research in a variety of pedagogical modes. Innovations in some cases overlapped so that some activities

exemplify more than one innovation. Activities have thus been described under the innovation they best exemplify.

## Chapter 3: Project outputs and findings

The ReMSTEP collaboration developed innovation in teacher education programs through 22 sub-projects (termed “activities”) that aimed to fulfil one or more of the seven key innovations. Each activity took the general ETMST/ReMSTEP approach and applied it to a different field, and so consequently each activity had a different output and thus there will be a wide range of findings across all activities. These activities are detailed in this chapter.

Underpinning a number of these innovations, particularly innovations 4, 5 and included in some activities in innovations 1 and 6, was the exploration of ways in which PSTs could fruitfully interact with scientists and mathematicians to develop new understandings of contemporary STEM research and development practices, and their social contexts, and to explore how these might be represented in school curricula. These interactions were varied, and ReMSTEP has enabled the evaluation of different models of interaction in order to develop insights into productive models of interaction. These insights include how to translate contemporary practice into engaging school activity and pedagogies, and exemplars of forms of approach, as well as practical issues around how such activity can be sustainably embedded into PST courses.

A major output of the project was a new, and hopefully sustainable network of activities between universities, faculties, science centres, schools and other important bodies that had been largely unconnected previously. For a network diagram representing these new connections, see *Appendix C*.

The intended project outcomes and the rationale for ReMSTEP have been described in chapters 1 and 2. Because of the nature of the acknowledged problems with both the preparation of maths and science teachers and in the achievements of primary and secondary students in measures of achievement such as TIMSS, NAPLAN and PISA, it was determined by the project team in formulating the project proposal that as we were dealing with a complex, multi-faceted series of interrelated problems, it would be necessary to formulate, implement and evaluate the impact of a variety of innovative practices designed to address these. It was thought to be highly unlikely that a single initiative would successfully address and remedy all facets of the issue.

Further, the stated parameters for the ETMST projects required a number of principles and practices, including multi-university projects characterised by closer cooperation between science and maths research centres, faculties of science and mathematics and teacher education faculties. Other important considerations were concerned with ‘real’, contemporary depictions and actions of mathematics and science professionals and approaches to dissemination and engagement which would maximise the impact of the project outcomes on practising teachers in both primary and secondary settings.

Thus, as indicated, the ReMSTEP project was never envisaged as a single project but rather as a series of interrelated activities devised to meet the overarching goals of both ReMSTEP and the ETMST program, and as a result, it was decided to group these activities under a series of broad innovations. Some activities were confined to a single university, although activities of the same type occurred at other universities, whilst others were spread across a number of universities. Some activities contributed to more than one innovation, although no university addressed all the innovations, at least to a high degree.

There were some changes to the intended innovations as the ReMSTEP project proceeded from the proposal stage to implementation and ultimately completion, with the following seven innovations being the final version. As seen below, some innovations were larger and more ambitious than others. Further, it was recognised that innovations 6 and 7 were largely comprised of outcomes of the first five innovations and were longer-term than could be achieved within the timeframe for the project. Thus, most activity was confined to innovations 1 to 5.



**Table 1: Number of tertiary students involved in ReMSTEP activities**

	Number of tertiary students		
Activity / Year	2014	2015	2016
ASELL for schools		5	5
Australian Mathematics & Science Partnership Program	82	84	53
Back to School		30	18
Communicating Science (IFM)	298	332	315
Contemporary science school project		10	
Creation of mathematics teaching videos			17
Digi-explanations		105	85
Discovery Science and Technology Centre Bendigo			185
Engaging with practices of contemporary science (EDF5674)		16	9
Inquiry Science	n/a	n/a	n/a
Institute of Frontier Materials (IFM) research practices video	n/a	n/a	n/a
Multidisciplinary Science and Technology in Education	10	15	17
New Science and Mathematics Elective		54	25
Quantum Victoria	n/a	n/a	n/a
Reconceptualising Rocks		35	37
Reconceptualising Chemistry	19	13	24
Schools Science Project (SCI3910) and Monash Science Squad		47	36
Science and mathematics specialist pathways in MTeach	42	41	40
Science in Schools		12	13
Scientists as Partners in Education (SPiEs)		5	7
Stem Cell Exploration	3	2	7
The Gene Technology Access Centre (GTAC) partnership	5	24	
TOTAL	459	830	893
		TOTAL:	2182

### 3.1 Innovation 1 – Contemporary science and mathematics integrated in initial teacher education units of study

**Description:**

This innovation engaged science and mathematics academic staff, research scientists and education staff in collaborative design and co-teaching of new units of study offered to both science students and pre-service teachers. Existing units already offered to both science/maths students and pre-service teachers were upgraded to include cutting edge scientific practices and experiences. This has fostered improved collaboration between these staff members within individual universities as well as between partner universities.

**Rationale:**

This collaboration between researchers and educators in science, mathematics and education was intended to reconceptualise the education of teachers of mathematics and science through active partnership between teacher educators, mathematicians and scientists.

**Activities:**

The activities that addressed this innovation are detailed in *Appendix B: Description and Impact Statements for Individual ReMSTEP Activities*, at the page number listed. Please note that some activities impacted more than one innovation, and so may appear more than once in this chapter.

• Communicating Science	p14
• Contemporary Science Schools project	p17
• Creation of mathematics teaching videos	p18
• Engaging with Practices of Contemporary Science (EDF5674)	p21
• Inquiry Science	p22
• Multidisciplinary Science and Technology in Education	p23
• Scientists as Partners in Education (SPIEs)	p34

## 3.2 Innovation 2 – Undergraduate science students engaging with schools

### Description:

This innovation provided undergraduate science students the opportunity to participate in classrooms as either a classroom assistant or as a science mentor. University research academic staff and teacher educators teamed up with science students to design stimulating activities for the classroom that showcase contemporary science. There was a strong focus on student recruitment into postgraduate teacher education and the development of students' skills, while promoting these university science students' consideration of teaching as a future career.

### Rationale:

These activities, in which undergraduate science students and pre-service teachers collaboratively explore the practices of cutting edge research facilities and in-school science teachers, offer opportunities to attract, recruit, and further support talented science students into the teaching profession.

### Activities:

The activities that addressed this innovation are detailed in *Appendix B: Description and Impact Statements for Individual ReMSTEP Activities*, at the page number listed. Please note that some activities impacted on more than one innovation, so may appear more than once in this chapter.

<ul style="list-style-type: none"> <li>Advancing Science by Enhancing Learning in the Laboratory (ASELL) for Schools</li> </ul>	p9
<ul style="list-style-type: none"> <li>Australian Mathematics &amp; Science Partnership Program</li> </ul>	p11
<ul style="list-style-type: none"> <li>Back to School</li> </ul>	p13
<ul style="list-style-type: none"> <li>Schools Science Project (SCI3910) and Monash Science Squad Website</li> </ul>	p30
<ul style="list-style-type: none"> <li>Science in Schools</li> </ul>	p33

### 3.3 Innovation 3 – Mathematics and Science teaching specialisations within primary pre-service teaching programs

#### Description:

This innovation introduced specialisations in science and mathematics into primary teaching programs, enabling the effective development of the skills required by all primary teachers while providing an emphasis on science and mathematics education. Mathematics and sciences academic staff and specialist researchers worked with teacher educators to develop materials and approaches to content knowledge and pedagogy in primary mathematics or science teaching, in ways that represent contemporary practice and align with the Australian Professional Standards for Teachers (APST). Upon graduation, it is intended that these teachers become specialised catalysts for improved science and mathematics teaching in their schools.

#### Rationale:

Opportunities for primary pre-service teachers to specialise in mathematics or science teaching within their existing programs has increased the number of specialist primary teachers while modifying university programs for future PSTs who choose to become specialist mathematics or science teachers.

#### Activities:

The activities that addressed this innovation are detailed in *Appendix B: Description and Impact Statements for Individual ReMSTEP Activities*, at the page number listed. Please note that some activities impacted more than one innovation, and so may appear more than once in this chapter.

• Communicating Science	p14
• Multidisciplinary Science and Technology in Education	p23
• New primary pre-service teachers science elective	p24
• Science and mathematics specialist pathways in Masters of Teaching (Primary)	p32

### 3.4 Innovation 4 – Specialist Science and Technology centre collaborations

**Description:**

This innovation involved pre-service teachers and university science students engaging with specialist science centre staff, including educators and research scientists from the Melbourne Museum (and other specialist sites), to provide opportunities for pre-service teachers and high-calibre science students to collaboratively develop high-quality resources for use in schools and in some cases to engage with school students in the delivery of these.

**Rationale:**

Specialist science centres already enrich (some) school students' access to cutting-edge science. These activities enabled these centres to provide additional experiences for pre-service teachers and specialist sites at which high-calibre undergraduate science students can engage with school students, as well as a focus for collaborative development of high-quality resources for use in schools.

**Activities:**

The activities that addressed this innovation are detailed in *Appendix B: Description and Impact Statements for Individual ReMSTEP Activities*, at the page number listed. Please note that some activities impacted more than one innovation, so may appear more than once in this chapter.

• Collaboration with the Gene Technology Access Centre	p34
• Contemporary Science Schools project	p17
• Discovery Science and Technology Centre Bendigo	p19
• Engaging with Practices of Contemporary Science (EDF5674)	p24
• New primary pre-service teachers science elective	p27
• Reconceptualising Rocks	p28
• Representing scientific research and development practice at the Institute for Frontier Materials	p30
• Science in Schools	p33
• Quantum Victoria	p25

### 3.5 Innovation 5 – Opportunities for students to interact with scientists in world-class research environments

#### Description:

This innovation involved exploring models through which PSTs and undergraduate science and maths students can interact with the scientific and mathematical research and development community and to develop from these interactions curriculum links, school activities, or learning resources. For a more detailed exploration of Innovation 5, please refer to Section 3 (p.32) of the separate volume *Appendix B: Description and Impact Statements for Individual ReMSTEP Activities*.

#### Rationale:

The objective of these activities was to expose PSTs and undergraduate mathematics and science students to current cutting-edge science research, to give them a chance to carry out some research work and to create connections between the curriculum, school students and scientists. These activities also aimed to empower them to communicate the research process and the applications of science to their students with confidence.

#### Activities:

The activities that addressed this innovation are detailed in *Appendix B: Description and Impact Statements for Individual ReMSTEP Activities*, at the page number listed. Please note that some activities impacted more than one innovation, so may appear more than once in this chapter.

• Advancing Science by Enhancing Learning in the Laboratory (ASELL) for Schools	p9
• Australian Mathematics & Science Partnership Program	p11
• Contemporary Science Schools project	p17
• Contemporary biology and environmental science in education	p15
• Discovery Science and Technology Centre Bendigo	p19
• Reconceptualising Chemistry	p26
• Representing scientific research and development practice at the Institute for Frontier Materials	p28
• Scientists as Partners in Education (SPIEs)	p34
• Schools Science Project (SCI3910) and Monash Science Squad Website	p30
• Stem Cell Exploration	p35

### 3.6 Innovation 6 – Building on existing ITE candidate expertise in mathematics and science

**Description:**

This innovation sought to develop a core group of postgraduate students who possessed undergraduate majors in mathematics, science and engineering as primary and secondary specialist teachers, with particular emphasis on developing knowledge and skills for middle years of schooling. As part of these enhanced programs, opportunities were created for the students to collaborate with science/mathematics researchers and educators to develop activities for partner schools.

**Rationale:**

Recruitment of students with undergraduate majors in mathematics and science will provide a core of pre-service teachers, who have been (and will continue to be), developed as primary and secondary specialist mathematics and science teachers.

**Activities:**

The activities that addressed this innovation are detailed in *Appendix B: Description and Impact Statements for Individual ReMSTEP Activities*, at the page number listed. Please note that some activities impacted more than one innovation, so may appear more than once in this chapter.

All ReMSTEP activities involving postgraduate students with undergraduate majors in mathematics, science and engineering have contributed to this outcome, including:

• Engaging with Practices of Contemporary Science (EDF5674)	p21
• New primary pre-service teachers science elective	p24
• Schools Science Project (SCI3910) and Monash Science Squad Website	p30
• Science and mathematics specialist pathways in Masters of Teaching (Primary)	p32

### 3.7 Innovation 7 – Building a recruitment pipeline of high potential mathematics and science teachers.

**Description:**

This innovation invited practising teachers, who have a learning area in science or mathematics or are primary trained science/mathematics specialists, to participate in the dissemination of the activities developed through the various ReMSTEP projects. These practising teachers are encouraged to mentor high-performing undergraduate science or mathematics students interested in pursuing a career in these areas of teaching, or to mentor pre-service teacher candidates about their career aspirations.

**Rationale:**

Working synergistically with all of the other innovations, but particularly innovation 2, it involved practicing teachers to participate in dissemination contributing towards building long term and ongoing relationships between all stakeholders.

**Activities:**

The activities that addressed this innovation are detailed in *Appendix B: Description and Impact Statements for Individual ReMSTEP Activities*, at the page number listed. Please note that some activities impacted more than one innovation, so may appear more than once in this chapter.

All ReMSTEP activities involving undergraduate mathematics and science students interacting with schools have contributed to this outcome, including:

• Advancing Science by Enhancing Learning in the Laboratory (ASELL) for Schools	p9
• Australian Mathematics & Science Partnership Program	p11
• Back to School	p13
• Schools Science Project (SCI3910) and Monash Science Squad Website	p30
• Science in Schools	p33



## Chapter 4: Project impact

The ReMSTEP project has resulted in significant impacts on a number of organisations and people, which were evaluated by a combination of qualitative and quantitative approaches. The qualitative data was primarily gathered through interviews with key academics and scientists who ran the ReMSTEP activities. The interview tool was developed by Prof Russel Tytler and can be found in *Appendix E*. Quantitative data was obtained through a variety of survey tools that were distributed either in-person or via SurveyMonkey. An example of the survey tools used can be found in *Appendix F*.

Impact summaries for individual ReMSTEP activities can be found in *Appendix B*. These summaries were derived from a more detailed impact analysis that was carried out for each ReMSTEP activity. For more information about these analyses, please contact Program Director Prof Stephen Dinham at the University of Melbourne.

The evaluative data has shown that the ReMSTEP project has been successful and fruitful in a variety of aspects, including an established network of key agencies involved in science and science teacher education, intensified connections between university science/mathematics and education academic staff, observed changes in PSTs' perceptions of and attitude towards scientists and science and/or mathematics teaching and learning, and improved capacity of both PSTs and in-service teachers in integrating contemporary science and mathematics practice into the curriculum.

### Collaboration and networks

#### With research agencies

Through the project, in-depth, extensive, and sustainable collaborations and partnerships have been developed among different faculties of higher education institutions, science and technology research centres, local primary and secondary schools, and other public organisations (e.g. Melbourne Museum). This breadth and depth of collaborations has never been achieved between the partners prior to ReMSTEP. A reciprocal collaboration model has been created between the research agencies and higher education institutions. As reliable and credible source of information and knowledge, research agencies offer valuable resources for universities, which can be easily accessed on-site and online. PSTs and undergraduate mathematics and science students were also rewarded by being involved in ReMSTEP, as it provided them with the opportunity to “learn different educational practices, which inform improvements to their own training process” (Luca Bertolacci, coordinator from VSSEC, MTeach program). In addition, the PSTs and mathematics and science undergraduates who visited specialist centres such as Museum Victoria have become ambassadors and advocates for these agencies. Hopefully they will transfer these

experiences into their future classrooms and encourage their students to connect with these sites and resources, maintaining the collaboration in the long-term.

Working with the PSTs and science undergraduates were valuable educative experiences for research scientists to understand how university students learn, as there are not many opportunities for them to be involved in such teaching activities. It gave them a new lens to see the subject they are working in, and allowed them to re-construct the public image of research scientists and their work. As Dermot Henry (Head of Science, Museum Victoria) put it:

*“Scientists are not necessarily boring people who spend all the time in a laboratory, but by and large are very fun loving people. Geology is not only about the product, such as the rocks, but also about interesting process like the volcanism. I’m always keen to spread the word about geology through the community in lots of different ways.”*

Most importantly, through ReMSTEP, scientists have gained experience in presenting and communicating their projects to a scientifically literate, but not expert, audience. Being skilled in communication is increasingly a priority for research departments for explaining their work and its importance to stakeholders, the general public and potential future students. The scientists do not always have the ability to translate their own research into everyday language and make it understandable. For many of them, this experience made them more aware of what is involved in communicating to non-expert audiences, and they gained a better understanding of tailoring the delivery of their research findings to these different audiences. They felt that the broader aspects of their research methodology, their own motivation for their research, and how that research can be used to address different problems should be the focus (Scientists’ survey, 2016, Reconceptualising Chemistry). This experience also assisted research scientists to reflect on the ways that their research could be presented in the school curriculum. It helped them grow the capacity to adapt their research and their language to the school level, and identify appropriate resources and tools to support the schools.

Visiting the research agencies, and interacting with the scientists there, has resulted in the re-examination of the PST’s and science undergraduates’ perceptions of the role of these agencies and of research scientists. According to the results of student (including both PSTs and science undergraduates) surveys, a range from 62.5 per cent to 100 per cent of respondents across different activities agreed that they gained new insights into scientists’ research and development practices and roles. A range from 32.3 per cent to 57.14 per cent participants reported positive change in their perceptions of scientists as people. The majority of respondents who indicated no change in their perceptions explained that it had already been positive in terms of their perceptions. The interviews conducted with the participants further illustrate how these changes happened. For example, the tour of the laboratories and storage units underneath and behind the Melbourne Museum provided

students with an insight into the significant role that the Museum staff have in contemporary research:

*"I didn't know there was so much research. Like when we went underneath ... I didn't realise all that was there. I didn't know any of that happened. I didn't even think about the fact they would do research h... and lots of the stuff that was actually on show - that they might use that for the research and stuff." (PST, 2016, Reconceptualising Rocks)*

PSTs also realised the importance of the Museum in information sharing and now regard it as a hub of education and resources. In addition, the experience of the scientists' presentations offered PSTs insights into the life of professional scientists and the realities of research:

*"I did really enjoy it, it's not every day that I get to see a scientist speak about their work, and the method involved in the work. I didn't realise the exact process of how to go about finding things out ... it was really interesting to see the scientific method at work, by professionals." (PST, 2015, Communicating Science)*

For some of the PSTs, this understanding of scientists and their work developed through the project reinforced their own identity as a teacher. It also enabled PSTs and in-service teachers to show their students the type of work they could aspire to, if they wanted to continue in the science pathway.

### **Cross-faculty collaboration**

Another significant success of the ReMSTEP collaboration was the cross-faculty engagement in maths and science teacher education. Education and science/maths academics gained familiarity with each other's work and forged on-going relationships, which significantly decreased the isolation between the two groups. Academics from different faculties met on a regular basis to share insights, expert knowledge, and resources across diverse activities. The science departments are now open to lending equipment to PSTs from education, and pathways have been opened that encourage teaching related projects to be completed within some professional practice units; for instance, some science academic staff allow teaching students to produce lesson plans/resources as part of their assessment tasks.

Through the collaboration, education academics developed their communication skills. Dr Melody Anderson, as the program coordinator of the Mathematics and Science Specialisation in UoM's MTeach (Primary), became more skilled in negotiating and managing changes across the program. Dr Christine Redman, an education academic, learned different ways to represent the ideas that she had encountered. They also became "more aware of their facilitator or conduit role between the Faculty of Science academics and the PSTs, due to their expertise in working with children, and their knowledge of the limitations where the PSTs might go with science education" (Duncan Symons, Lecturer in Science Education, UoM)

MTeach). As science teacher educators, their own understanding of science education, and in particular STEM education, has evolved through the interaction with science academics:

*"I feel like that first year in particular it was the skills and understandings from each of the disciplines science, technology, engineering and mathematics was slightly lost. They were having lots of fun, but I think it became a bit difficult to really pin point those disciplines and develop those specific underpinning skills and ideas there. I feel like as we went through we learned that students really needed more, as we gave them the underpinning framework for science. What unites the STEM disciplines and why do we put them together. That made me think, well the framework that needs to underpin a STEM-based approach to education is a statistical framework. A framework that actually requires a student to think initially about a question that they can ask that has specific elements to it that can be answered through collecting numerical, quantitative data. Using the statistical investigation framework to underpin the STEM unit allowed each of the disciplines to actually come to the fore. So, I was saying before in that initial stage everything was a little bit vague and there wasn't that same rigor and depth of understanding in the different disciplines. But by asking them to use that statistical framework it forced the students to make sure that they were very careful when collecting the data, which was again forcing them to think carefully about how they measure the data, about how they manipulated the data, which required arithmetic and algebra in the curriculum and issues of variability. That underpinning statistical framework exposed each of the underlying disciplines, which was for me a massive, huge light bulb moment."*

Interacting with their science colleagues also built up teacher educators' confidence. Dr Elise Roper (PST Contributor, Stem Cell Exploration) noted:

*"... that's really important in terms of our confidence levels that this project has brought. it's changed my focus in how I want to teach PSTs, how I want to bring contemporary science ideas into my classroom and hopefully into their classroom in the future, because we've been able to draw in some very contemporary science around stem cells and infuse it directly into the brand-new VC study design".*

Accompanying the cross-discipline collaboration are innovations in teaching approaches. As Dr Jo Raphael (Project Coordinator, Stem Cell Exploration) commented:

*"It just helps me to view my pedagogy differently when I can mix it up with another area, so what was able to happen as that my science colleague was able to come into my drama education class, I was able to go into her science education class, and we were able to put our combined knowledge together to produce something new and different and interesting. So, it keeps my practice fresh and alive by being able to do that."*

The education academics appreciated the enormity and wealth of knowledge that was brought to the table by the academics from the Faculty of Science. As Duncan Symons put it:

*“Because they have a breadth of understanding of science concepts, that actually they were not too focused on one specific area of science. I think that probably if we were dealing with scientists who are very niche focused, for example, in they were in a medical laboratory and they were researching a very specific form of disease, then I think it would have been less valuable.”*

For science and mathematics academics, the collaboration with faculty of education provided them an opportunity to reflect on their own teaching and learn about pedagogy in science/maths teaching.

*“One of the problems with universities is that scientists lecturing in science do not have any education background so they have no idea of the pedagogy. It's a huge problem because the way they teach is the way they were taught, which typically is very didactic and not well thought through. They stood and essentially taught from the textbook. And most of us turn around and do the same thing because it is very content laden in science courses to get through all this content with no appreciation that 80 per cent it doesn't really get in. So, it is better to take this content and make the ideas really stick ... it requires teaching approaches to achieve that so they can go away and learn more about it, which is an education approach.”* (Jon, science academic, MTeach)

Working closely with each other also encouraged academics to reflect on the difficulties that they encountered throughout the engagement. The main barriers in cross-faculty collaboration include lack of discipline/education knowledge, and the lack of willingness, enthusiasm, and time from both sides. It became difficult when academic staff from science and mathematics' disciplines, who do not necessarily have a background in education, attempted to cross that boundary. PSTs “usually have very limited subject knowledge, so it was difficult for the academic staff to know where to begin and end” (Duncan Symons, Lecturer in Science Education, MTeach). This is echoed by science academics, as they commented that people who had been brought up in a science background entirely and taught in science probably do not know what it means to be in education. These difficulties indicate that a cultural shift in the way education and science faculty staff inter-relate may not be easily achieved in the short-term. At some point, the outcomes of ReMSTEP would need to become recognised at a more formal level in respective faculties to ensure sustainability.

### **Interaction with local schools**

This project also encouraged the interaction between universities and local schools, and resulted in better-prepared university academics who have the willingness, enthusiasm and skills to engage with school teachers. In addition, dialogues have been set up between

schools that participated in this project to share experiences and classroom teaching practices, which was not a common occurrence prior to ReMSTEP. The school teachers gained much in terms of professional development, particularly in terms of inquiry-based learning, collaboration, dialogic teaching and contextualized experiences. As commented by one of the interviewed teachers:

*"I have to say, we didn't have much experience of science at Teachers' College. So, for me this is a real reinvigoration of what I have learnt in the past. And I hope that I can build on it. I'd like to become more proficient and feel confident about my teaching about the concepts of science. In the past I have probably been the person who tries to engage the children. But to the best of my teaching I've probably been more the director and I've been the person who is out the front giving the information to the children. Whereas, this sort of experience lends itself to the children enquiring more."* (School teacher, SCI3901 & Science Squad)

Graduate teachers were keen to pursue more extensive collaboration outside of the project. The experience with ReMSTEP also led to a change in teaching styles, as one of the interviewed graduate teachers advised:

*"The program encouraged me to change my teaching style, from focusing on the curriculum to getting the students interested; from focusing on the result to focusing on getting the students to go through the scientific process. Rather than concerning about whether the students learn the fact right or not, I have put more efforts to bring the scientific thinking into the classroom and make the students think like a scientist."* (Graduate teacher, Reconceptualising Rocks)

ReMSTEP activities also produced a variety of resources for school teachers to access, which feature contemporary science practices. For example, the stem cell activity offered valuable resources to teachers across Victoria, who can now implement a very new aspect of the VCE study design in Unit Two, and have resources and support to enable them to do so. The ASELL activity demonstrates the change that ReMSTEP had brought to the resources producing approach:

*"Before the establishment of the partnership with ReMSTEP, the focus had been on laboratory activities that were scientifically sound and applied good pedagogy. However, the generation of student interest and relevance were not prominent. Since the formation of the partnership, the Victorian Node [of ASELL] has focused on the inclusion of contemporary science and industry links and the development of science conceptual learning. The involvement of ReMSTEP in ASELL Victoria has changed the priorities and sharpened the focus."*

*There has been an attempt to integrate representational challenges into the laboratory activities although there is still work to be done in this area. This was not a goal before the partnership with ReMSTEP and is not evident in the*

*approach of other nodes.”* (Focus group, ASELL for schools in collaboration with ReMSTEP)

As ReMSTEP was not a research project *per se* we did not seek ethics approval to investigate the primary and secondary school student experience of interacting with ReMSTEP activities, although ethics approval was obtained for other aspects of the project involving the adult participants. Rather, the impact of ReMSTEP on school students was observed by PSTs and in-service teachers. According to the results of PSTs’ and in-service teachers’ surveys, a range from 33 to 80 per cent of respondents across different activities agreed their students had developed new understanding of the nature of scientific practices as a result of the project. A range from 90 to 100 per cent of respondents observed their students were productively engaged with learning science. A range from 67 to 100 per cent of participants believed these activities featuring contemporary scientific practices positively impact on students’ engagement with science. Specifically, schoolteachers noted that students who participated in the Growing Tall Poppies programs were more likely to participate in senior secondary science subjects, in particular physics, after participating in the project (Australian Mathematics & Science Partnership Program). They also commented on the interest of their students in the topic material was much higher than what would normally have been achieved in the classroom. In the Discovery Centre program, the students who were being taught in the Explore phases of the 5Es<sup>d</sup>, by either the PSTs or the Discovery Centre staff, were highly engaged, and more than willing to participate in the activities presented than they would have been in their normal class setting, as noted by the classroom teachers in interviews. Because of the notable improvement of student engagement, teachers expressed their passion to follow up on the program by implementing highly engaging activities in the classroom that were similar to what was done in the program.

### Impact on PSTs

The project provided new study options and additional experiences to infuse PSTs with cutting-edge science and mathematics practices. According to the responses of PST surveys, the majority reported a positive experience with different ReMSTEP activities. All surveyed PSTs reported that this had been a valuable part of their teacher education/professional development experience. Over 90 per cent of all respondents enjoyed the process of participating in this project and agreed that the process had been effective in supporting their learning/professional development. A range from 48 to 100 per cent of PSTs felt the ReMSTEP project had worked well. A range from 67 to 100 per cent of participants acknowledged the valuable opportunity that the project had provided them to collaborate with research scientists on an authentic science project.

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<sup>d</sup> Engage, Explore, Explain, Elaborate, and Evaluate.

## *New knowledge and skills*

The most notable outcome that ReMSTEP achieved is a series of changes the project induced in PSTs' knowledge, skills, perceptions, attitude, and capacity in relation to science/mathematics and science/mathematics teaching. Engaging with either the science/mathematics academic staff or the scientists in research centres or other public organisations provided the PSTs with up-to-date knowledge and practice in a variety of areas. The survey data showed that a range from 57 to 100 per cent of respondents reported they had learnt some useful and interesting science concepts through the project.

Working side by side with research scientists provided PSTs a more in-depth understanding of a science topic and current research in the area. They could view latest research facilities across different laboratory sites, and gained insights into how current research is applicable to consumer and industrial applications. Some PSTs could better understand how some fundamental theories of science were applied in current research projects. They were also exposed to practical activities with an inquiry and contemporary science focus and engaged in reflection on what makes a good laboratory learning activity. In addition, PSTs learned new approaches to teaching science, including the 5E model and action research. The latter, for example, shows how mathematics could be designed to be engaging:

*"So when we were organised into tribes and being placed in primary school settings, my tribe decided to specifically focus on statistics. So what we did we created our own situation. So I said I wanted to buy a puppet for the class, but she doesn't know what puppet to get. So we read a picture book and the students had to identify which character appeared most to help me make a decision what puppet to buy. So we designed a picture graph together as a class and they were really engaged because they really wanted to know which puppet I would buy for my class next year."* (PST, Back to School)

The value of bringing applied knowledge to the classroom has also been highlighted by PSTs:

*"A lot of students have the 'why am I doing this?' and 'how can I use this knowledge in careers related to science?' The project enabled me to display my passion and to show my students how biology can go beyond the classroom. There is meaning to why we teach these difficult complex ideas."* (PST, Contemporary biology and environmental science in action)

## *Shifted perceptions and attitude*

The experience with the ReMSTEP project also led to a shift in PSTs' perceptions of and attitude towards science and science teaching. The survey data showed that a range from 33 to 100 per cent of PSTs across activities observed a positive change in their attitude towards science/maths and/or science/maths teaching, and in their understanding of the role of science/maths teacher.



Experience with ReMSTEP allowed PSTs develop new perspectives of a particular science area. To the PSTs, science was no longer seen as ‘all-known’ or contained within a textbook, but as a dynamically evolving process:

*“I have noticed a change in that I now see that geology is an evolving science that has a role in the future of our earth and is not just a science of learning about the past. I can now see the importance of this science in our everyday lives and think it is important that students are made aware of this.”* (PST, Reconceptualising Rocks)

*“I have thought a lot more about the disconnect between secondary science and real science. Without [ReMSTEP] I probably would have still taught secondary science in a very traditional high school way. But I am very conscious now of why I shouldn't do that and why I should challenge the textbook sort of ideas, because it is true that it doesn't reflect what really happens in [science] research. It has given me permission to change the way I teach it.”* (PST, Engaging with practices of contemporary science (EDF5674))

*“I think one of the best aspects of the digi [-explanation] is that it forces you to think about why you are teaching a topic/concept. It brings relevance to the curriculum both for the teachers and the students. Sometimes teaching science can feel like you are just regurgitating the curriculum. Producing a digi [-explanation] brings perspective.”* (PST, Contemporary biology and environmental science in action)

In some cases, previously unpleasant experiences of learning a science subject had been replaced by new positive perceptions of the same subject:

*“I found earth science not as interesting as other science areas during my secondary school experience. However, this program allowed me to understand how interesting earth science can be when presented by passionate and knowledgeable individuals.”* (PST, Reconceptualising Rocks)

*“It shows that mathematics relates to the real world around us. Makes it more interesting, rather than dry and boring. It helps us understand about applications of mathematics. Good to know where graphic designing and pixels of pictures come from – I did not know that there is mathematics behind these.”* (PST, Mathematics Videos)

A PST who participated in the ‘Reconceptualising Chemistry’ activity reminisced about his own high school experience, having found chemistry “a very hard and confusing topic” and had questioned the importance of what was being taught in secondary schools: “Why are we learning this, what’s the point, am I ever going to use it in the future?” His perception changed through taking part in the ReMSTEP project as he was presented with ways that scientists had applied their chemistry learning and understandings to research problems. Through ReMSTEP he gained the insight that “it was good to be able to see that, see many ideas, we got to see all the presentations not just the one we were working with, so having a

whole lot of applications and being able to use it was really good". The new perception of a particular science subject enables PSTs to link the subject with other areas of study. As one of the PSTs in Reconceptualising Rocks described, "I think it sort of highlighted the connection between earth science and other areas, so, history, chemistry, biology and physics or the sort of big ones in the school curriculum". Such understanding would contribute to the implementation of integrated STEM units of study in school at different levels.

In addition, the ReMSTEP activities offered PSTs a lens through which they could recognise the importance and value of integrating contemporary science into the classroom, particularly as there are not a lot of appropriate resources suited for the VCE content and in a language that is accessible to the students:

*"I think there is a real lack of connection between the VCE expectations, around what is expected for people to understand, and then having that as something that is contemporary, and what we are currently doing in Australia, promoting science in Australia."* (PST, Contemporary biology and environmental science in action)

Others emphasised the importance of connecting with industry, particularly those who don't have an industry background:

*"Industry experience verses classroom experience, bringing the two together and being able to pool resources is very valuable in the classroom ... finding reliable resources was challenging and working directly with scientists added significantly to the quality and credibility of the content."* (PST, Contemporary biology and environmental science in action)

The importance of linking science/mathematics learning to the real world and life was also highlighted by a number of PSTs:

*"I do think it has changed my view on the purpose of [teaching] science. For me it's about providing students with all the tools so that they can go out into the world and when they see a whole lot of texts that are science related they can come to their own conclusion on them."* (PST, Engaging with Practices of Contemporary Science (EDF5674))

*"It is important in helping students justify their commitment to and efforts on science and mathematics learning. We are living in a scientific world and everything we see is science related. By bringing those daily aspects into the classroom or the lab, it can better integrate them instead of just having questions about things like atoms, but students can see and experience first-hand everyday things like perfumes and cosmetics and the science behind them."*

*It will also assist the students to combine knowledge from the classroom and then take that outside into the real world to understand a particular issue. Having that on the school grounds and a forest nearby, for example, provided an opportunity for*

*students to connect the classroom learning to outside the classroom learning. Rather than just sticking with the notes, they engage at different levels. Even moving from the classroom to outside helps the students to refocus on a new aspect.” (PST, Back to School)*

The shifted perceptions of science also encouraged PSTs to redefine their role of science (and maths) teachers, as facilitators rather than the preacher or the vessel of knowledge, as illustrated by the following statement:

*“Especially with science knowledge, I can be there to point out resources and do demonstrations but in this day and age of information, you want to know about penguins then you can watch a David Attenborough documentary on YouTube. You have all your information at your fingertips. I can understand that back in the day you could just have an Encyclopaedia Britannica and a teacher and that's where you got your information. I see myself as someone that shows them the value, modelling what it might look like, but more as a facilitator.” (PST, Back to School)*

Moreover, the experience with ReMSTEP provided PSTs a chance to reflect on some issues existing in science/mathematics education at different levels. One is the use of technology:

*“There are often advantages of integrating ICTs into the learning to provide students visualised learning experiences, and allow them to collaborate online. They can help to overcome some of the resistance points in students learning because it is a natural aspect of their lives, reducing the cognitive load and the struggle for the students will make it much more enjoyable for them. However, teachers also need to pay attention to the down side of using technology, avoiding making the students feel like putting the materials into a black box of technology without appreciate what it means.” (PST, Back to School)*

PSTs had opportunities to explore the pros and cons of a student-centred learning strategy by seeing the implementation of this strategy in class. The advantages were that the school students were involved, and they were finding the material more interesting than a normal class. However since there were four different groups in the class, “there were some groups that were doing the work and others were slacking off.” (PST, Back to School). This approach requires extensive planning by the teacher, as specific types of activities need to be prepared to engage students with hands-on activities and to collaborate in groups. Students need to be given a well-defined role rather than a task, and throughout the process, students should be allowed to discuss their roles and responsibilities with the teacher to make sure they are in line with the task objectives. As a result, “students would take ownership and be empowered through the process.” (PST, Back to School)

Some of the ReMSTEP activities provided PSTs opportunities to experience teaching at both primary and secondary levels, which allowed them to learn the difference between the two levels of education. As one of the PSTs in the Back to School activity commented:

*“Differences between primary and secondary teaching are vast. For the issue of behavioural management, I think that secondary school students are more sensitive in the way that you interact with them. In the primary school setting this is not necessarily the case. The kids forget quicker at the primary school level than in the case of secondary school.” (PST, Back to School)*

Even within the secondary years, differences in students’ learning experience were observed by PSTs:

*“In year 7, students are very excited. They have lots of ideas, lots of preconceptions about what science is from primary school. I had a lot of girls saying this is so exciting, we're doing 'real' science. In year 9, it becomes a bit more formulaic. It seems like they have become use to being told what's the right way to do something. They were more concerned with getting right rather than exploring the science through the task. Then by year 11 they are just concerned with the facts.” (PST, Back to School)*

In relation to teaching approaches, the change of PSTs’ perceptions of science has led to the transition of their focus from content teaching to promoting different mindsets in the classroom. As one of the PSTs stressed: “One of the things I can do to change that mindset is through real life examples using concrete materials to make it more accessible for the students.” (Reconceptualising Rocks). Other foci that changed included ongoing assessment and timely feedback to students rather than pre-and post-assessment. Understanding the nature of science resulted in a change of attitude towards mistakes:

*“I would be engaging students more and giving them the confidence to try ... it’s OK to make mistakes. There is an element of failure in [doing] science as well. Scientists ... big names, still have that in [their work] ... as well. It’s OK to fail.” (PST, Engaging with Practices of Contemporary Science (EDF5674))*

### **Improved confidence and capacity**

The knowledge and skills that PSTs gained from the project together with their developed understanding of science contributed to the improvement of their confidence in and capacity of teaching science. According to the survey results, a range from 33 to 100 per cent of participants across different activities appreciated the engagement with new and interesting approaches to teaching science, and gained ideas for bringing contemporary science practices into the school curriculum. A range from 78 to 100 per cent of PSTs agreed that they had gained valuable ideas about how to support students to learn about what science professionals do, and their thinking. Over 90 per cent of respondents felt they were more capable in understanding and communicating science/mathematics ideas to students. More than two-thirds of PSTs felt more confident in teaching science and mathematics-related topics at school.

Being exposed to cutting-edge science research has led to the growing confidence of PSTs in teaching science in their own practice:

*"I have to say I am pretty okay with immunology and immunotherapy now. I would be pretty comfortable teaching it." (PST, Contemporary Biology and Environmental Science in Action).*

*"This program revealed that Earth Sciences can be much more engaging and relevant than I ever imagined. I feel much more prepared and excited about approaching Earth Science in my teaching." (PST, Reconceptualising Rocks)*

Constructing a coherent contemporary view of the nature of science also appeared to provide PSTs with the language and confidence to engage in professional discourse, which challenged and further enriched their understandings of sciences. Several PSTs self-reported improved confidence and competence in their professional practice when exploring science with their students as a way of knowing and understanding the world.

The project also developed PSTs' capabilities of providing quality science teaching in five ways. First, PSTs' skills in applying enquiry-based learning have been honed. The examples given below vividly illustrate this point:

*"At the start, with the Biology 1 and 2 subjects we gave them a bag of yeast and we said prove to me how this is alive. That was for the first unit. Half the kids really took the bull by its horns and just did it. They came up with really inventive ways of proving it. I realised that it is good to incorporate more enquiry-based learning into my classroom. You need to get them to the level to engage in that enquiry or design their own experiments. I felt that was a lot more engaging for them. It took them a bit more time, but it was better than us putting a plant in water and letting a fan go and waiting to see how long the water level goes down." (PST, Back to School)*

*"I liked the "story-telling" element of how a single rock/pebble has travelled through the rock cycle over millions of years. The use of a concept map helped, and I can see myself doing that with my students. Incorporating media/video presentations is something I would definitely like to do." (PST, Reconceptualising Rocks)*

*"We used the 'thinking through the lesson plan' template, which I found very useful. It focused on both the teacher and student learning. One of the best aspects of the template is that the lesson planning had things like 'what are your mathematical goals for the lesson?' or 'how would you anticipate student responses', or 'what are your expectations for students in what they are working on and for completing the task?' Those sorts of things provided one resource that accessed the important low inference observation skills. So I think it was*

*important for my professional development as a teacher.”*  
(PST, Reconceptualising Rocks)

Second, the PSTs found that they would be able to replicate experiments that were done with the students, if they did not require specialist or dangerous equipment or materials such as liquid nitrogen. They were able to produce their own lesson for their science topic, with ideas on how to teach topics that they would not have thought of themselves.

Third, PSTs were able to provide context to the principles that they will teach to their students when they enter the classroom. By engaging with a scientist and “trying to get them to talk about the overall picture of the applications” (PST, Reconceptualising Chemistry), PSTs could justify the pedagogical value of teaching techniques and compare the research to the curriculum, which was reported by the participants as thought provoking and valuable. PSTs indicated that the activities they developed through ReMSTEP would enable their future students to understand what a ‘real’ scientist was doing, the topics being explored and the current research.

Fourth, the ReMSTEP experience encouraged PSTs to implement integrated STEM teaching:

*“Because of the STEM Australia initiative, the government wants every student to appreciate each of these four domains, but also integrate them more into each other. It is not like it will mesh into one big subject but more about interdisciplinary and integration of subjects. I would like to take a themed approach, like aquarium for example, bring in physics such as the fluid dynamic of the fish swimming and also the bio-diversity. This would bring in all 4 subjects into one theme.”* (PST, Back to School)

Other techniques that PSTs learned through ReMSTEP include the 5E model they used in the placement, the ongoing professional learning, peer coaching, and low inference observations, and the integration of technology into science teaching, particular since technology is now a regular part of students’ lives.

All the benefits that PSTs had gained through ReMSTEP have the potential to be transformed into school contexts. The rewarding visits to the Museum, the exciting excursions, or the process of working with scientists to develop teaching resources are all likely to be translated into primary or secondary schools and ultimately impact on students:

*“The project was increasing the self-efficacy of these PSTs and changing their personal-professional identity in some aspects. They see themselves proficient in science and mathematics, hopefully both, and what we know is that if there teachers are going out and feel confident, they would incorporate science on a regular basis, into their work programs, and make it enjoyable and giving students that appetite for learning science then it should flow through to the ultimate purpose, which is to increase the students’ learning outcomes. So if the most effective element that has the biggest impact on learning is a quality*

*teacher, we are producing more as in number of high quality mathematics and science teachers then it follows that we are going to increase student learning outcomes.” (Dr Melody Anderson, MTeach (Primary) coordinator, UoM)*

### **Impact on tertiary science students**

Another key aspect of the ReMSTEP project was to offer an opportunity for university science and maths students to engage with schools in order to build a recruitment pipeline of high potential mathematics and science teachers. The science undergraduate and higher degree research students have learned the complexities and challenges of the teaching landscape, and increased their capabilities by engaging with students, PSTs and scientists. This has increased their ability to teach and explain the science that they are learning or researching. Some of the science students noted that they will be continuing their work into a scientific field, while others were motivated to consider taking up one of the available pathways to teaching as a career.

According to interviews with science students, ReMSTEP assisted them to develop new understanding of science teaching and learning, including teaching as a complex activity, different teaching approaches, and the use of technology to facilitate teaching. They learned that there are a lot of different components that fit together in teaching, such as classroom management, content, and pedagogy. Science teaching could be delivered in different ways to make a difference, as illustrated by an interviewed science undergraduate:

*“Normally, teachers are standing up so they are looking down at their students. But the teacher in the class I observed tried to get down to the same level with the students. To me it showed how the teacher could build a closer relationship with students, which will reduce the fear of students and encourage them to ask for help. Teachers also have to create a safe environment for students to learn, which means teachers have to respect students. They have to present themselves respectful, but not like an authority figure. When a student makes a mistake they shouldn't laugh at them because everyone makes mistakes. It's part of learning especially in science. Science is more about trial and error.” (Science undergraduate, Science in Schools)*

The innovative and effective use of ICT in classes that science students attended resulted in a change of their attitudes towards the role of technology in teaching science. Rather than ICT being seen as distractors for students, if employed in a right way it can improve learning and engage students. Rather than ‘feeding’ the students with information, the use of technology enables learner-centred teaching, which focuses on discovering information. In this case, students ‘feed’ themselves, as shown in the example below:

*“At high school one of the tasks they have to do is introduce 3D shapes to their friends and they have to teach each other about these shapes. So for the 3D*

*shapes lesson, the teacher divided instruction into 3 sections, such as easy level, intermediate level and advanced level. What I learned from this was that they have to plan their lessons around these different categories, so they have these 3D models and the students need to interact with them in specific ways. One of the ways they did this was to find a model they were working on online, say a pyramid. So they can find out how to identify the pyramid and then relate this to the physical model they have in the classroom. Then they can show it to people and explain it.”* (Science undergraduate, Back to School)

Participating in ReMSTEP also allowed university science and maths students to learn about the factors that impact student learning, and the experience helped them to understand science/maths education needs to be tailored to the audience and that science/maths teachers need to encourage questions and reflections rather than just lecturing about a topic. It also highlighted the importance of making science learning interactive and engaging. A balance between the science content and the fun of learning could be achieved. The clinical experiences provided by ReMSTEP could also be transferred to their future work. As one of the interviewees stated:

*“After taking this course I felt more like a clinical interventional practitioner, which means I can clinically address or identify my students’ weaknesses or areas they could work on and I could intervene by using different teaching approaches or switching methods to get them back on track. So from that aspect it does lead me to have higher employability.”* (Science undergraduate, Science in Schools)

More importantly, the experience with ReMSTEP made science students reflect on the value of teaching as a career and encouraged a number of them to consider taking up one of the available pathways to teaching as a career.

*“I was thinking you never get told, 'oh you would be a great teacher'. You get told you be a great this, that and the other, scientist, musician, lawyers, never you would be a great teacher.”* (Science undergraduate, Schools Science Project (SCI3910))

*“When I got into the ReMSTEP program I could see that there are not so many people who want to do teaching in mathematics. So it opened up a new perspective for me. I think teaching plays a very important part in young people’s lives. And I think one of the ways that teaching feeds back into the community is education.”* (Science undergraduate, Back to School)

Some students initially fostered ideas of becoming secondary teachers but changed their focus to possible careers in primary education:

*“But now it is something I would consider - actually going into teaching. Personally I thought it wouldn't be as much primary school teaching, just because generally the teachers do not specialise as much in just one field as they do in*



*high school teaching. Yeah, but now I would actually consider teaching a younger group than before.”* (Science undergraduate, Schools Science Project (SCI3910))

Pursuing a teaching career does not necessarily have to be in a school setting but could be outside the classroom:

*“My placement at GTAC offered me a valuable opportunity to teach outside the schools, which I found was very creative and exciting. And I plan to teach either in the school or in a science program such as through Melbourne Zoo or Museum Victoria.”* (Science undergraduate, Science in Schools)

Through taking part in this ReMSTEP project, students on a career trajectory to become scientists gained an understanding and appreciation of the practice of teaching. This understanding will enhance their skills and abilities to communicate their science discoveries to the public, the younger age group in particular, which will prove useful in their future careers:

*“You have to get yourself down to the students’ level, sitting down and talking to them, in order to see and feel the difference in taking that approach.”* (Science undergraduate, Back to School)

## Appendix A

### ***Certification by Deputy Vice-Chancellor (or equivalent)***

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

**Frank Anastasopoulos, Acting Director**

Major Initiatives, Contracts and Grants  
Research, Innovation and Commercialisation  
The University of Melbourne

Name: ..... Date: 7/3/17  
Incorporating UoM Commercial Ltd and the  
School of Melbourne Custom Programs

Professor Jim McCluskey

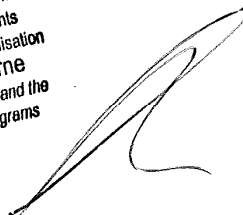
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School of Melbourne Custom Programs



## **Appendix B**

### ***Description and impact statements for individual ReMSTEP activities***

## Section 1 – List of activities by innovation

### 1.1 Innovation 1 – Contemporary science and mathematics integrated in initial teacher education units of study

**Description:**

This innovation engaged science and mathematics academic staff, research scientists and education staff in collaborative design and co-teaching of new units of study offered to both science students and pre-service teachers. Existing units already offered to both science students and pre-service teachers were upgraded to include cutting edge science practices and experiences. This has fostered improved collaboration between these staff members within individual universities as well as between partner universities.

**Activities:**

• Communicating Science	p14
• Contemporary Science Schools project	p17
• Creation of mathematics teaching videos	p18
• Engaging with Practices of Contemporary Science (EDF5674)	p21
• Inquiry Science	p22
• Multidisciplinary Science and Technology in Education	p23
• Scientists as Partners in Education (SPIEs)	p34

## 1.2 Innovation 2 – Undergraduate science students engaging with schools

### Description:

This innovation provided undergraduate science students the opportunity to participate in classrooms as either a classroom assistant or as a science mentor. University research academic staff and teacher educators teamed up with science students to design stimulating activities for the classroom that showcase contemporary science. There was a strong focus on student recruitment into postgraduate teacher education and the development of students' skills, while promoting these science students' consideration of teaching as a future career.

### Activities:

<ul style="list-style-type: none"> <li>Advancing Science by Enhancing Learning in the Laboratory (ASELL) for Schools</li> </ul>	p9
<ul style="list-style-type: none"> <li>Australian Mathematics &amp; Science Partnership Program</li> </ul>	p11
<ul style="list-style-type: none"> <li>Back to School</li> </ul>	p13
<ul style="list-style-type: none"> <li>Schools Science Project (SCI3910) and Monash Science Squad Website</li> </ul>	p30
<ul style="list-style-type: none"> <li>Science students in schools</li> </ul>	p33

### 1.3 Innovation 3 – Mathematics and Science teaching specialisations within primary pre-service teaching programs

**Description:**

This innovation introduced specialisations in science and mathematics into primary teaching programs, enabling the effective development of the skills required by all primary teachers while providing an emphasis on science and mathematics education. Mathematics and sciences academic staff and specialist researchers worked with teacher educators to develop materials and approaches to content knowledge and pedagogy in primary mathematics or science teaching, in ways that represent contemporary practice and align with the Australian Professional Standards for Teachers (APST). Upon graduation, it is intended that these teachers become specialised catalysts for improved science and mathematics teaching in their schools.

**Activities:**

• Communicating Science	p14
• Multidisciplinary Science and Technology in Education	p23
• New primary pre-service teachers science elective	p24
• Science and mathematics specialist pathways in Masters of Teaching (Primary)	p32

## 1.4 Innovation 4 – Specialist science and technology centre collaborations

### Description:

This innovation involved pre-service teachers and science students engaging with specialist science centre staff, including educators and research scientists from the Melbourne Museum (and other specialist sites), to provide opportunities for pre-service teachers and high-calibre science students to collaboratively develop high-quality resources for use in schools and in some cases to engage with school students in the delivery of these.

### Activities:

• The Gene Technology Access Centre	p34
• Contemporary Science Schools project	p17
• Discovery Science and Technology Centre Bendigo	p19
• New primary pre-service teachers science elective	p24
• Reconceptualising Rocks	p27
• Representing scientific research and development practice at the Institute for Frontier Materials	p28
• Schools Science Project (SCI3910) and Monash Science Squad Website	p30
• Science students in schools	p33
• Quantum Victoria	p25

## 1.5 Innovation 5 – Opportunities for students to interact with scientists in world-class research environments

### Description:

This innovation involved exploring models through which PSTs can interact with the scientific and mathematical research and development community, and develop from these interactions curriculum links, school activities, and communication resources. For a more detailed exploration of Innovation 5, please refer to Section 3 of this document (p37).

### Activities:

<ul style="list-style-type: none"> <li>Advancing Science by Enhancing Learning in the Laboratory (ASELL) for Schools</li> </ul>	p9
<ul style="list-style-type: none"> <li>Australian Mathematics &amp; Science Partnership Program</li> </ul>	p11
<ul style="list-style-type: none"> <li>Contemporary Science Schools project</li> </ul>	p17
<ul style="list-style-type: none"> <li>Contemporary biology and environmental science in education</li> </ul>	p15
<ul style="list-style-type: none"> <li>Discovery Science and Technology Centre Bendigo</li> </ul>	p19
<ul style="list-style-type: none"> <li>Reconceptualising Chemistry</li> </ul>	p26
<ul style="list-style-type: none"> <li>Representing scientific research and development practice at the Institute for Frontier Materials</li> </ul>	p28
<ul style="list-style-type: none"> <li>Scientists as Partners in Education (SPIEs)</li> </ul>	p34
<ul style="list-style-type: none"> <li>Schools Science Project (SCI3910) and Monash Science Squad Website</li> </ul>	p30
<ul style="list-style-type: none"> <li>Stem Cell Exploration</li> </ul>	p35



## 1.6 Innovation 6 – Building on existing ITE candidate expertise in mathematics and science

### **Description:**

This innovation sought to develop a core group of postgraduate students with undergraduate majors in mathematics, science and engineering as primary and secondary specialist teachers, with particular emphasis on developing knowledge and skills for middle years of schooling. As part of these enhanced programs, opportunities were created for the students to collaborate with science/mathematics researchers and educators to develop activities for partner schools.

### **Activities:**

All ReMSTEP activities involving postgraduate students with undergraduate majors in mathematics, science and engineering have contributed to this outcome, including:

• Engaging with Practices of Contemporary Science (EDF5674)	p21
• New primary pre-service teachers science elective	p24
• Schools Science Project (SCI3910) and Monash Science Squad Website	p30
• Science and mathematics specialist pathways in Masters of Teaching (Primary)	p32

## 1.7 Innovation 7 – Building a recruitment pipeline of high potential mathematics and science teachers.

### Description:

This innovation invited practising teachers, who have a learning area in science or mathematics or are primary trained science/mathematics specialists, to participate in the dissemination of the activities developed through the various ReMSTEP projects. These practising teachers are encouraged to mentor high-performing undergraduate science or mathematics students interested in pursuing a career in these areas of teaching, or to mentor pre-service teacher candidates about their career aspirations.

### Activities:

All ReMSTEP activities involving undergraduate mathematics and science students interacting with schools have contributed to this outcome, including:

<ul style="list-style-type: none"> <li>Advancing Science by Enhancing Learning in the Laboratory (ASELL) for Schools</li> </ul>	p9
<ul style="list-style-type: none"> <li>Australian Mathematics &amp; Science Partnership Program</li> </ul>	p11
<ul style="list-style-type: none"> <li>Back to School</li> </ul>	p13
<ul style="list-style-type: none"> <li>Schools Science Project (SCI3910) and Monash Science Squad Website</li> </ul>	p30
<ul style="list-style-type: none"> <li>Science students in schools</li> </ul>	p33

## **Section 2 – Individual activities**

### **2.1 Advancing Science by Enhancing Learning in the Laboratory (ASELL) for Schools (Deakin University)**

#### **Output**

This activity was run in collaboration with the Australian Maths and Science Partnerships Program, with the aim of bringing university science students, science education staff and teachers together to develop practical activities for the secondary school curriculum. Laboratory Learning Activities (LLAs) were developed to suit the ASELL for Schools project for Years 7-10. They included contemporary science with an inquiry focus and strong industry links; for example, one activity linked to the Institute of Frontier Materials.

This project introduced three innovative elements into the practical activity development:

- Representation of contemporary science research contexts.
- Representational construction/modelling focus consistent with contemporary scientific practices.
- Development by pre-service teachers working alongside scientists, science educators and teachers.

This activity also produced support materials for teachers and LLAs for Year 7-10 students in contemporary science. These were developed with an emphasis on a representation construction approach and inquiry skill development and inquiry learning, by academics and practicing teachers in schools during workshops. These materials will be published for all Australian science teachers to access, on the ASELL for Schools website and on the ReMSTEP website.

#### **Impact**

The academic staff from the Deakin Faculty of Education worked closely with the science faculty staff in organising this collaboration, and the scientists involved have achieved significant changes in their understandings of inquiry pedagogies.

The involvement of ReMSTEP in ASELL's Victorian Node has changed the priorities of the program. Previously, the focus had been on laboratory activities that were scientifically sound and applied good pedagogy, but had not looked at the generation of student interest or relevance to the curriculum. Since the formation of the partnership, the Victorian Node of ASELL has focused on the inclusion of contemporary science, industry links and the development of science conceptual learning. The participating PSTs gained insight into the way teachers think and the content knowledge of practicing teachers, have been exposed to

practical activities with an inquiry and contemporary science focus, and engaged in reflection on what makes a good laboratory learning activity.

The activities have been taken up by a number of schools. Feedback from teachers via surveys has shown that teachers have found the workshops and activities enjoyable and very useful.

## 2.2 Australian Maths & Science Partnership Program (La Trobe University)

### Output

As part of the Australian Maths & Science Partnership Program (ASMPP), projects were conducted at La Trobe University to enhance the ways in which undergraduate and postgraduate science students engage with schools. This involved undergraduate and postgraduate science students participating in three separate activities: Growing Tall Poppies, In2Science, and FARlabs. It was also used as an opportunity to incorporate science and mathematics PSTs into the AMSPP projects, where they gained experience in world-class research environments.

In the collaboration with Growing Tall Poppies, ReMSTEP brought together pre-service teachers with the intensive 3-day program conducted at La Trobe University, which already involved Year 9 and 10 students working with science undergraduates. In these intensives, the PSTs observed and participated in the activities with the enrolled Year 9 and 10 students, learning the inquiring and contemporary nature of content delivery between the undergraduates and the secondary students..

Working with the Department of Chemistry and Physics at La Trobe, ReMSTEP recruited undergraduate physics and chemistry students to the In2Science project, which trained them to be volunteer peer mentors in Year 8/9 science and mathematics classes.

FARLabs.edu.au, a free online tool to access real laboratory equipment, was defunded in 2015. ReMSTEP came on board to support the program, which allowed it to continue operating as an online e-laboratory for PSTs and teachers of physics and general science to utilise in their teaching practice.

### Impact

The overall experience of all participants has been positive, across the Growing Tall Poppies, In2Science and FARLabs programs. School students that participated in the GTP programs found that they were more likely to participate in senior secondary science subjects, in particular physics, after participating in the program. The FARLabs program has had generally good performance with over 53 in-service and pre-service teacher signing up in 2016 alone, and usage increasing over time.

The science undergraduate and HDR students involved in GTP and In2Science have increased their graduate capabilities to teach and explain the science that they are learning or researching, by engaging with students and becoming mentors to them. Most of the undergraduate and HDR students noted that they will be continuing their working into a scientific field, although they expressed that they would consider teaching if they were not able to find a position in their chosen field. Most high school students have reported via surveys that they have learnt something from the GTP programs that would not have been

taught at schools, and that it has given them interest in continuing to study science into senior high school, in order to continue into tertiary education.

## 2.3 Back to School (University of Melbourne)

### Output

Undergraduate mathematics students and PSTs with mathematics expertise worked together to provide enriching mathematics activities for primary and secondary school students. The primary aim of this project component was to enable undergraduate mathematics students to open their eyes to a teaching career, while also giving PSTs a new perspective on science and mathematics. For many PSTs, their only experience with science or mathematics has been their own experiences as high school students, which is often reported as negative. This project allowed PSTs to not only acquire an appreciation of science and mathematics, but also allowed undergraduate mathematics students to experience the school teaching environment.

This two-day program brought together 15 science undergraduates and 15 pre-service teachers (PSTs) from the University of Melbourne, in 2015 and 2016. The aim of the program was for science undergraduates to learn about teaching, and for PSTs to learn about teaching science.

On the first day, pairs of PSTs and undergraduates planned lessons on a mathematics or science topic set by the placement schools, East Bentleigh Primary School and Bentleigh Secondary College. The PSTs assisted the undergraduates to understand teaching concepts and educational principles. On the second day, the science undergraduates delivered the lessons they and the PSTs had planned together.

### Impact

As a result of the interaction between tertiary science students and PSTs, long-term friendships and partnerships were developed.

This activity successfully motivated the science students to consider teaching as their career option: All interviewed science students mentioned an intention to become a school teacher sooner or later in their lives. More than that, the activity enabled the participating science student to notice the high demand for mathematics teachers in Australia, and encouraged them to reflect on the importance of teaching in nurturing young generation.

In addition to impact on science students' career aspirations, the activity assisted them to develop a new understanding of science teaching and learning, including teaching as a complex activity, different teaching approaches and learning styles, use of technology to facilitating teaching, and the importance to make science learning interesting and engaging.

## 2.4 Communicating Science (Deakin University)

### Output

As part of an undergraduate unit on science communication, scientists working in the Institute for Frontier Materials were invited to present to undergraduate science and education students in a variety of science, education and engineering courses. This experience provided an opportunity to both the scientists and the undergraduate students to engage in the practice of communicating science in an authentic context. For the scientists, this was the opportunity to communicate their cutting edge research to a scientifically literate audience, albeit one that was unfamiliar with the field and inexperienced in the art and practice of research. For the students, the experience allowed them to gain insight into the work of a research scientist and that of a science communicator by reinterpreting and representing this research for secondary school students.

### Impact

As a direct result of this project, close links have formed and relationships have developed between the research scientists working at the Institute for Frontier Materials and academic staff from the School of Education and the Faculty of Science, Engineering and Built Environments.

Significant progress has been also made in forging links across the science and education faculties, as a result of this work. Videos have been produced and refined for use in presenting the motivations and research practices of young scientists, and activities are being developed, some of which have been trialled successfully with groups of teachers.



## 2.5 Contemporary biology and environmental science in education (Deakin University)

### Output

In this activity, “digi-explanations” were produced by PSTs as an assessment task within their studies for a Master of Teaching degree. A digi-explanation is a video-based multimedia presentation, which aims to explain one concept within contemporary science, and includes an interview with a scientist working in the field. The project required the PSTs to relate contemporary research to concepts in the senior secondary curriculum. The PSTs sourced a scientist who is engaged in an area of research to assist in the unpacking of the concept of interest.

The products of this activity were a series of digi-explanations of scientists’ work and activities as examples of representation of contemporary biology/environmental research in the VCE Study Design. These short videos (3–5 minutes) can be used as an aid in the teaching of a concept in the senior biology curriculum. Students also completed an evaluation questionnaire and made short videos of 2–3 students responding to the activity. This project will continue to produce these multi-media resources for wider application across Year 7–12 school curricula. The assessment task will remain an integral part of the teacher education program in the Senior Biology unit.

### Impact

As a result of the activity, teacher educators established strong networks with science faculty, and were involved in discussions regarding the next phase of ReMSTEP, building on the cross-faculty engagement. The combination of cross-faculty and PST engagement has been one of the best outcomes of this activity. The scientists participating in the activity developed an understanding of how they can contribute to formal classroom environments, grow their capacity to adapt their research and their language to the school-level, and identify appropriate resources and tools to support them. The participating pre-service teachers benefited through the resources development process.

Particularly, the PSTs recognised the importance of linking industry and contemporary research with the curriculum. They found that finding reliable resources was challenging and working directly with scientists added significantly to the quality and credibility of the content. According to the feedback of participating PSTs, they found it useful to learn how to productively integrate technology, particular since technology is now a regular part of students’ lives. They gained confidence in teaching difficult concepts, and realized the importance of integrating contemporary science into the classroom, particularly as there are not a lot of appropriate resources suited for the VCE content and in a language that is accessible to the students. They were enthusiastic about using these resources and approach for their own classrooms, and felt they were particularly suited to supporting personalised learning and students learning at their own pace.

## **2.6 Contemporary Science School project (Deakin University)**

### **Output**

This activity aimed to raise the science knowledge and awareness of primary teachers, enabling them to provide engaging learning opportunities for their students. Four local primary schools in the Burwood area, each with two science leaders, attended regular meetings to discuss contemporary science including curriculum, pedagogy, resourcing, and opportunities. PST members of the Science and Sustainability Education Club at Deakin University were involved in school-based activities such as Science Week.

The outputs included activities focusing on inquiry science, representation construction, and contemporary science activities, increasing interaction between teachers, PSTs and scientists. Resources that provide contemporary science opportunities were gathered into a portfolio to showcase this project.

### **Impact**

There is an evident shift in how the universities interact with the local schools. Deakin academics are now better prepared to engage with teachers in the schools. Developing the relationship with the primary schools is an ongoing project, as is the relationship with the Science and Sustainability Education club. Next Science Week will be planned in greater detail, with grants sought and more pre-service teachers involved. Pre-service teachers, as volunteers involved in the activity, gained valuable school-based experiences and up-to-date subject knowledge through the science week.

## 2.7 Creation of mathematics teaching videos (Monash University)

### Output

This activity was a collaboration between the Faculties of Education and Science at Monash University. A series of three short videos for pre-service and in-service teachers was produced that inspired thinking of mathematics as a beautiful, creative and relevant discipline and also provided ideas and activities for use in the classroom.

The vast majority of resources available for mathematics teachers are aimed at the mechanics of teaching or the mechanics of mathematics. The primary goal of this project was to produce content that showcases the nature and beauty of mathematics. They provide teachers with inspiration for classroom activities that deal with the ideas, rather than the technical aspects, of mathematics.

These three videos have been produced for the engagement of PSTs and teachers, and comprise of an introduction by Rebecca Cooper describing the educational purpose of the videos, an introduction by Norman Do of the maths content with links to real life examples, and questions designed to stimulate and challenge the educators' thinking and current practices in maths education.

### Impact

All PSTs and in-service teachers who watched the videos felt they had learned about current mathematical practices and had gained ideas for how to bring contemporary mathematical practices into the school curriculum.

The collaboration between the faculties had other positive outcomes. The teacher educator on the project was also involved in another project in the School of Mathematical Sciences. The aim of the new project is to promote discussion on teaching practice in tertiary mathematics education.

The videos and questions for educators are free and publically available on the Monash Science Education Research Group webpage. The Maths Association of Victoria (MAV) were excited about their potential and were keen to promote the videos to secondary mathematics teachers. The resources will be useful to challenge PST and in-service teacher thinking and spark professional discussion about the nature of mathematics and how this is conveyed in the secondary mathematics classroom.

There is a possibility (and it has been requested by teachers in the focus groups) that more videos be added to the collection in the future. There has also been interest for the team to present the ideas on the speaking circuit.

## 2.8 Discovery Science and Technology Centre Bendigo (La Trobe University)

### Output

La Trobe University's Bendigo campus established a partnership with Discovery Science and Technology Centre (DSTC) Bendigo. This partnership incorporated the Multidisciplinary Science and Technology in Education program (MSTiE) for 3rd year Bachelor of Education (Primary), and the La Trobe Discovery STEM Initiative (LTDSI) for 2nd year Bachelor of Education (Primary) students.

The activities the PSTs conducted as a part of the LTDSI were:

- An introductory session at DSTC to introduce the PSTs to DSTC and explain what was going to be done at DSTC for LTDSI.
- Interactions and planning of the LTDSI activities for each class with a "mentor" in-service teacher at a local primary school.
- Planning and team teaching of an engaging lesson to a class of primary students in a class room in conjunction with the mentor teacher.
- Assisting and participating in the workshop for the same primary school class at DSTC.
- Completion of a journal for their formal assessment of the program.

PSTs were engaged with the science communicators at the DSTC in contemporary illustrations of primary science exhibitions and workshops. The PSTs observed the way DSTC ran its programs and interacted with the primary school students, and assisted in facilitation of the workshops as appropriate. The activities at DSTC were based around interactive exhibits which illustrate a basic principle of science, and encourage students to consider areas of their everyday life where they have experienced it.

### Impact

The PSTs, primary school students and DSTC staff enjoyed the program, and thought it was a valuable partnership. PSTs recognised the value in using DSTC as a resource for teaching their students in the future. PSTs said they gained knowledge of the Primary Connections units and the e5 model of teaching that they had not previously known about, and the local teachers saw new approaches to teaching science that they had not previously implemented in their own practice.

The PSTs also said that they found 'science was easier to teach and more interesting than they have previously experienced,' and that they would be more comfortable with teaching science in their own practice. Teachers also commented on the interest of their students with the topic material was much higher than what would normally have been achieved in the classroom.



## 2.9 Engaging with Practices of Contemporary Science (EDF5674) (Monash University)

### Output

At Monash University a new unit within the MTeach course, EDF5674: “Engaging with practices of contemporary science”, was developed to promote pre-service and in-service teacher understanding and engagement with practices of contemporary science. It was trialled in semester 2 of 2015 and refined in semester 2 of 2016.

This unit was designed for MTeach pre-service and in-service teachers to explore general understandings of the nature of science including mathematics and to explore how these different understandings influence the teaching and communication of Science students in schools. The PSTs arranged to visit a research facility (either the Monash Centres of Excellence or the Melbourne Museum), where they interviewed expert scientists to identify and analyse essential practices of contemporary science that can be integrated into their professional classroom practice. The unit had three key learning objectives:

- Understand how sciences and mathematics knowledge, processes and communication shift over time through the influence of social and technological change.
- Explore the diverse and changing understandings of the Nature of Sciences (NoS) while challenging participants to re-conceptualise and articulate their own personal contemporary view.
- Investigate first hand contemporary practices of science and examine how the new knowledge created has significantly changed to become more inter-/multi- and trans-disciplinary.

### Impact

This program had a significant effect on building the confidence and ability of surveyed PSTs and in-service teachers to communicate a coherent and more contemporary view of science. Many of the PSTs spoke of how their understanding and view of science had changed during the unit from one in which they originally privileged knowledge of science or mathematical content to one which included broader understandings of the processes by which science is undertaken. Participants were keen to revisit these ideas throughout the course, and to actively explore and debate alternate views. The collaborative nature of the ReMSTEP project required members of both the education and science faculties to meet on a regular basis to plan and assist with each of the Monash project initiatives. This promoted the sharing of insights across the diverse projects, and the sharing of both expert knowledge and resources. All project members acknowledged the mutual benefits of the ReMSTEP initiative, and were supportive of maintaining or extending opportunities for collaboration in the future.

## **2.10 Inquiry Science (La Trobe University)**

### **Output**

ReMSTEP worked in partnership with the Faculty of Education at La Trobe to develop a topic on “Inquiry Science” that was offered as a topic in the newly developed Masters of Teaching (MTeach) course. The Inquiry Science topic was an option in the Practitioner Research Project that was undertaken in the second year of the MTeach. It gave PSTs the opportunity to link research into approaches to teaching science through inquiry-based pedagogy with their professional experience placement. La Trobe also developed a series of illustrations of practice in inquiry science that were presented as resource materials for this MTeach topic.

### **Impact**

Unfortunately, the project was not successfully run, as the trial participants pulled out during the initial trial and there was not sufficient time to run another trial before the ReMSTEP project concluded. The resources and framework developed were passed onto to the course coordinator of the Practitioner Research Project, for the next available time to trial the project.

## 2.11 Multidisciplinary Science and Technology in Education (La Trobe University)

### Output

This activity involved PSTs designing and implementing a unit of work in a field of science and technology at their primary school placement. Expert science knowledge from scientists at La Trobe University, and materials and equipment from the School of Molecular Sciences were brought together to support the PSTs in teaching their unit of work.

The activities in detail were:

- Arranging meetings between PSTs and scientists to discuss what could be done in a classroom relating to the PSTs' chosen topic. These meetings discussed how topics could be taught in interactive and interesting ways using support from La Trobe University.
- Providing materials and consumables for activities that would not have been able to be completed without support, e.g. solar cars that the students build in their class.
- Classroom visits from scientists, planned by the PSTs, in order to increase engagement.

### Impact

The experience of the PSTs was mixed in the final year, where there was an inability to provide the amount of resources requested to all PSTs, as some requests were too expensive to be feasible, and so some PSTs opted out of the program. The PSTs that did participate in the program found the experience to be positive, especially for the primary school students who were in regional Victoria who would not normally be able to experience such activities without the support of ReMSTEP.

The scientists gained experience in demonstrating and explaining science concepts to both PSTs and primary school students. Their skills and views in teaching improved by giving them experience with teaching students who are much younger than they would typically interact with, by seeing how 'simple' science incursions increase a student's attention and enthusiasm to do science.



## **2.12 New primary pre-service teachers science elective (University of Melbourne)**

### **Output**

The Melbourne Graduate School of Education developed a new elective focusing on an inquiry unit that integrates science and mathematics at the point of pupils' learning needs.

PSTs initially contributed to the design of the unit, and then trialled this unit of work in selected primary schools. The PSTs took part in on-and-off campus engagement with experts in contemporary science and mathematics practices.

### **Impact**

Positive results have been achieved through this activity in terms of improving participating PSTs' capability of providing quality science/mathematics teaching. All surveyed PSTs agreed that they gained ideas about bringing contemporary science practices into the school curriculum, experience in understanding and communicating science/mathematics ideas to students, and insights about supporting students to learn about science/mathematics professionals' thinking and practices.

From the PSTs' perspective, school students who involved in the activity have been benefited in a number of ways. All responding PSTs agreed that students had been productively engaged with learning science, and the activity has positively impacted on students' engagement with science.

## 2.13 Quantum Victoria (La Trobe University)

### Output

In collaboration with the specialist science and mathematics centre Quantum Victoria, La Trobe University built practicum opportunities for pre-service teachers as a series of professional development and practicum experiences for Master of Teaching students over the course of their first two semesters. QV was also to develop a series of illustrations of practice materials for PSTs to draw upon in their training and also later during their career. Through these illustrations of practice, the PSTs would be able to engage with contemporary science and mathematics education pedagogies.

### Impact

Unfortunately, this program did not run, as lead times required by Quantum Victoria were too long to be able to organise an adequate experience with the PSTs at Quantum Victoria. There was a conflict of KPIs between ReMSTEP/LTU and Quantum Victoria where QV needed school students to come through the door, and ReMSTEP was not able to fund students to come to Quantum Victoria with PSTs. The placement office at LTU also had trouble matching PSTs who would participate in this program to places at Charles La Trobe College.

There were significant interactions between the education and science faculty staff in trying to collaborate to get PSTs into Quantum Victoria. This collaboration has led to the science and education faculty staff learning about what drives each other, which would be beneficial in the future when collaborating.

## 2.14 Reconceptualising Chemistry (Deakin University)

### Output

Undergraduate pre-service teaching students training to be chemistry teachers worked closely with postgraduate research science students from the Institute of Frontier Materials at Deakin University. From these one-on-one discussions, the pre-service teachers have developed teaching resources that address key criteria, including identifying the practices used by the scientists' to develop new knowledge and techniques, and identifying links to relevant chemistry in Victorian and national curricula.

On-campus students of the Chemistry Curriculum Unit visited the IFM Research Facility in Week 2 of the second trimester to listen to the Research Fellows and Research Doctoral students from the Institute for Frontier Materials (IFM) give presentations on their research projects. The PSTs were then given the opportunity to talk to the research chemists about their projects, with a view to developing a teaching module that could be used to teach 'cutting edge chemistry' and represent the work of the scientists. The research chemists were available to collaborate with the students by answering their questions throughout the trimester.

As part of the unit, PSTs produced a teaching module that represented the work and scientific practices of the scientist. The teaching module produced included teaching activities, teacher notes and student activities, and contextual video or posters. Some PSTs were able to trial their modules within schools when on practicum.

### Impact

This ReMSTEP experience was perceived to be a positive one across all program stakeholders. Comments from surveyed participants indicated that the program allowed the PSTs to gain insights into the daily work of a research scientist and of their scientific activities on the University campuses. PSTs obtained a stronger understanding of current areas of chemistry research through interacting with scientists, and were able to provide context to the principles that they will teach to their school students when they enter the classroom.

PSTs became aware of how scientists are focused and take ownership of their research. Scientists gained a better understanding of tailoring the delivery of their results to different audiences. They felt that the broader aspects of the research methodology, their own motivation for the research and how research can be used to address different problems should be the focus of their presentations to the PSTs. The PSTs developed new approaches to science teaching that they could use in their future teaching, including how to embed contemporary science and science teaching practices into the curriculum.

## **2.15 Reconceptualising Rocks (Deakin University, University of Melbourne)**

### **Output**

Reconceptualising Rocks was a program designed in collaboration between Melbourne Museum, Deakin University and the University of Melbourne. The program connected pre-service teachers to scientists, contemporary science, and museum pedagogy practices for the learning and teaching of Earth Science.

The goals of the program were to improve the competence and confidence of participating pre-service teachers in the teaching of Earth Science. The participants' content and pedagogy knowledge was enhanced by connecting them to world class scientists, contemporary science and museum education practices.

Melbourne Museum acted as a contextual setting for the project, and provided expertise as a key communicator of science in Victoria and a contemporary site for learning. The program was promoted to pre-service teachers through the Master of Teaching (Science) at the Melbourne Graduate School of Education and through the Community Science Project unit at Deakin University to students completing either a BSc or a BSc/BTeach degree.

### **Impact**

All surveyed participants (n=22) reported that this activity worked well and they enjoyed the process of participating in this activity. With respect to the effectiveness in supporting PSTs' learning and interacting with scientists from the Museum, 92 per cent of participants responded positively. Particularly, new science concepts were one of the key gains cited by the respondents with an 85 per cent strongly agree rate.

Over two thirds of respondents were surprised by how much they learnt about science practices and how these might be represented in the curriculum. Ninety per cent of respondents reported that they had learnt things about engaging with contemporary science that would influence their teaching in the future, and gained experience in understanding and communicating science ideas to students.

The evidence also showed that the activity was successful in offering new and interesting approaches to teaching sciences (e.g. exposure to new techniques), and building confidence of the participants in teaching science-related subjects at school.

## **2.16 Representing scientific research and development practice at the Institute for Frontier Materials (Deakin University)**

### **Output**

This project aimed to represent the work of the Institute for Frontier Materials (IFM) through the videoing of scientists and through developing activities that exemplify contemporary materials science concepts. The materials developed were used with PSTs to raise their awareness of the nature of such research and development and how it might be represented in the curriculum.

This project exposed students to current contemporary research and development practice with an emphasis on the broader perspective of Science and Engineering. In doing so it introduced the idea of invention and innovation and theory and practice, research and development and the application of science and technology. IFM was seen to be an authentic environment and therefore an ideal context for exploring the broader concept of STEM in practice.

One of the gaps addressed is the idea that school science tends to deal with historical notions where examples or exemplars of current applications are given, but not necessarily explored in contemporary research and development context. In this activity, we built on this by providing a sense of a living, breathing science, by engaging students with what teams of scientists do, as well as with and the contemporary practice of science.

### **Impact**

The project is not yet complete. What has been achieved to date is a sharper understanding of the operation of a contemporary science research and development institute and the exploration of ways to interpret this for the school curriculum. As part of this, the team has grappled with the nature of inter-disciplinary STEM practices with a strong focus on engineering and design.

Significant progress has been also made in forging links across the science and education faculties, as a result of this work. Videos have been produced and refined for use in presenting the motivations and research practices of young scientists, and activities are being developed, some of which have been trialled successfully with groups of teachers.

Challenges have included the difficulty of translating cutting edge science into 'do-able' and interesting school activities, and engaging schools in the project when resources have yet to be developed. There has been some difficulty in matching the work of IFM to the school curriculum which tends to focus on canonical science rather than inter-disciplinary developmental science and mathematics. Once these activities have been refined and extended, the resources will be available more generally, and accompanying teacher education material will be written to help PSTs understand the nature of contemporary STEM and its relevance, and ways to interpret this for school students.

## 2.17 Schools Science Project (SCI3910) and Monash Science Squad Website (Monash University)

### Output

Two resources were produced – a new science undergraduate unit (SCI3910) and an interactive website, Monash Science Squad (MSS).

#### 1. New science unit (SCI3910)

In this unit, students further developed employability skills through a placement in a school. Each student was required to research, develop, manage and teach a science-based module that matches the learning outcomes specified to them by their supervising teacher. Prior to their school placement, students participate in a series of workshops on understanding and catering for different learning styles, motivation, team work, goal setting, planning, management, leadership, effective communication and presentation skills, asking the right questions and reflection.

#### 2. Monash Science Squad Website

MSS was a platform that supports school's children engagement with science. Primary school students used the platform to reflect on and ask questions about science activities they encounter outside their normal classroom program. Most of the learning took place outside of school during evenings, weekends and holidays, e.g. through visits to museums, parks and discovery centres. The design was intended for parents to support their children in their learning by overseeing these activities. Participating children could record their science-related learning experiences on the website. Volunteer undergraduate science students monitored the site, answered questions, and gave appropriate feedback.

### Impact

There have been mutual benefits for members of both the education and science Faculties, especially the sharing of insights across diverse projects, and the sharing of both expert knowledge and resources. A number of participating science students were motivated to consider taking up one of the available pathways to teaching as a career, with some science students who initially intended to become secondary teachers changing their focus to careers in primary education (as schools participating in the subject were all primary schools). Science undergraduates participated in the activities were impressed by the approaches to science education which were modelled, and often commented that they had had poor experiences of Science students in schools as learners. It became clear that their experience in learning science had too much emphasis on content. They responded to and applied the notion of inquiry-based learning and collaborative learning in a true sense. The school teachers involved gained much in terms of professional development, particularly in terms of inquiry-based learning, collaboration, dialogic teaching and contextualized experiences. They were keen to pursue more extensive collaboration outside of the unit.

## **2.18 Science and maths specialist pathways in Masters of Teaching (Primary) (University of Melbourne)**

### **Output**

With the support of the ReMSTEP program, the Master of Teaching (Primary) was been modified to allow students to specialise in teaching Mathematics and Science from as early as first year.

The existing program already required 25 point of mathematics education study, as well as 12.5 points of science education. To create these specialisations, existing units were changed and a new elective was created, with the specialisations awarding a minimum of 50 points within the 200-point program. To gain entry into these specialisations, applicants were chosen on the basis of previous study, employment, or other experience in the field. Their results in Primary Mathematics Education, a compulsory first-year subject, were also examined.

### **Impact**

Nine out of ten participating PSTs surveyed claimed that there had been a positive change in their attitude towards science and science teaching. All respondents claimed that they had been engaged in new and interesting approaches to teaching science, such as new models, new questioning techniques, and new resources. They also highlighted the benefits of learning things about engaging with contemporary science that will influence their teaching in the future, and felt they had gained experience in understanding and communicating science/mathematics ideas to students.

The science and mathematics specialisation pathways established collaborations across different faculties at the University of Melbourne, and also developed partnerships with a range of research centres. From the perspective of science and education academics, this kind of cross-faculty collaboration benefited both sides. The input from science and mathematics faculties strengthened the specialisation program, by supporting the science education faculty in the development of those mathematics and science subjects. From the involved scientist's perspective, they were able to find new ways to get other people to understand science by interacting with education academics, the PSTs, and the school students.

## 2.19 Science students in schools (University of Melbourne)

### Output

Science graduate students from the University of Melbourne undertook a placement at Albert Park College, a school into which the Gene Technology Access Centre (GTAC) provides outreach programs. Prior to the Science students working in the school, GTAC developed their expertise for working with school students, including developing inclusive questioning techniques and facilitating interaction. In the Secondary College setting, the teachers worked with the science undergraduates to share their expertise at the teacher level. The resulting learning, reflection and synthesis of the Science graduate students' placement experience was central to a Professional Skills subject contributing to their Master of Science degree.

### Impact

At GTAC, students had camaraderie and connectedness with the science educators. At Albert Park, there was an approach at the school to support the next generation of educators that made participants feel supported as potential teachers. The school was very flexible in their approach, and partnerships were very strong going into the third term of 2016.

This project found that science students really want to work with people working at a level of science understanding near their own. As a result of this, requests to work in secondary are much higher. This is not just about the knowledge and the age range—a key understanding is that science educators really want to get to the 'meaty' end of the science, which often means working with older students.

The science students participating in the program learned about the factors that impact student learning, and gained practical experience in teaching in schools. The placement helped them to understand that science education needs to be tailored to the audience, and science teachers need to encourage questions and reflections rather than just lecturing about a topic. It also highlighted the importance of making science learning interactive and engaging; aiming for a balance between the science content and the fun for learning. Through the activity, they felt more confident in explaining scientific concepts to the public, especially to the younger age group.



## 2.20 Scientists as Partners in Education (La Trobe University)

### Output

In 2015, Scientists as Partners in Education (SPIEs) allowed PSTs to engage with a scientist to create a primary school student activity. The scientists were given the option to deliver a lesson on who they were, what their field of science is and why it matters. This was followed by a classroom experiment or activity analogous to their work and fits into the curriculum. One of the most common questions asked in a science classroom is “why?” This project sought to enhance the way teachers can approach this question by enabling the teacher to provide answers which are engaging and contemporary.

The initial activity involved a research scientist working with a PST which produced an activity for grade 5/6 students, called Grime Detectives. This involved students using cotton swabs and agar plates to find and test where the most “grimy” surface would be. The second iteration of the activity involved creating a seminar series that was recorded for PSTs and in-service teachers, where the senior scientist introduced their work and their career followed by an activity that the teachers could easily do in their own classroom.

### Impact

The undergraduate and postgraduate students gained an insight into how they can incorporate their current or prior education into their teaching at the university, as well as into primary or secondary teaching should they decide to pursue a career in education. It also introduces them to the complexities and challenges of the teaching landscape.

A pool of resources have been produced that will be able to be accessed by PSTs and teachers for their use in their classrooms, increasing the efficacy of teaching science and allow them to answer the question “why are we learning this?”

The research scientists gained experience in delivering their recent research findings to an educated, but non-expert audience. While the seminar style of delivery is standard for scientists, they were forced to frame their work to allow PSTs and In-service teachers to pass it on to school students in a way that is relatable to the current Australian curriculum. The scientists found that incorporating aspects of their work into the school curriculum was easy enough once the technically intricate parts of their work have been removed. The fundamental principles of their research were easily grasped by PSTs and teachers; it is hoped that this extends to students as well, though the teacher’s experiences.

Unfortunately, low attendance (despite high acceptance rates) by both PSTs and teachers to the seminar series affected the effectiveness of this program. Due to PST practicum occurring during semester, most were not able to make the seminar at 5 pm in Bundoora.

## 2.21 Stem Cell Exploration (Deakin University)

### Output

Two teaching and learning sequences about stem cells were developed by Deakin University to support the VCE Biology Study Design (2016 – 2021). The first sequence dealt with the science/biology of stem cells, cell growth and differentiation, while the second dealt with the social and ethical issues related to stem cell research.

The first sequence was a series of activities supported by resources already available online. The second was a three-week series of activities that drew on web resources and a role-play activity exploring ethical issues around stem cells, for which video support material was developed.

Three volunteer PSTs worked with education academics to develop two sequences of classroom activities. They also participated in a Science Teacher's Association of Victoria (STAV) VCE Biology teachers' workshop, where they presented aspects of the sequence. This activity provided an opportunity for Master of Teaching Biology students to focus towards the development of teaching material in a contemporary area of biology. These resources will be further workshopped and developed prior to trialling with PSTs and testing with teachers at the STAV VCE Biology conference.

### Impact

There was an appreciation that academic staffs from both science and education faculties brought specific skills to enable schools to refocus how science is enacted. From teacher educators' perspectives, working with a science colleague helped them to view their pedagogy differently. This combined knowledge led to the development of new and interesting teaching practices. The activity also benefited the participating stem cell scientist, who did not have a teaching background, in terms of developing her understandings of how to bring stem cell science into the classroom for students.

More importantly, this activity allowed the pre-service teachers to identify the importance of using relevant contexts in their teaching, along with how to teach it more effectively and with confidence. They also recognized the importance of integrating contemporary science into the classroom, particularly as there are not a lot of appropriate resources suited for the VCE content in a language that is accessible to the students. Linking industry and working directly with scientists contributed significantly to the reliability and credibility of the resources, and the pre-service teachers were enthusiastic about using these resources and approach, and particularly support personalized learning and students learning at their own pace.

## **2.22 The Gene Technology Access Centre (Deakin University, University of Melbourne)**

### **Output**

Pre-service teachers at both Deakin University and University of Melbourne worked with the Gene Technology Access Centre (GTAC) educators and scientists (including PhD research scholars) to produce educative resources that interpret the cutting-edge science involved for both pre-service teacher education programs and schools. The three project topics were designed specifically to fit into the primary and secondary science curriculum, and were:

- Bionic Eye
- Stem Cells
- Adaptations.

These activities were trialled in-class with pre-service teachers and then converted into teacher-ready resources made available on the ReMSTEP website.

### **Impact**

The resources created have been used by over 1500 biology teachers, and once they are made available on the ReMSTEP website, this activity is expected to increase.

The scientists involved were very interested in learning about the skills and processes that go into the design of education resources, and said that it was a good exercise in explaining their work to the general public. For the GTAC staff, their strategy of consulting scientists in the development of teaching resources was validated, and their processes have been improved by the activity. PSTs were able to contribute to the initial design of the resources.

The cross-fertilizations between GTAC, UoM and the scientists involved was extremely beneficial, but suffered from a lack of coordination and planning in the early stages. Memorandums of understanding should be established early in future projects to reduce scheduling clashes.

## Section 3 – Innovation 5 supplementary information

This section contains more information about the impact of innovation 5 overall, when considering the multiple models employed in service of this innovation.

### Exploring models of interaction

The activities are framed within a model represented by Figure 1 which identifies three broad categories of participants involved in the interactions: STEM professionals who might be science researchers, museum scientists, or post graduate researchers; STEM Educators who might be teacher educators, teachers or science centre staff, and PSTs or undergraduate STEM students whose role may vary depending on the activity. Within innovation 5 the participants have interacted in different ways, articulated below, and the activities have led to multiple forms of experience and resources development. The aim of the Innovation 5 activities has been to explore a range of such models to ascertain a) the nature of productive interactions and the conditions under which these can be optimised, b) procedures for translating contemporary science interactions into worthwhile school activities, c) the challenges associated with the different approaches, and d) the payoffs for PSTs, teacher educators, and science researchers.

As a result of this suite of REMSTEP Innovation activities a number of outcomes have been achieved or are in an advance state of the process of being achieved:

- A set of school activities representing contemporary scientific practices
- A set of teacher education activities to consider ways of incorporating contemporary science into school curricula
- Teachers who have been exposed to translating contemporary scientific practices into the curriculum
- Web materials illustrating contemporary science curriculum activities
- Knowledge of what works, in PSTs and teachers translating scientific practice into the school curriculum

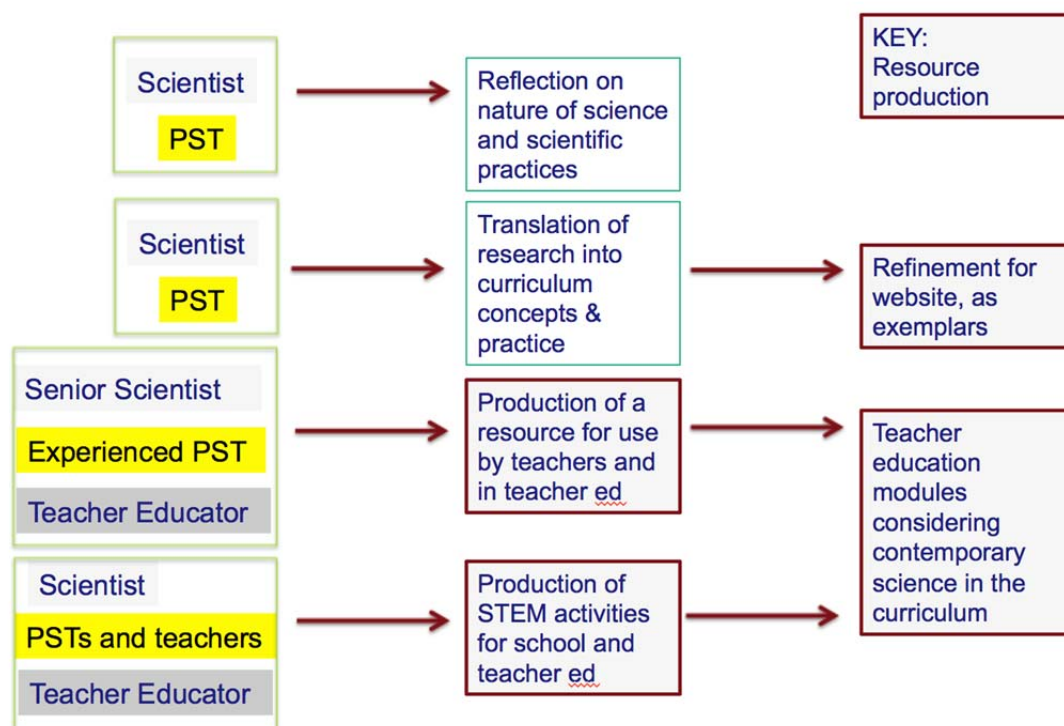
The eight Innovation 5 activities at Deakin vary across the dimensions of: the nature of the interaction, the extent to which the activity was embedded in a unit, the degree of management of the interaction, the interaction pattern (how many PSTs working with how many scientists), the extent of resource focus, the time over which the interaction takes place, and the focus, either on knowledge or process. Table 1 summarises these variations and how they relate to the individual activities.

Table 1: Dimensions along which the Innovation 5 activities vary

Dimension	From ....	To ...
Nature of interaction	Direct interaction (most)	Virtual interaction (IFM)
Embeddedness	Embedded in unit (Chem/Biol)	Volunteer (Stem cells)
Degree of management	Managed interaction (Chemistry, Workshops)	Student finds scientist
Interaction pattern	One on one (Biol, Chem)	Scientist with group (Comm Sci, Workshops)
Resource focused	Resource production (most)	Individual insight
Time	Short term (Comm Sci)	Extended (Chem, Stem Cells)
Focus	Scientific knowledge	Scientific practice

The different activities are conceived of as a staged process, in some cases the interaction with PSTs leading to exemplar resources that form the basis of teacher education activities discussing possible interactions with contemporary science. Figure 2 shows the different models of interaction between Scientists, PSTs and educators that were explored, and the types of outcomes and resources that resulted.

Figure 2: Resource production models for the Innovation 5 activities



- The first model is that used in the Communicating Science activity where the materials produced were for within – unit purposes and aided reflection on scientific practices and how they might be communicated.
- The second model involving scientist and PST interactions leading to resources for schools is exemplified by the Biology multimedia productions and Reconceptualising Rocks. Nevertheless it is expected these multimedia exemplars will be useful as resources also for PSTs.
- The third model is that used in the STEM Cells activity where PSTs with experience in the field worked with a teacher educator and senior scientist to produce web materials for use in schools, and also in teacher education.
- Finally, the fourth model is that used in the IFM and the REMSTEP/ASELL activities, where scientists, PSTs, teachers and teacher educators worked together in various combinations to produce resources for schools that act as the basis for further teacher education activities.

### Challenges for models of interaction

While contemporary science is often represented in science textbooks as ‘modern applications’, the idea of individual schools or teachers drawing on local scientists and cutting edge research is not often entertained. Reasons have to do with practicalities such as time, and lack of knowledge, or histories of practice of relying on textbooks. REMSTEP offered a proving ground for examining how PSTs/ teachers can productively engage with the STEM research community, and the conditions under which contemporary ideas can translate into school activities. Certainly, with the Science as a Human Endeavour strand of

the curriculum, we have encouragement to represent scientists and their practices in school science activity.

Through observations of interactions, interviews, and survey responses, a number of challenges were identified, and strategies developed to overcome these:

1. There were sometimes difficulties with determining, for some contemporary scientific research and development practices, just what should be focused on in translating this into school activities. A number of strategies were adopted including:
  - Taking the conceptual principle underpinning the research and devising activities exploring a simpler but related phenomenon, but with the cutting edge research and practices being represented as context.
  - The scientists learnt to put more emphasis on the broad framing and social purposes of their research, including economic and/or environmental constraints or aims, rather than simply focus on theoretical abstractions.
  - It was sometimes useful to have teachers and/or education academics working with PSTs and scientists to explore the translation process to make judgments about what would engage students, and what learning might be focused on.
  - Sometimes where the details of contemporary ideas did not suggest an engaging story for school students, the broad story of how the science was practiced sometimes took precedence, such as focusing on discussions of the role of mathematical modelling in systematically investigating new materials.
2. In some cases it took imagination to devise activities and contexts that would engage students. An example would be the translation of testing procedures of new materials, including destructive tests, into such testing of everyday materials. In that case the scientist's story became the backdrop to and justification for more traditional inquiry investigations.
3. In some cases it was difficult to find curriculum outcomes at the appropriate level to match the ideas underpinning the scientific practice. At times it was helpful to also look at the technology curriculum.
4. The interactions of PSTs with scientists depended to some extent on the maturity and experience of the PST. Unsupported interactions between younger undergraduate PSTs sometimes led to superficial exploration of the scientist's work. In that case, the suggestion is that more structure needs to be provided for younger students.
5. In any interactions questions of time, and rewards for both parties needed to be considered. In some projects involving mature volunteer PSTs undertaking serious work with senior scientists there was considerable commitment and investment of conceptual resources. For interactions that were part of unit assessment the rewards were sufficient for serious attention to the task and time was able to be made, sometimes with support such as in the chemistry, or communicating science activities.

## Outcomes and impact of Innovation 5 activities

The outcomes of the Innovation 5 activities were evaluated through online surveys, interviews, focus groups and evaluation of student artefacts, as well as field notes about the nature and progress of activities.

From these evaluation data general statements can be made about the success of these activities for PSTs (n=1,233), in that they:

- enjoyed interacting with scientists,
- often gained new insights into the nature of science and scientists' practice,
- often gained new perspectives on scientists as people,
- gained ideas for how to represent contemporary science in the curriculum; and
- gained new and important science understandings.

In surveys the range of 'agree' and 'strongly agree' responses to questions relating to gaining new insight into scientists' practices, learning interesting science concepts and engaging with new and interesting approaches to teaching science varied from 67% to 100% on the 2016 surveys. There were positive benefits for the scientists (n=30) also, in that they gained:

- insights into how their work might translate into the curriculum,
- experience in communicating their research to the public.

The latter is an important finding in that the reason why researchers were keen to have their post-graduate researchers interpret their research for PSTs was to gain experience and clarity about the purposes and public relevance of their research. Insights were also gained into the practical ways of supporting PSTs and scientists in these interactions, including the amount of scaffolding, and the provision of advice concerning how contemporary research might be packaged to produce engaging and educative school activities.

As a result of the Innovation 5 activities are a whole, a number of significant outcomes and impacts can be identified:

1. Closer relations between the education and science-engineering researchers. This is evident in frequent meetings and discussions aimed at achieving a common view about the nature of scientific practices and their educational exemplification, and has led to further joint activity including significant partnerships on research and practice proposals.
2. PST-scientist interactions are now embedded in teacher education courses in a number of units, and an understanding of mutual benefit has been reached that will help sustain this in the future.
3. Development of insights that can be extended more widely into how to manage PST-scientist interactions within a number of models or approaches, including growing experience of a number of science and education academics with translating contemporary practices into exemplar curriculum activities.



The production of a number of resources for teacher education and schools that exemplify the representation of contemporary scientific practice in school curricula. These resources will be available on the website targeted at teachers, and also as resources for teacher education in raising awareness of the role of contemporary scientific research and development in the curriculum.

### What have we learned?

There are a number of key learnings that have come from the suite of innovations concerning the representation of science practices in school curricula:

1. There are significant benefits for PSTs and teachers in interacting with scientists in terms of their understandings of the contemporary relevance of scientific work, the nature of scientists' practice, and sharpening of knowledge.
2. There are benefits in bringing together scientists, teacher educators, pre-service teachers and teachers to undertake the translation process – the process of translation is not straightforward and within these wider groupings there is a need for 'brokerage' across the scientific and education cultures.
3. A variety of strategies, and flexibility in approach, is needed in this translation process.
4. Interesting and innovative school activities can arise from these links, often involving combinations of the STEM disciplines, and industry relevance.
5. The translation of these practices into schools depends on teachers having a flexible view of the curriculum.
6. PSTs learn about the nature of scientific practice, the process of curriculum development, and teaching and learning innovation.
7. The experience is educative for the scientists who need to learn how to present key aspects and wider significance of their work, and be flexible in responding to pedagogical needs.
8. New knowledge is thus created for each of the participant groups in these 'scientists and teachers and schools' partnerships.

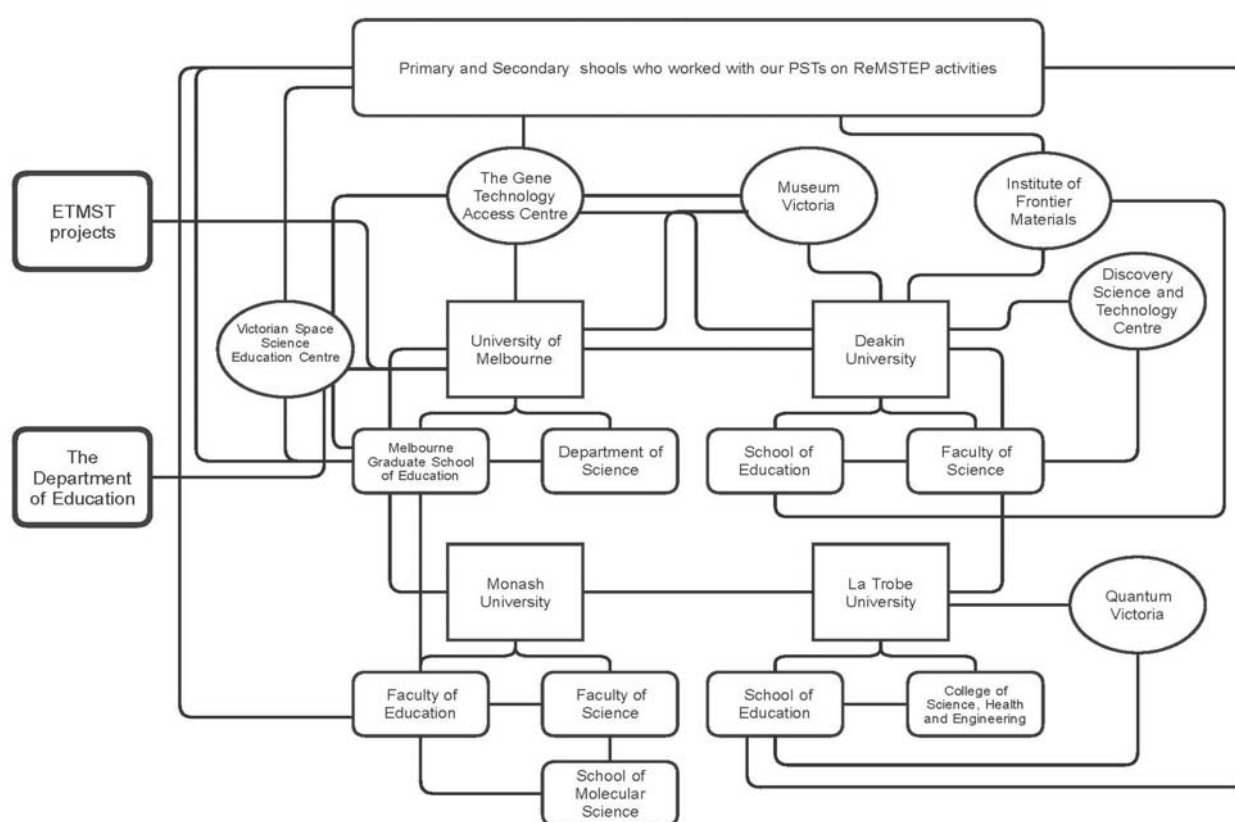
The REMSTEP experience has broken significant new ground in exploring different arrangements by which scientists can partner with educators and contemporary scientific practice can be represented in the school curriculum. The project offers a model for transforming the school science and mathematics curriculum through increasing its relevance and representing the thinking and working of STEM professionals and the critical role played by STEM in society. The project is thus a significant pilot of what could be a significant circuit breaker for STEM in schools.

# Appendix C

## Diagram 1

### ReMSTEP Connections

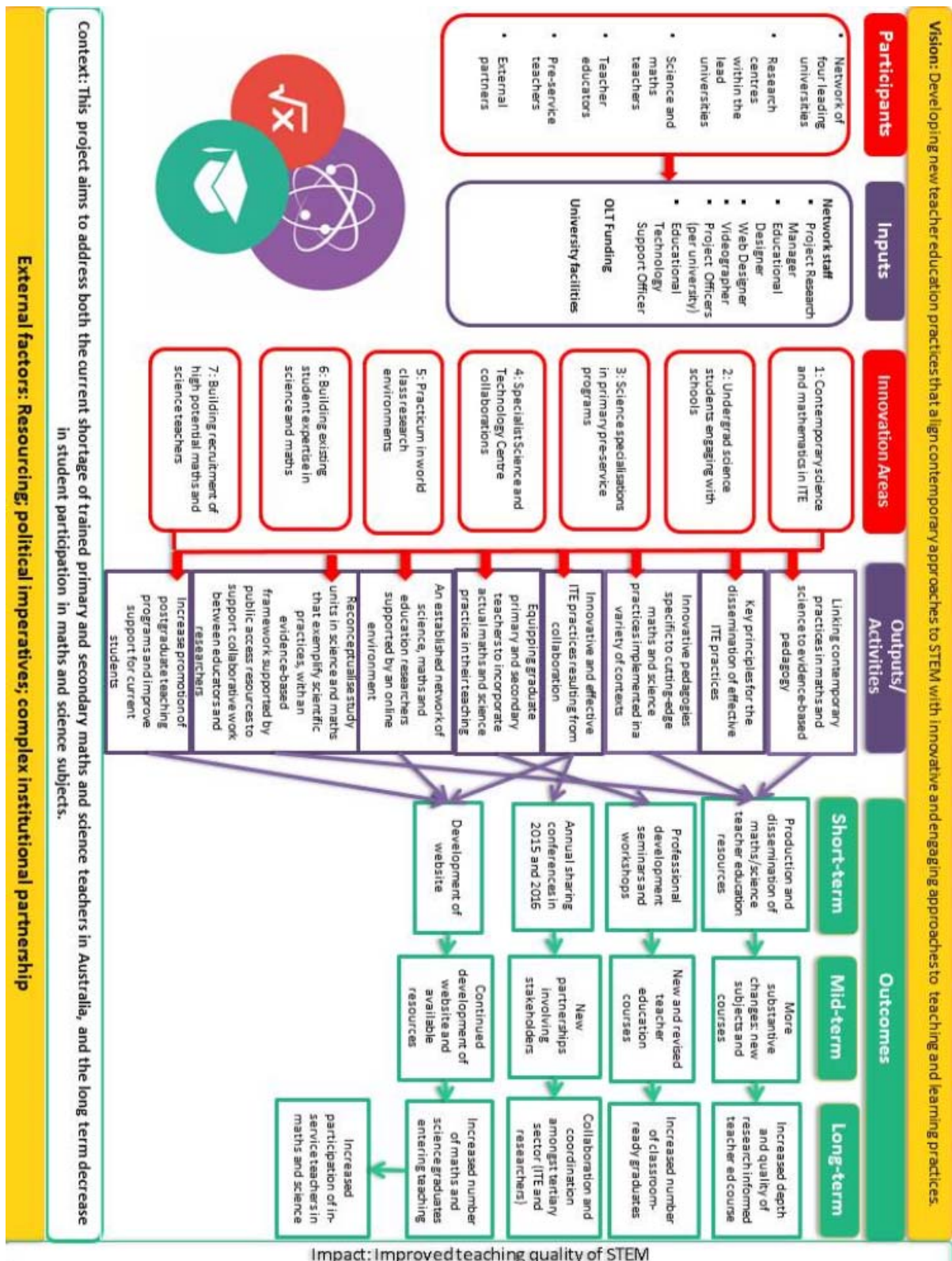
This network diagram details the novel connections between departments, institutions, primary and secondary schools and other important bodies, created by ReMSTEP activity.



# Appendix D

## Diagram 2

### The ReMSTEP Program logic



# Appendix E

## Interview questions used during evaluation

- Project name
- Who was involved?
- What was done (in broad terms)?

### Project rationale: what is the intention?

- Is there a theoretical basis or model, or literature that informed the project?
- What gaps do you see are addressed with this project?

### Project activities

- What was the nature of the activities – provide examples?
- What was the nature of engagement of PSTs or teachers with contemporary science/mathematics practices?
- What aspects of science/mathematics practice were represented to the PSTs? How was this orchestrated? In what sense do you regard this as innovative or significant?
- What changed curriculum / classroom practices are envisaged, flowing from the project? By what means were these changes supported?
- What opportunities were there for science/mathematics students (undergrad or HDR) to reconceptualise their perceptions of school science or mathematics learning and teaching?

## Results

### Experience of participants

- What was the experience of PSTs or science and mathematics students, school students, teachers, scientists, teacher educators?
- What evidence is available to identify the experience? (surveys, notes, video, etc.)

### Project outputs

- What resources were produced and what is their quality (and where can they be found)?
- What understandings or models have resulted, concerning how to engage PSTs with contemporary science and mathematics practice?

### Project outcomes: What were the outcomes for the different players?

- Is there evidence of a cultural shift in the way education and science faculty staff inter-relate as a result of this project?

- What have research scientists or mathematicians gained by participating in the REMSTEP project? Have their views about teaching and learning science and mathematics changed as a result of the project?
- What have science or mathematics undergraduate or HDR students gained by participating in the project? Is there evidence of a shift in science or mathematics students' perception of teaching as a worthwhile career path?
- What evidence is there of improved learning and engagement of PSTs, or of teachers, as a result of the project? What did PSTs learn about the nature of science, or how to incorporate science/mathematics practices into the curriculum?
- What has been learnt about the efficacy of incorporating contemporary science/mathematics practices in the school curriculum? What evidence is there of improved learning and engagement of school students, as a result of the project?
- What principles can be taken from the project concerning processes for bringing contemporary science and mathematics research and development practices into teacher education?

## **Concluding discussion**

### **Challenges**

- What was the nature of challenges to successful implementation?
- What changes were made, from which we can learn?

### **Impact**

- What is the short/medium term impact of the project (ongoing processes, commitments, existence of resources, over a 1-3 year projection)?
- What are the longer-term implications?

### **Sustainability**

- What has been learnt about processes for incorporating contemporary science and mathematics practices in teacher education?
- In what sense is the project sustainable?

### **Scalability**

- What is the possibility of the project processes and outcomes being reproduced at scale?

# Appendix F

## Sample survey questions used during evaluation

The following questions were either asked in person or via SurveyMonkey. The response options were:

Strongly Agree / Somewhat Agree / Neither Agree nor Disagree / Somewhat Disagree / Strongly Disagree / N/A

There was also an open-text box for additional comment. The questions given were:

### *As a result of the ReMSTEP activity:*

1. I learnt some useful and interesting science concepts
2. There has been a positive change in my attitude towards science and/or teaching science
3. There has been a change in my understanding of the role of science teachers
4. I have been surprised by what I learnt about science/mathematics practices, and how these might be represented in the curriculum
5. I was engaged in new and interesting approaches to teaching science
6. I have learnt things about engaging with contemporary science that will influence my teaching in the future
7. I gained ideas for how to bring contemporary science practices into the curriculum
8. I have gained experience in understanding and communicating science/mathematics ideas to students
9. I gained valuable ideas about how to support students to learn about what science/mathematics professionals do, and their thinking
10. I feel more confident in teaching science/mathematics-related subjects at school
11. Students developed new understandings of the nature of scientific practices
12. Students were productively engaged with learning science
13. These activities featuring contemporary scientific practices positively impact on students' engagement with science.
14. I felt the ReMSTEP activity worked well
15. I enjoyed the process of participating in this project
16. The process was effective in supporting my learning/professional development
17. I gained a lot by interacting with science/mathematics professional(s) in the project
18. This has been a valuable part of my teacher education experience
19. Other than the Science and Mathematics Specialisation Pathways in MTeach, have you participated in any other ReMSTEP activities?
20. Would you like to participate in an interview to further share your experience with ReMSTEP activities?

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