

## ReMSTEP project report: Monash University Masters of Teaching Unit EDF5674 – Engaging with practices of contemporary science

The Faculties of Education and Science at Monash University have collaborated to undertake three different REMSTEP projects initiatives. This report focuses on the evaluation of a new Master of Teaching (MTeach) and Master of Education (MEduc) initiative.

### Project overview

- **Project name**

MTeach & MEduc - EDF5674. Promoting pre-service and in-service teacher understanding and engagement with practices of contemporary science.

- **Who was involved?**

*Project leaders;*

- o Prof Deborah Corrigan
- o Prof Cristina Varsavsky

*Project Co-ordinators;*

- o Lisa Fazio
- o Joanne Burke
- o Dr Matt Hall

*Project contributors;*

- o Greg Lancaster
- o Associate Prof Gillian Kidman
- o Dr Kelly-Anne Twist
- o Dr David Overton

Unit cohorts in 2015 (n=16) & 2016 (n=9) consisting of MTeach and MEduc pre-service and in-service teachers.

Monash University Research Centres: Water Studies Centre, SKB Lab, Quantum Fluids Research Group, Myopathy Research Team, ARMI – Kaslin Research Group, ARMI – Ramialson Research Group, Lithgow Lab, Behavioural Ecology Research Group and,

Melbourne Museum Scientists: Biology, Geoscience and Palaeontology

## ● What was done (in broad terms)?

A new unit offered by the Faculties of Education and Science within the MTeach and MEduc courses ([EDF5674 – Engaging with practices of contemporary science](#)) was initially developed and trialled in Semester 2 of 2015 and then refined and offered again in semester 2 of 2016. It has been primarily designed for MTeach and MEduc pre-service (PSTs) and in-service (ISTs) teachers to explore general understandings of the contemporary practices and nature of science (including mathematics) and to explore how these different understandings influence how science can be taught and communicated in schools. The PSTs also arrange to visit one of a number of science research facilities (Monash Centres of Excellence or specialist scientists at the Melbourne Museum) where they interview expert scientists to identify and analyse essential practices of contemporary science that can shape or be integrated into their professional classroom practice.

The unit has three key objectives which align with the ReMSTEP project aims:

- Understand how sciences (including 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 Science (NoS) while challenging participants to re-conceptualise and articulate their own personal contemporary view.
- Identify and 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.

## Project rationale: what is the intention?

### ● Is there a theoretical basis or model, or literature that has informed the project?

The rationale underpinning the offering of the MTeach unit identifies the need to better inform PSTs of the contemporary practices in science (and mathematics) and the range of critical thinking skills needed to be taught to better prepare students for future careers in STEM. An analysis of the reported broad understandings of the nature of science held by the general public (Cobern & Loving, 1998; Lederman, Abd-El-Khalick, Bell & Schwartz, 2002; Schwartz, Lederman & Crawford, 2004) reveal how these different views can markedly change the way science and mathematics is communicated and the authority it is afforded. The unit encourages PSTs to empower their students with the skills to identify and develop sound scientific practices that rely on a logical analysis of evidence to form rational conclusions. PSTs are also encouraged through their readings and workshop discussions to identify and revise their own views of the nature of science and to reflect on how their views may shape their classroom practice.

Their views are again tested and informed during their visits to research facilities and interviews with practicing scientists. A schema developed by Corrigan (see Lancaster & Corrigan (2016)) attempts to assist the PSTs in their analysis of the methods and intentions of the different types of science communication engaged in by contemporary scientists. This

approach is seen as innovative as it tries to assist the PSTs to distinguish between the broad areas of complex cognitive engagement needed for effective communication with different audiences for different purposes. The schema identifies 5 areas of science cognitive engagement that scientists, technologists and researchers are likely to engage with;

**General public engagement** - is where scientists are seeking to effectively communicate insights into big ideas or complex processes using simple metaphors or analogies which are designed to convey the key ideas in intelligible ways .

**Informed engagement** - describes engagement by those who are conversant with a scientific field or discipline. They are informed and seek opportunities to share and improve their knowledge and understanding amongst competent peers with similar interests or expertise.

**Applied engagement** - describes a broad engagement by scientists, engineers, technical designers and science communicators who apply current scientific knowledge to develop real world applications of technology or provide insights into fundamental processes of science.

**Focused engagement** – deals with the routine practicalities of communication practices within and between scientific or industry research centres. Examples could include system approaches for regular reporting on project challenges and achievements to project personal, routine laboratory meetings, initiatives exploring workflow or communication practices and team reviews of technical protocols.

**Expert engagement** - involves science discipline authorities or research leaders acknowledged by their peers as experts and visionaries, e.g. Nobel Laureates, Prime Minister’s Prize for Science, Eureka Prizes, Australian Institute of Physics awards, and Australian Academy of Science award winners.

The PSTs investigate using this framework in analysing the different types of science cognitive engagement employed by various scientists and science communicators in their day-to-day practice.

- **What gaps do you see are addressed with this project?**

The ReMSTEP project has been helpful in identifying important gaps that exist for many PSTs between their understandings of the practices of contemporary science and their past experiences of learning science and mathematics in their undergraduate or secondary school years. For many mature-aged PSTs undertaking a transition into education, their experiences of science were often completed some years ago and likely limited in scope by the technology available at that time. The practices of science have undergone significant changes in recent years with the availability of new technologies and advances in information technology allowing science and mathematics to be undertaken and communicated in new ways. The various research facility site visits and scientist interviews

arranged by the PSTs are seen as a significant attempt to improve their awareness of contemporary practices in science and acquaint them with the range of skills needed to be taught to students to enable them to undertake successful careers in STEM.

## Project activities

- **What was the nature of the activities – provide examples.**

A number of key themes are explored throughout the unit using targeted readings, research literature, face to face workshops, multimedia activities, interviews, surveys and online discussions. The following ideas are explored in depth;

- What is science and the nature of a scientist's work? (Carey & Smith, 1993)
- Exploring the changing nature of public science (Nowatny, 2005)
- Developing and exploring views of the nature of science (Cobern & Loving, 1998)
- Investigating the differences between contemporary science practices and changes in school science education (Osborne et al, 2003; Hodson, 2003)
- Examining authentic scientific inquiry as a context for teaching the nature of science (Bell, 2001; Schwartz & Crawford, 2006)
- The implications of the NoS as a human endeavour for teaching and learning science (Carey & Smith, 1993)
- The challenges of interviewing scientists and science communicators (Laudel & Gläser, 2007)
- Science under attack and science denial (Nurse, 2011; Cook, 2013)
- Exploring narrative as an effective method of science communication (Clough, 2011)

As previously stated, PSTs arrange to attend a site visit at a research facility where they conduct interviews with one or more scientists. This activity is a hurdle task designed to inform PSTs about the nature of contemporary science practices and allow them to investigate and explore the communication of science across a range of diverse authentic settings.

The unit has two main assessment tasks. The first task challenges the PSTs to create a multimedia representation which conveys their personal view of the nature of science. The rationale for this is to encourage the PSTs to develop and practice skills in creating and critiquing visual images or multimedia which has now arguably becoming very much mainstream form of contemporary educational communication. Multimedia channels such as, YouTube.com, Vimeo.com, Vevo.com and Dailymotion.com already provide access to a multitude of video resources from which educators can source and share useful multimedia artefacts. It is considered essential that PSTs are skilled to select discerningly from these rapidly growing collections given they consist of such diverse quality.

Another innovative approach used in the unit encourages PSTs to review, articulate and defend their personal view of the NoS. This approach was initially adopted to encourage PSTs to develop and refine their views of NoS and to assist them to form a more coherent view that they felt more confident to share and discuss. Although there has been considerable research into the views of NoS held by a wide cross-section of the community, from the general public to students, scientists and science educators, there appears to be far less research literature which reports on ways of developing activities by which PSTs can effectively evaluate and articulate a coherent personal view of NoS. In initial workshops the

PSTs are introduced to a provocative NoS collaborative card activity outlined by Cobern in Cobern & Loving (1998). In line with the approach advocated in their paper the PSTs are encouraged to work initially as individuals and then form larger and larger groups to select or reject (by consensus) written statements about science that align with one of six broadly identified views of NoS. Through creating opportunities for peer discussion and debate, PSTs are encouraged to construct and revise their view of NoS and invited to reflect on changes in their positional understanding.

The activity has been adopted because it does not privilege one view of NoS over another or encourage all PSTs to adopt one 'currently acceptable' view, but reveals how contemporary understandings of NoS change and will continue to change over time. The NoS theme is periodically re-examined at key points throughout the unit and is seen as a mechanism for identifying and tracking changes in individual thinking about attitudes and values of science.

The second assessment task is a written assignment in which PSTs provide a critique of how their understanding of practices of contemporary science have been informed by their engagement with the unit readings and activities and can be purposefully integrated into the professional classroom practice. This task is summative in nature and represents the learning which students have engaged with in this unit and the impact such learning may have on their educative practices.

- **What was the nature of engagement of PSTs or teachers with contemporary science/mathematics practices?**

This unit was purposely designed to address this challenge. It encourages PSTs to explore their current understandings of the NoS and practices of contemporary science and to contrast their views with those known to be widely held by society in general (Cobern & Loving, 1998; Schwartz & Crawford, 2006). The PSTs are challenged through constructing visual representations to identify contemporary science (and mathematics) practices and to make them explicit. They are then encouraged to reflect on their reconceptualised understandings of NoS and provide insights into the thinking that has shaped the design of their representations.

In addition, in order to build authentic understandings of contemporary science practice, each PST 'shadows' a research scientist and engages them in conversations intended to explore the scientists' views of NoS and research practice as mapped against a framework of five levels of science cognitive engagement.

- **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?**

A key focus of the unit is encouraging PSTs to examine understandings of the NoS and to reflect on how these different views may challenge and influence the reconceptualisation of their own personal view. Using this reflective approach is considered innovative as it does not privilege one particular view at the expense of another. PSTs are encouraged to appreciate how science or maths educators holding different views of NoS may approach the task of teaching similar lessons in vastly different ways and in doing so appreciate how these understandings often influence professional practice in subtle but significant ways.

Another innovative idea underpinning the unit is the investigation of how science and mathematical practices have significantly changed and developed over time. As mentioned earlier, the use of new analytical approaches and the advances in information and computational technology have made many past experimental practices redundant. Faster and more comprehensive computer modelling and increasingly sensitive data loggers now allow scientist to develop new simulations with greater precision and iterative power. With reducing costs and technical advances, approaches such as 3-D printing, chip based bio sensors, gamification and augmented reality afford teachers and students with opportunities to investigate highly complex virtual systems which were once considered the exclusive realm of scientists. Increasingly these digital simulations and models can be investigated by students in everyday classrooms. The adoption of inquiry and problem based pedagogical approaches teamed with new technology also provide students with many new and more authentic learning opportunities and experiences. A key idea underpinning the unit is encouraging the PSTs to consider how their new understandings of contemporary science practices will impact on their professional practice and the science learning undertaken by their students.

- **What changed curriculum / classroom practices are envisaged, flowing from the project? By what means were these changes supported?**

The changes envisaged from this project are consistent with the unit objectives and when realised should result in greater understanding of how science is practised and communicated through more authentic and engaging teaching of science and mathematics. The unit objectives are;

- Understand how the knowledge, processes and communications of sciences shift over time through the influence of social and technological change.
  - Explore the diverse and changing understandings of the 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 creation of new knowledge has significantly changed to become more inter-/multi- and trans-disciplinary, e.g. Nanoscience, and Bio-informatics.
- **What opportunities were there for science/mathematics students (undergrad or HDR) to reconceptualise their perceptions of school science or mathematics learning and teaching?**

The unit is offered during semester two each year with a cohort consisting of pre-service and/or in-service teachers who are either teaching or undertaking professional experience placements in schools. The majority of the cohort consists of PSTs who are required to undertake 15 days professional experience placement concurrently with the unit. This provides the PSTs (and ISTs) with an important opportunity to reflect on and apply the learning they have undertaken in the unit in their professional classroom practice and to initiate and reflect on professional conversations in schools.

## Results

### Experience of participants

- **What was the experience of PSTs or science and mathematics students, school students, teachers, scientists, teacher educators?**

In order to evaluate the PSTs' and ISTs' experience in this unit a number of different forms of data were collected from both cohorts. Each year, PSTs were invited to participate in both pre and post unit focus group discussions facilitated by an independent research assistant. In addition, at the completion of the unit each cohort were encouraged to complete an online survey and the University wide unit evaluation (SETU) survey to provide feedback on their experience. Despite numerous attempts to gain feedback from the participating scientists only two were able to make time to discuss their involvement with an independent researcher. Both reported that they welcomed being involved in the collaboration and these sentiments were again echoed more widely in the feedback reported by the student cohorts to the researcher during the post unit focus group meetings and in unit workshops. All of the scientists who participated during the first year (n=16) with one exception expressed interest in being involved in the program in an ongoing basis. The scientist who withdrew reported enjoying the involvement but requested to skip a year due to the relocation of his experimental labs in 2016.

One of the key findings was the acknowledged impact that the collaborative discussions of NoS had on building the PSTs and ISTs' confidence and ability 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. This acknowledged shift was evidenced by a number of students in their writing for assessment tasks, during workshop discussions within the unit and feedback given during the post unit focus group meetings facilitated by the research assistant.

When asked about the impact they considered the unit may have had on their understanding of science and their future professional practice students replied,

*PST (6-2016) - "I have thought a lot more about the disconnect between secondary science and real science. Without it [EDF5674] 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 (1-2015) – "Questioning and actually reflecting on ... what I think about science and what other people think about science and trying to figure out ... what you know, what a coherent view [of science] is because a lot of these things aren't ... necessarily explicitly looked at ... [in other units]."*

*PST (5-2016) – "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[s] on them."*



*PST (7-2016) - "I have come from a research background so I know how science is being done and what happens in a lab and so on. I guess I'm thinking about it more through this unit, of how to actually teach it to students because it is not something that they learn in [secondary school] science. It is more just isolated facts that they learn in schools."*

*PST (2-2015) – "If I was doing an interview for a science position I think it gives me a better understanding to talk about science education in a way that I think would stand out to employers, compared to people who hadn't done this unit or something similar."*

*IST (2-2016) – "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 (2016) – "I found that I better understand the purpose of curriculum requirements to teach SHE [Science as a Human Endeavour] and the importance of SIS [Scientists in Schools]. I also better appreciate the limitations of curriculum in conveying authentic science practices."*

The vast majority of the PST cohorts in 2015 (n=16) and 2016 (N=9) reported finding the multimedia assessment task highly challenging. Many of the PSTs discussed in workshops how they did not feel confident about creating and critiquing visual representations compared with the more familiar and widely practiced writing of critical essays for assessment. This lack of confidence was also reflected in the number and frequency of clarifying questions fielded by the unit lecturers regarding the implementation of this assessment task. This view of feeling apprehensive and ill equipped to undertake what was seen by most as a highly creative task was similarly reported by the PSTs that were interviewed in the post unit focus groups.

*PST (1-2016) – "... especially in the first assignment until I did the assignment the guidelines was not clear. I didn't understand what I was doing ... so when I am getting on to do the assignment then I realize then [I am] alright. ...It wasn't clear."*

*PST (2-2016) – "... the assignment task wasn't clear on what we were expected to do. That's what I felt."*

All of the PSTs and ISTs from both years were in agreement that the visit to the research labs or the Melbourne museum to interview real scientists was very beneficial for their learning about contemporary science practices. They particularly enjoyed being shown around the research laboratories and having discussions with many scientists about what they saw as the disconnect between how scientific research is undertaken and idealized 'school' science.

*PST (4-2016) – "... it was good for me to see firsthand a lot of what they were doing. The scientist I interviewed, she was fantastic. She bought up herself all of the issues we see with teaching and science and she was emphasizing that high school science was too boring and it should be more authentic and it doesn't [at] all reflect her experiences of working in science."*

*PST (6-2016) – "They really are the next level of ... making teaching experiences really engaging and authentic. They [teachers] think it is going to be a lot of work and what if it*



*doesn't work? ... and so they fall back to the safety of doing something that is really predictable."*

*PST (1-2015) – "Yeah that was really good. I enjoyed ... the interview part [of] the site placement and talking to a working scientist and finding out what they value ... the importance of creativity and collaboration and what they ... know".*

- **What evidence is available to identify the experience? (surveys, notes, video, etc?)**

Two of the PSTs from the initial cohort (2015) and six PSTs from 2016 agreed to be interviewed by an independent researcher about their experiences with the unit. The interviews were recorded and transcripts were made to assist with the unit evaluation. Approximately half of the 2015 and a third of the 2016 cohort completed the normal university online survey SETU data for course evaluation. As previously mentioned two of the research scientists from research facilities visited by PSTs were also interviewed by the independent researcher however these were both very brief. Both scientists were supportive of the programs.

### **Project outputs**

- **What resources were produced and what is their quality (and where can they be found)?**

A number of multimedia resources have been identified and made available for access via the internet or directly developed for inclusion in the unit. These are currently stored on the Monash University unit Moodle website. In addition a number of online resources were used throughout the unit for unit readings and student investigation. Where possible some of these will be made available for inclusion on the ReMSTEP project website for partner access. In 2016 six students produced brief multimedia interviews recording their experiences during their research visits and findings from the interviews with scientists. Generally these are of low quality and unedited, however they were posted up on the unit Moodle site and provided excellent conversation starters in the unit workshops.

- **What understandings or models have resulted, concerning how to engage PSTs with contemporary science and mathematics practice?**

Given the overwhelming support from the PSTs for their research site visits and the rewarding conversations they had while interviewing their scientists it is now considered a priority to see how similar experiences can be integrated into the remaining PST method courses. The majority of PSTs reported that after visiting a research facility and talking to 'real' scientists they now felt that they had improved understandings of contemporary science practices and how science is undertaken by scientists. Many of the PSTs acknowledged that before their site visits they knew very little of how 'big' science is undertaken in world leading Centres of Excellence and their existing views were limited to highly contextualised educational experiences in undergraduate labs or even earlier high school settings:

*PST (4-2016) – "She (scientist) put a real emphasis on collaboration and communication and how critical those skills are to what she does and how you don't think about that from a high school perspective. You really don't think of science as about collaboration and the multidisciplinary nature of what is done in a contemporary research group."*

*PST (2 - 2016) – “There was a few things that ... I wouldn’t have thought was important [before doing the unit] that when I got to do ... the interview [with the scientist] towards the end of the subject ... a lot of things came up that we’d talked about ... and it was ... confirmed ... by the working scientists”.*

### **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?**

The collaborative nature of the ReMSTEP project has required members of both the Education and Science Faculties to meet on a regular basis to the plan and assist with each of the Monash project initiatives. This has promoted the sharing of insights across the diverse projects and the sharing of both expert knowledge and resources. All project members acknowledge the mutual benefits of the ReMSTEP initiative and are supportive of maintaining or extending opportunities for collaboration in the future.

- **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?**

From an Education Faculty perspective it has been helpful to explore and share the scientists’ understandings of the NoS and their assessment of the essential contemporary skills needed by secondary students to successfully engage in STEM careers. They are quick to acknowledge how rapidly science research is evolving through the development of new technology and advances in information technology and how this poses significant challenges for teachers and science education.

- **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?**

At this point in the project it is difficult to evaluate the success of the innovations being trialled as it will take several years before any reported outcomes from changes in classroom practice can be attributed to improved student engagement with STEM courses in the tertiary sector.

- **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?**

The researchers at Monash University acknowledge that although the two cohorts of PSTs in 2015 and 2016 have been small (total n=25) the general findings from the PST focus meeting interviews, workshop feedback, online surveys and unit assessment tasks suggest that many of the approaches and activities used throughout the unit were largely successful in achieving the intended unit outcomes.

A surprising finding was that encouraging the PSTs to re-conceptualise their personal view of the NoS proved much more effective and engaging than originally anticipated. Participants were keen to revisit these ideas throughout the course and to actively explore and debate alternate views. The changing personal view of NoS as articulated by individuals at various times throughout the unit also provided insights into how their views of NoS and

contemporary sciences were changing over time. This provided a powerful insight into the impact that robust discussion and debate can have on changing long held views.

Constructing a coherent contemporary view of NoS also appeared to provide participants with the language and confidence to engage in professional discourse which challenged and further enriched their understandings of sciences. Several participants 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.

- **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?**

Initial feedback from PSTs and unit lecturers during the first iteration of the unit confirm that the unit objectives appear sound. Feedback from PSTs suggests the nature and effectiveness of the current assessment tasks could be improved with the addition of clarifying details and a more succinct rubric. The long term impact of the unit on improved learning of contemporary practices in science and mathematics in school classrooms will take several iterations before it becomes apparent.

- **What principles can be taken from the project concerning processes for bringing contemporary science and mathematics research and development practices into teacher education?**

One of the more immediate successes of the program has been the highly productive collaboration of academic staff from both the Faculty of Education and the Faculty of Science. The regular meetings have been beneficial for project guidance and extended opportunities for mutual partnerships between the Faculties across other areas not previously attempted.

## Concluding discussion

### Challenges

- **What was the nature of challenges to successful implementation?**

Initially there were a number of challenges to confront the ReMSTEP collaboration at Monash University. Many of these were associated with project staffing changes, establishing viable accounting systems across Faculties, delays in funding from the project partners and Human Ethics constraints.

- **What changes were made, from which we can learn?**

When undertaking multi-partner projects it is important that strong and effective pathways of communication are established from the outset and maintained throughout the life of the project.

### Impact

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

The initial impact of the project will result in the establishment of a new MTeach/M.Ed unit which will focus primarily on exploring the practices of contemporary science and mathematics. The initial funded research offers the potential to hone the effectiveness of the unit in its first years of establishment. Beyond this the unit will continue to be evaluated using the normal SETU processes of unit evaluation.

- **What are the longer-term implications?**

The sustainability of the unit is strongly supported by both the Faculty of Education and Science. The unit is seen as ongoing for the foreseeable future.

### Sustainability

- **What has been learnt about processes for incorporating contemporary science and mathematics practices in teacher education?**

Answered previously above

- **In what sense is the project sustainable?**

The sustainability of the unit is strongly supported by both the Faculty of Education and Science. The unit is seen as ongoing for the foreseeable future.

### Scalability

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

There are no immediate limitations on the unit catering for larger numbers of students should it grow in interest. The unit could increase by 100% before requiring additional staff resources.

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