Premier’s Macquarie Capital Science Scholarship

Learning for teaching for learning

Rahab Jarvis
St Clare’s College, Waverley

Sponsored by



Introduction

The Premier’s Macquarie Capital Science Scholarship allowed me to visit The European Organisation for Nuclear Physics (CERN), Switzerland to witness Particle Physics research and experiments first hand; to Culham Centre for Fusion Energy, England to gain insight into Nuclear and Medical Physics and to a science educators Conference in England to further develop my practice as a Physics teacher and to make worldwide contacts in my field which will lead to innovative teaching and learning experiences for my students.

Additionally, I met with industry experts in both particle physics and in particular The Standard Model of Matter and Nuclear Physics with particular focus on medical imaging and using nuclear physics as a diagnostic tool through university, hospital and school visits.

The reasoning behind the design of my tour was derived from my belief that teachers who know their content well are more equipped and to produce and deliver lessons to their students that are engaging, well informed and meaningful. This has always been a priority for me as a teacher and is particularly important as a newly qualified teacher of physics. In order to do this, I need to be up to date with the latest research and development beyond the scope of the curriculum and teaching and employ methods that are creative and innovative that may be employed to impart complex and often abstract notions of the world in which we live.

I can vividly recall the moment that I learnt that the 3 ‘fundamental’ components of an atom were not as I had been led to believe. That the proton and the neutron themselves were not fundamental as I had always understood them to be but made up of smaller units of matter. This was a challenging and confronting moment for me both as a student and as a teacher and what fuels the basis of my enquiry into the field of Quanta to Quarks and Nuclear Physics.

Physics and science in general is a field which is constantly changing. It is challenging within the teaching profession to keep abreast with all of these changes as they occur and I found this to be particularly true when I spoke with other Physics teachers and ask them for advice on the Quanta to Quarks topic in the HSC Physics Syllabus. Many of those I spoke with admitted feeling overwhelmed or out of their depth with this topic and in particular with The Standard Model content and the current research that is surrounding it. When I saw the advertisement for the Premier’s Teacher Scholarship I knew immediately what my topic of choice would be.

Focus of the Study

The focus of my study tour was three-fold. Firstly I was to travel to the European Organization for Nuclear Research (CERN), Switzerland. It would be here that I would meet with scientists working on 2 of the major experiments – ATLAS and ALICE. The expressed focus of the science team was to gain a better understanding of the primordial matter that existed moments after the big bang. This is achieved by facilitating mostly proton to proton collisions at almost the speed of light and then measuring what is created immediately after the impact. It is through these collisions that science is able to better understand and piece together The Standard Model of Matter. The standard model of matter including quarks and leptons uses accelerators as a probe to investigate the structure of matter.

The second focal area of my tour was to gain a deeper understanding of nuclear and medical physics, in particular the medical and industrial uses of nuclear energy - in particular how the understanding of the nucleus has led to large science projects and many applications, gaining an understanding of the basic principles of fission and fusion reactors and learning how neutron scattering is used as a medical probe by referring to the properties of neutrons. This included discussions with the nuclear facilities to identify specific applications that occur at their facilities and their partner organisations. I was able visit Culham Centre for Fusion Energy.

Previously I had visited the Lucas Heights reactor in September of 2011 which gave me an understanding of fission reactors which was then built upon by my visit to the Culham Centre in Oxfordshire; England which is focused on fusion energy. Terrestrial fusion is seen as a viable option for meeting the energy needs of the future but requires immense heat and more sophisticated methods of plasma control. This is a significant scientific and technical challenge that is the focus of current research and testing. Meeting with industry experts and visiting the research facilities allowed me the opportunity to ask questions as they arose and to gain a deep and thorough understanding of the principles of Physics as related to the Junior and Senior Physics units. This experience will allow me to create richer experiences for the students in the classes.

The third component to my tour focused on the presentation of this information. Education for myself and education on how to teach the content and education on what are the best models, theories and laws to discuss with students when teaching these complex concepts. I focused a lot on how The Standard Model and Nuclear information is disseminated and taught in other intuitions such as schools and universities and took the opportunity to increase my critical network of teachers and industry experts. I was able to discuss the material in relation to the NSW Syllabus and share teaching methods, models and techniques.

Significant Learning

The study tour was conducted in December 2011 and January 2012. I visited tertiary institutions, Scientific Research and Application Facilities and met with teachers and practitioners and experts in their fields to discuss the nature of Particle Physics in particular paying attention to the standard Model of Matter and the use of Nuclear Physics as a medical diagnostic tool.

European Organization for Nuclear Research (CERN), Geneva; Switzerland

CERN is an impressive institution. The sheer magnitude of the operation, the level of international collaboration and the openness to the public and future scientists was really extremely extraordinary.

CERN is a laboratory designed to study the fundamental building blocks of matter and the forces that hold them together. These fundamental building blocks are referred to as the ‘standard model and in order to do such research, huge accelerators are required. These accelerators use powerful electric fields to give energy to packets of particles (usually protons). Magnetic fields are then used to guide particles through the machines. Machines can be linear or circular. The bigger machines are circular so that more and more energy can be added with each additional lap, as the particles are accelerated to near the speed of light.

The world’s largest particle accelerator is at CERN, the Large Hadron Collider (LHC). It is a machine that is installed in an underground tunnel with a 27km circumference which was previously home to the Large Electron Positron Collider. By increasing the energy levels of the collisions of particles to higher energies than ever before, Physicists are able to make further progress in understanding how our universe is made and how it came to be. Through the collisions of particles are extremely high energy levels, scientists are able to create particles that existed moments just after the big bang but are now extinct. This provides insight into the early universe moments.

By using highly specialised detectors designed to measure different properties of the particles produced during the collisions, physicists are able to measure the energy of the particles and using the magnets built into the detectors they can also bend the paths of electrically charged particles to assist in identifying the particle types.

The particle detectors invented and tested at CERN for their research are now used in techniques for medical diagnosis.

Culham Centre for Fusion Energy, Oxfordshire; ENGLAND

Culham is one of the world’s largest Fusion Laboratories. It works in partnership with scientists from around the world to develop fusion energy as a new source of clean energy. Fusion is the process that powers the Sun and it is this fusion energy that makes life on earth possible. Through my visit to Culham I was introduced to the reality of Fusion Energy on earth (Terrestrial Fusion) as a real source of energy for our growing demands.

Terrestrial Fusion will use 2 heavier types (or isotopes) of hydrogen; deuterium with one nucleus of one proton and one neutron and a tritium (1 proton and 2 neutrons). Under extreme heat and pressure these 2 nuclei fuse together to produce a new helium nucleus (alpha particle) and a high energy neutron. I was able to gain a deeper understanding of how fusion reaction occurs and how the energy from the neutron can be captured and used to heat steam to generate electricity just like in a conventional fossil-fuel power station.

I was fortunate to go on a personalised tour with Dr Phil Dooley around the fusion reactor and to meet with many of the physicists and engineers working on the project. Whilst I was on my tour I was able to ask many questions about the sustainability of the project, the expense, the environmental impact and other questions that have given me a wider scope of understanding of Nuclear Energy which will ensure that I have a broad base from which to teach my students. I was able to take a number of resources away with me to distribute in class and will utilise the institute through Skype lessons as we require. This is a real potential and benefit of the study tour as it shows the students that science is real, the people are real and the results are real. It brings experiences to the classroom that otherwise would be available.

Professor Peter Higgs; University of Edinburgh

Meeting Professor Higgs was undoubtedly one of the major highlights of the Premier’s Teacher Macquarie Capital Science Scholarship and a great personal honour. It was Professor Higgs who in the late 1960’-s with 3 other theoretical Physicists postulated the existence of a particle that must give mass to all other particles and now forms the basis for the major focus of research at CERN. The Higgs Particle or Higgs Boson is the elusive particle that if found will perfect and finalise the Standard Model of Matter and it is expected that it will either be found to exist or found to not exist this year. If it does exist, then there should be enough energy generated in the LHC this year to re-create it.

I was fortunate enough to be given a 2 hour meeting with Professor Higgs to discuss with him what inspired him to get involved in Physics as a career, what led him to postulate about the Higgs boson, Higgs Field and Higgs Particle and what he envisages the results to reveal this year.

From the experience of talking to such a real live icon in Physics, I can pass on to my students the notion that the physics concepts are real and can be measured. My first-hand experience translates to enthusiasm in the classroom which alone justifies the Premier’s Teacher scholarship.

Simon Bates; University of Edinburgh/Martin Hendry; University of Glasgow/Professor John Wilson; Heriot-Watt University, Edinburgh; SCOTLAND

I had a number of appointments to meet with Physics experts in Particle and Nuclear Physics both theoretically and those applying the theories experimentally. With those that I met I was able to ask questions in relation to the Standard Model of Matter and Nuclear and Medical Physics. I discussed teaching methods, models and theories that are proven useful in the transfer of this complex topic and the direction that future studies and research may take in this field. I was able to take away with me some resources that I will be able to use within a class room situation that will assist in making the learning process more tangible for my students. The meetings also allowed me to broaden my scope and my understanding of the topics that I was directly researching and those that are more widely related.

Association of Science Educators Conference – Liverpool; ENGLAND

I attended a three day Science Educator’s conference in Liverpool. Attending the conference provided me the opportunity to meet more industry experts and discuss how the specific of scientific discoveries can be unpacked and presented to teenage students studying Physics. It was an opportunity to create a specific network that I have since been utilizing and with whom I am hoping to create out-of-class opportunities and experiences for my students. Through attending the lectures and workshops, I was able to see presentations on world-class research in physics and engage in global networking.

A major strength of the conference was the focus on the global networking opportunities. The conference is established in such a way that it encourages the sharing of ideas, collaboration to tackle the challenges in science teaching, and to develop resources together that foster a high quality of learning for the students whilst supporting continual professional development for the science educators. It was a fantastic opportunity and experience to be a part of and I have included many of the resources I gathered whilst there are now included into teaching programs throughout the faculty with much success.

Science Museum – London/Natural Histories Museum – Edinburgh/Dynamic Earth – Edinburgh

Museums have a variety of ways in which they visually display complex and challenging concepts through the use of models and diagrams. This is an incredibly powerful teaching tool as it provides a visual representation for concepts. The Science Museum in London has dedicated an entire section to the field of Nuclear and in particular Physics. Visitors are able to walk around and see the equipment previously used in a time line affect which illustrates the advances made in this field and to the benefit of humans and health also.

From these visits I was able to take away ideas and concepts that can be replicated in the classroom setting and ideas on how to create a more tangible classroom for my students. Seeing, touching, feeling and hearing are all important aspects of learning and from the visits to museums and the resources I have taken from these trips I have been able to make alterations to my class room and my classroom activities that are more innovative, current and up to date and relate more directly to the world that my students are currently living in which is leading to more powerful and positive classroom experiences.

Conclusion

The experience that I have had as a result of my participation in the Premier’s Macquarie Capital Science Scholarship is one of many dimensions. It has added a new dimension to my teaching practice through personal experience leading to a deeper understanding. It has added an experience that has invigorated not just me but my students, fellow teaching staff and those with whom I interact. To have been a part of such an incredible opportunity has ensured that I have a strong network of industry experience across the globe that are enthusiastic, driven and motivated about the education of Physics whom I can access both personally and professionally.

The students that I have the charge of teaching have benefitted across a broader range of their physics and general science than just those topics and fields explored during this tour. These experiences and insights are transferrable to a wider range of topics, such as appreciating that science is real, how scientific research is conducted and how fields of knowledge are developed and expanded. It has demystified many areas of complex science. Many of the experiences that I had and the people that I met could not be limited to precise and discreet topics and so demonstrating to my students that Physics is everywhere and can be applied in a variety of different ways.

Employing innovative teaching methods and introducing more tangible experiences to the classroom such as Skyping to world-class Research labs extends the range of activities for learning that can be engaged in for student centered learning and richer experiences. Furthermore my continued interaction with newly established network of physics educators and industry professionals means that my teaching and my students learning will continue to be enriched.

Knowledge and experience are inextricably linked. Learning through experience is a powerful education tool and I have experienced this first hand and will use the energy and passion that I have derived from this study tour to impart my knowledge with confidence and enthusiasm. A teacher that knows her content well is far more equipped to create meaningful and memorable lessons that will encourage and support students to have a lifelong love of learning. The Premier’s Teacher Scholarship has certainly allowed me to access my lifelong love of learning and I will enjoy sharing my experiences and my knowledge with my students in the hope that they will also.

References

Davies, P. God of the New Physics: The fundamental structure of Matter. (London: Penguin Book, 1988), 144-163European Fusion Development Agreement. Energy, Powering Your Home. (FOM – Institute for Plasma Physics, 2005).

Penrose, R. The Standard Model of Matter of Particle Physics: A Complete Guide to the Laws of the Universe. (London: Random House, 2004), 627-654

Rationale statement in the NSW HSC Physics Syllabus

Scottish Qualifications Authority. PHYSICS Advanced Higher (4th edition, published December 2004)

Websites

[Culham Centre for Fusion Energy](https://ccfe.ukaea.uk/)

[A video by CERN on Peter Higgs](https://www.youtube.com/watch?v=kw0iRW2hoC4)

[CERN – Public access information site](https://public.web.cern.ch/)

[NSW Board of Studies Stage 6 Syllabus – Physics](https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/physics-2017)