REMSTEP project report Communicating Science

Project overview

Scientists in Seminar (Communicating Science)

Who was involved?

Project team: Dr John Cripps Clark; Dr Leissa Kelly; Kathleen Hayes;

Tutors: Dr John Cripps Clark; Dr Leissa Kelly; Kathleen Hayes; Dr George Aranda; Jason Major; Dr Adam Cardalini; Dr Linda Hobbs

Students: Second (mainly) year BSc & BTeach students (315)

Research scientists: from the Institute of Frontier Materials (10)

What was done (in broad terms)?

As part of an undergraduate unit on science communication, scientists working in the Institute for Frontier Materials were invited to present to undergraduate students (from first to fourth year) in a variety of science, education and engineering courses and ranging 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 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. In doing so, this project developed new teaching practices of the unit that aligned contemporary scientific research with innovative and engaging approaches to teaching and learning.

Project rationale: what is the intention?

The program aimed, in an authentic context, to give students the opportunity to:

1. translate original communication from scientists to school students;
2. produce a range of resources suitable for use in schools; and
3. enable students to work collaboratively on a creative communication project.

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

Theories of *authentic learning* in teaching and learning (Butin, 2003) informed the development of this project, as well as a variety of literature across the field of science communication. Aside from Mercer-Mapstone & Kuchel's recent work (2015), there is a paucity of literature investigating the practice of teaching science communication to undergraduates.

What gaps do you see are addressed with this project?

The most exciting and authentic science communication occurs when communicating contemporary science and scientists. Although there are many science communication courses there are very few (and none for undergraduates) that link research scientists and current research to students to provide opportunities for the students to interpret and communicate cutting edge science concepts and research to specific audiences, including secondary school students and the general public. And, consequently, there is also no almost no research.

Project activities

What was the nature of the activities – provide examples.

The project was designed to provide authenticity to an existing science communication course through inviting working scientists into the seminars to address the students and students would then prepare a teaching resource (first year) or profile (second year)

1. Preparation

Students prepared questions and researched the science behind the presentation

2. Scientists presented their work to Science Communication students

Scientists working in the Institute for Frontier Materials were invited to present to undergraduate students during seminars. The presentations were for about 20 minutes followed by 10 minutes of discussion. Scientists remained available via email for students to consult.

2. Students, in groups, had a set of activities to prepare for and process the presentation of the scientist.

This included preparing questions, researching the science involved in the research and working on jigsaw activity to interpret the presentation.

3. Students, in groups, produced a resource for secondary classrooms

In 2015, groups of students planned how to create a resource aligned with AUSVELs that communicated an aspect of the scientist's talk to secondary school children. Given free range to be creative with resource.

In 2016, the students developed a research profile of the scientist (including the work practice and the process of the science) for an audiences they chose from a variety a stakeholders including industry, general public, secondary schools and government.

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

On-campus students of the Communicating Science Unit were visited by Research Fellows, Research Doctoral students and staff from the Institute for Frontier Materials (IFM) in 2015 in week 6,7 &8 and in 2016 in weeks 5&6 of the 1st trimester to give presentations on their research projects. The undergraduate Communicating Science students were then given the opportunity to talk to the researchers about their projects and practices with a view to developing a teaching activity that could be used to teach the 'cutting edge science" and/or represent the work of the scientists to a target audience. The research scientists were available to collaborate with the students by answering their questions throughout the seminar and subsequently via email.

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?

Both personal and professional aspects of science research practice were presented to the undergraduate students through the scientists' presentations and subsequent discussion with students. This had a significant impact on students as many were had only an indistinct understanding of research practice and it gave them valuable insight into not only the scientific research undertaken but also the human side of the endeavour.

It was innovative in actively engaging undergraduate students and researchers in an environment where students worked collaboratively to produce a resource which could be used in schools.

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

The experience and understanding of contemporary science practice had the opportunity to influence teaching within schools through two indirect pathways:

1) A significant proportion of students in the program are enrolled or will enrol to train as teachers; and
2) A number of the students because of their experiences in the Scientists in Seminars program were recruited into the *Successful Students - STEM* Student Ambassadors program which places Deakin science and engineering students in science, mathematics and technology classrooms in Geelong secondary schools.

What opportunities were there for science/mathematics students (undergrad or HDR) to reconceptualise their perceptions of school science or mathematics learning and teaching?

The undergraduate science/mathematics students are challenged to reconceptualise their understanding of learning and teaching through:

1. The experience of contemporary research as part of science education through exposure to contemporary research of the scientists; and
2. Subsequent construction of the resource (and in-class and online discussion with other students and with the scientists) which aimed to produce creative and engaging communications.

Results

Experience of participants

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

Undergraduate science communication students were able to personally meet and talk with research scientists practising cutting edge research. They also experienced the process of producing an authentic piece of science communication with authentic feedback from a research scientist on whose work it was based.

It is worth noting that not all participating students were PSTs and they came to this unit from a variety of science and education degrees, some of which had no teaching component.

Scientists had the opportunity to communicate their research to undergraduate students and potential future researchers or teachers.

Tutors experienced the presentation by the scientists and also organized its preparation with the scientists and its subsequent interpretation by students.

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

The project ran during 2015 and 2016. During this time data was collected from participating students, tutors and scientists to provide supporting evidence of the benefits of the experience to these stakeholders. The following research instruments were used to obtain data from the sources listed:

Participant	Number	Year	Type
Students	32	2015	Focus group interviews
Students	31	2016	Survey
Tutors	6	2015	Interviews
Tutors	7	2016	Interviews
Scientists	10	2015	Interviews

2016 Student Survey results (written responses are quoted from below)

From the activity…	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree	Not applicable

I gained new insights into scientists' research and development practices	6.5%	71.0%	12.9%	3.2%	3.2%	3.2%
My perceptions of scientists as people changed in a positive way	6.5%	25.8%	48.4%	12.9%	3.2%	3.2%
I learnt some interesting science concepts	16.7%	40.0%	30.0%	6.7%	3.3%	3.3%
There has been a positive change in my attitude towards science and/or teaching	6.5%	32.3%	48.4%	6.5%	3.2%	3.2%
I was engaged in new and interesting approaches to teaching science	10.0%	23.3%	36.7%	20.0%	6.7%	3.3%
I have learnt things about engaging with contemporary science that will influence my teaching in the future	9.7%	41.9%	29.0%	6.5%	3.2%	9.7%
I gained ideas for how to bring contemporary science practices into the school curriculum	6.5%	32.3%	35.5%	6.5%	6.5%	12.9%
Overall I felt the REMSTEP activity worked well	3.2%	45.2%	32.3%	9.7%	6.5%	3.2%

Project outputs

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

Over the course of the two years that the project was running, students enrolled in the Communicating Science Unit were asked to produce a resource aimed at different audiences.

In 2015, the Communicating Science students were asked to produce a variety of resources were produced with the intention of using them in primary/secondary classrooms however this did not eventuate. The primary goal was to develop our students experience and skills in communicating contemporary science and scientific practice and the resulting quality of the resources were too variable for practical use.

In 2016 a number of profile pieces were produced on the presenting scientists. These pieces were developed with the aim of using them online, potentially as part of Deakin's promotional material or for the students to use for their C.Vs. The pieces were shared with the scientists who gave feedback to the students. An examples of profiles is included below.

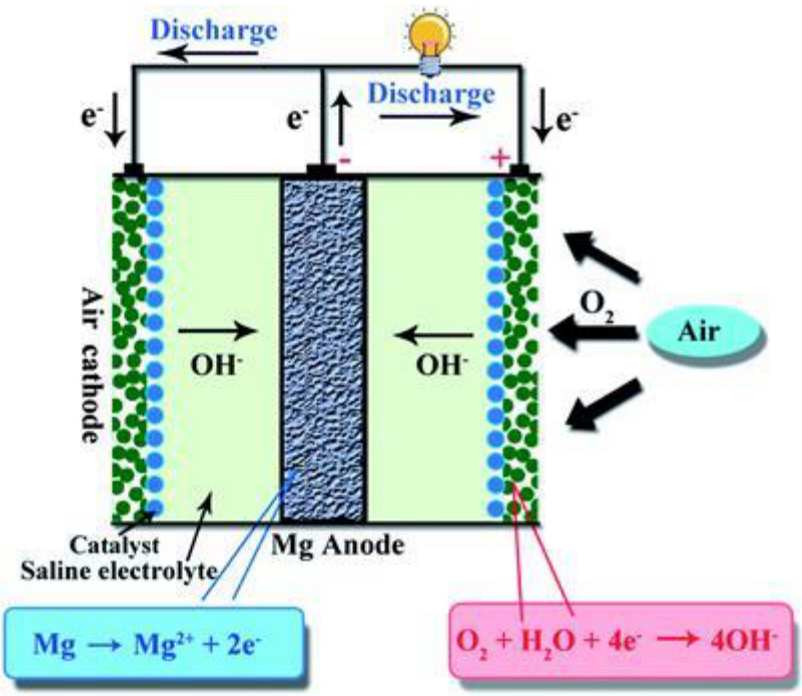
Two research papers regarding the student experience and the development of the activity are in the process of being written.

Example Profile: Profile of Dr Timothy Khoo Profile, written for secondary students.

How's your phone going? Still holding charge? How about your laptop, how many hours of work can you get out of it before you're looking for a power-point, or asking for a charger? Well, chances are your battery is reaching the end of its life. Modern high tech devices require a lot of power, meaning they require complicated batteries. Unfortunately, these batteries do not last very long in the grand scheme of things. It seems after a year or so, batteries can't go a few hours without running on empty.

Well Dr Timothy Khoo may have a solution for you. As an engineer, his research has been centred mainly around batteries, how they work and how they can be improved. Dr Khoo is a post-doctoral engineer at Deakin University, currently working in the Institute for Frontier Materials, his recent research has been of Magnesium/Air batteries, a potential alternative to the Lithium-Ion batteries used in modern devices. Dr Khoo began this research at Monash University and continued it into Deakin University.

We usually use Lithium ion battery for smartphones and laptops. However, he tries to make "Future Battery", which is using air. Magnesium/Air battery uses magnesium as an anode, oxygen in air as a cathode and chloride ionic liquid as electrolyte solution.



Magnesium has potential of highly charge capacity and energy density because using oxygen as a cathode. Furthermore, it is low cost and easy to handle.

This battery is expected to use from biocompatible devices to vehicle! But these batteries are not possible yet, still studying now!

Dr Khoo currently works as a Business Development Manager in the Institute of Frontier Materials at Deakin University. Much of his work involves the business side of his actual research. Managing assess to insure maximum results are achieved with the funds available and being able to present his and his team's research to potential and current investors. So while Dr Khoo's research is aimed at something that many people attribute to science, improved technology, his work involves much of the neglected, possibly more important side of science, the money, gathering it through grants, managing it for the research team, then presenting their results. This makes his job a 40+ hours a week task, which doesn't wrap up when he leaves the lab. Lot of planning goes into every day of work, emphasising the level of effort required by a single scientist to improve batteries.

You're likely reading this article on a computer or tablet and probably until now hadn't given much thought to what's powering it. In all likelihood, it's a Lithium-Ion battery, a battery that runs well, but dies exponentially fast. Ask any trades person who uses tool that are powered by lithium-ion batteries and they will tell you that these batteries will work well for a while but once they start to go, they're next to useless and need replacing. However, if Dr Khoo is successful in his research, we could be looking at a new generation of batteries that last longer and go harder, which will be better for the economy, and much better for the environment.

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

This project has refined our understanding of the development in students of the disposition and skills to communicate contemporary scientific research and research processes. The project modelled engaging students in groups to produce useful communication artifacts while, at the same time, giving meaningful experience and feedback on communication to scientists in a supportive and familiar environment. The problem addressed was not only to engage students in the communication of contemporary science and mathematics practice but for scientists to communicate their own understanding and experience of scientific practice and this communication to be developed into artefacts which can be used in the classroom. This reciprocity is a key feature of the sustainability and transferability of the project.

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?

As a result of this project education staff and research scientists at Deakin University have gained familiarity with each other's work and built stronger relationships. This is a reinforcement of existing aims to connect with and educate science students in an engaging and authentic manner and a realization of how that can be effectively achieved through collaboration.

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?

Research scientists have gained experience in presentation and in communicating to a scientifically literate, educated, but not expert, audience. Being skilled in communication is increasingly a priority for research departments for explaining their work to stakeholders, the general public and potential future students. For many scientists this experience made them more aware of what is involved in communicating to non-expert audiences and inspired interest and confidence in communicating authentic research as part of teaching science undergraduates.

One of the scientists reflected that it was a valuable experience not just for them but for the students.

I also think for the students it was a good experience, just to have an idea what they would face if they would do a PhD, what would their life look like. I think it was a great idea."(2015)

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?

The Communicating Science students participating in this project have gained insight into the realities of science research and science communication at a professional level. There is evidence that the experience gave many students ideas and confidence for teaching science in schools in the future.

Regarding 2015 task (resource for students)

- "*if you go into teaching it will definitely be useful to be able to come up with your own resources for your class but also the skills in being able to explain to a younger generation, that's always going to be useful for the future"*

Regarding 2016 task (profile)

- *"I can see how communication as a scientist can be essential to career and research success"*
- *"it does make me think about if I could get invite researchers when I am teaching in high schools"*

Comments from the survey in 2016 revealed that students felt that they had gained*:*

- *An interesting outlook on career pathways*
- *Insight into the day to day life of a materials engineer*
- *A sense of what is involved to be a head scientist at an organization*
- An *interesting new perspective on a professional scientist's work and life*
- *A better appreciation for the work put in by the scientist and how much time they must commit to their work.*

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 initial experience of the scientists' presentations was valued by many students for its insight into the life of a professional scientist and the realities of research.

(2015) (student) I did really enjoy it, it's not everyday 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

Often the presenting scientist had not too long ago been a student themselves at Deakin. This in particular captivated their attention as students saw someone not dissimilar to themselves working and presenting as a professional scientist:

(2015) *so for me the best thing was seeing somebody similiar to me, someone who was a student and see where their work took them and how far they took their work and some of the discoveries they were able to make and how nobody else had made those sort of discoveries, so it was really groundbreaking.*

Participating students who were interested in becoming teachers were very positive about the experience and the associated task of producing a resource (2015) or writing a profile (2016):

If you go into teaching it will definitely be useful to be able to come up with your own resources for your class but also the skills in being able to explain to a younger generation, that's always going to be useful for the future. (2015)

I think it was pretty good because I'm learning to be a teacher so I'm going to learn how to communicate the science to the students. (2015)

It does make me think about if I could get invite researchers when I am teaching in high schools, (2016)

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?

Not applicable to this activity.

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

Careful scaffolding is needed when tasking students with communicating high level scientific research. Students need to have clear instructions to produce products which they perceive to be useful. Both the presentation by scientists and any follow up task needs guidance to help students consolidate and interpret the information which they may find challenging.

Tutor: A lot of it went over their heads, so the scientist needs to learn too; it's a bit of exercise for both; the scientists learn how to communicate which they sort of did okay in some bits but generally not, so either way it has to work from both ends. (2015)

Tutor: The way that I actually got them engaged was to go through the seminar or through the video recording with them again. And break it down and get them to talk about what the science was and what they found out. (2015)

Being able to find points of relatability is a key to students' motivation and engagement in the task.This can take place either scientifically, such as familiarity with the topic:

The activity was a good idea and I can see how it would be beneficial but it was not in our field so there was little interest and it did not change our perspective in science we are interested in. (2016)

So for me the best thing was seeing somebody similiar to me, someone who was a student and see where their work took them and how far they took their work and some of the discoveries they were able to make and how nobody else had made those sort of discoveries, so it was really groundbreaking. (2015)

Concluding discussion

Challenges

What was the nature of challenges to successful implementation?

The challenge to a successful implementation revolved around coordination and timing: coordinating presentation times with the scientists and ensuring enough time for the follow up task which required splitting the task over two weeks. While this allowed more time as the task was a group project, there were difficulties for some groups whose members only attended one out of the two weeks.

What changes were made, from which we can learn?

Doing the SiS activity over two years allowed for refining and changing the activity in the second year, based on feedback from the previous year.

In 2016 the output product was changed from an educational resource for school students to a written profile piece for a specific audience. The timing of the scientist's presentation was also altered, with students given time to research their audience and develop questions prior to the presentation.

Impact

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

Over the short term, students gained insights into the daily work of a scientist and the scientific process that underpins their research. This proved to be a valuable learning experience for the students as they were able to see the connections for incorporating contemporary science into the classroom as part of the Science as a Human Endeavour component of the curriculum. This was reflected in student comments:

Rather than being given a positive view of a researcher's life we were told exactly how it was. How the good days and bad days go, which was good. (2016)

Furthermore, some students were able to clarify their aspiration for career and further study, particularly their preference for teaching over scientific research. One student felt that:

It will definitely be useful to be able to come up with your own resources for your class but also the skills in being able to explain to a younger generation, that's always going to be useful for the future. (2015)

What are the longer-term implications?

In the longer term this activity has facilitated the strengthening of relationships with the science department, to the extent that scientists are now asking to be included in the SiS activity in future years.

Sustainability

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

The SiS activities conducted at Deakin University through the Communicating Science Unit have provided education students with an understanding of the work of a scientist and with contemporary STEM research methodologies. Students have been provided with an authentic experience in translating an original communication from a scientist into a resource appropriate for school students or the general populace. This activity has proved to be a valuable exercise in incorporating science practices in teacher education. The reciprocity of the relationships built up between the teaching team and the research institute is key to effective implementation of this project.

In what sense is the project sustainable?

The establishment of a consistent and coherent protocol for the teaching team and the research institute has enabled the development of the program and has made it sustainable. The strong relationships and goodwill that have developed between the education academics and research scientists ensures that the Scientists in Seminars (SiS) component of the Communicating Science Unit will be ongoing. Discussions are underway to make the SiS aspect of the unit an assessable task.

Scalability

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

The project is scaleabe. The model of teaching in the Scientists in Seminars module could be adopted by any tertiary institution teaching science communication and with research scientists who have a mandate or commitment to disseminating their research. With institutional support the project could link students and scientists across institutions.

References

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