THE WINSTON CHURCHILL MEMORIAL TRUST OF AUSTRALIA

Report by Nicolette Hilton

The Northern Districts Education Centre (Sydney) Churchill Fellowship to study innovative practices that improve engagement of students in science and promote a positive learning culture – USA

Signed ……. Dated …….

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INTRODUCTION

I have been a science teacher in NSW schools for several years. I began my teaching career in a school where innovative teaching practices were encouraged and supported and I witnessed the difference this made to the engagement and motivation of the classes I taught. I made it my personal mission to increase the profile of science within that school and the local community. The work I did in increasing the profile of science was recognised through an Australian Government Quality Schooling Award and the Minister for Education's Medal of Distinction in Education in 2008. I have been recognised also as a BHP Billiton Science Teaching Award finalist, Australian Academy of Science, Science Teacher Award and as a UNE Young Distinguished Alumni Award recipient.

A need for an increase in science graduates from tertiary institutions has been recognised and publicised nationally in Australia. A direct correlation between student interest, engagement and motivation in secondary school has also been established. The middle school years have been shown to be a particularly crucial time in terms of student engagement and connection in science. Passionate teachers create passionate learners, however, the task of promoting an interest and passion in students for science is more easily done when teachers have access to quality resources and professional development. Receiving The Northern Districts Education Centre (Sydney) Churchill Fellowship has provided the opportunity to travel and seek these quality resources and programs from some of the United States of America's leading science education providers.

I am immensely grateful to Mr Peter Merry for providing The Northern Districts Education Centre (Sydney) Churchill Fellowship. It has indeed been a once in a lifetime opportunity to see some of the world's best science education centres, museums and curriculum developers. It has been a privilege to travel as an Australian Churchill Fellow and I represented the Australian Churchill Trust with pride.

Thank you also to Mr Peter Russo, CEO of the Australian Science Teachers Association and Mr Peter Hall Director of Studies at The Armidale School. They have supported my passion and vision for science education in Australia through their generous words and encouragement. Without their support I may have never has this incredible opportunity.

This report is dedicated to the vast number of passionate science educators I met during my journey across the USA. All were hugely inspiring, supportive andwilling to sacrifice their time to meet with me. In particular I would like to thank the organisers of the NSTA national conference in San Francisco, Dr Thomas Emrick of the National Science Resource Center, Ms Michele Glidden of Society for Science and the Public, the Smithsonian Museums, Luther Richardson of Columbus High School and Dr Chris McKay, Dr Liza Cameron and Dr Rakesh Mogul of NASA and all the incredible science centers I visited throughout my stay. I hope to maintain contact with all of you, without you my experience would not have been the immense success that it is.

EXECUTIVE SUMMARY

Nicolette Hilton
53 Dumaresq Street, Armidale
Science Education Officer, Teacher Earth Sciences Education Programme
0437 775 780

The Northern Districts Education Centre (Sydney) Churchill Fellowship to study innovative practices that improve engagement of students in science and promote a positive learning culture – USA.

Highlights:

- NSTA National Conference on Science Education - valuable information and resources for assisting students to become inquiry based learners. These materials include teaching scientific inquiry and process and teaching content through inquiry-based learning.
- NASA Spaceward Bound Expedition - bringing astrobiology into the secondary school science classroom. Connecting astrobiology content across the different disciplines of science and developing inquiry-based lessons.
- Science Centers across the USA - many varied high quality outreach programs that may be suitable for implementation out of Australian science centers and museums.
- National Sciences Resource Center with Dr Thomas Emrick - looking at the importance of modelling good questioning for students and questioning as the crucial starting point in learning the inquiry process.

Recommendations:

- Interactive professional development opportunities for primary and secondary teachers to learn how to teach open-ended inquiry.
- Professional development opportunities for primary and secondary school teachers on questioning. Teachers may need assistance in ensuring they are modelling quality questioning techniques in their classrooms.
- The outreach programs offered by science education providers in Australia (including science centers and museums) are of high quality. I endorse and support these programs, however I would recommend that these providers regard the programs being organised and facilitated out of the science centers in the USA and consider implementing these programs.

Dissemination:

- Dissemination of teaching resources through science education conferences (ASTA conferences, Teacher Earth Sciences Education Programme workshops), ASTA publications, to interested parties and organisations.
- Discussion of experiences and findings on inquiry-based learning, particularly open-ended inquiry, with interested colleagues and parties.
- Discussion of education programs facilitated through museums and science centres with interested parties.

PROGRAMME:

San Francisco

- Five days at the National Science Teachers Association National Conference on Science Education
- Ms Julie Smith - The Tech Museum (San Jose)
- Ms Erica Friesen Barrueto - The Lawrence Hall of Science (Berkeley)
- Ms Lindzy Bivings - California Academy of Sciences
- Exploratorium

Mojave Desert

- 2 days with NASA Spaceward Bound Mojave Expedition - Zzyzx Desert Studies Center. Dr Liza Cameron and Dr Rakesh Mogul

Phoenix

- Ms Dianne McKee and Ms Caroline Starr - Arizona Science Center
- Grand Canyon Education Center

Atlanta

- World of Coca Cola
- Georgia Aquarium
- Fernbank Science Center
- Ms Mary Johnson - Coca Cola Science Center (Columbus)
- Mr Luther Richardson - Columbus High School

Orlando

- Ms Heather Norton - Orlando Science Center
- Dr Patricia Gills - Kennedy Space Science Education Center

Washington DC

- Ms Tanya Garner and Ms Tricia Edwards - Spark Lab Lemelson Center
- Ms Michele Glidden - Science for Society and the Public
- Mr Michael Hulslander - How Things Fly National Air and Space Museum
- Dr Thomas Emrick - National Science Resources Center

MAIN BODY

Academic studies on factors affecting student's choice of science and engineering as a career have been carried out nationally and internationally and they yield similar results. The quality and relevance of the tuition they receive in their science classrooms directly affect their decision to continue to study in the area of science(Aikenhead1996: Ainley 1993: Fullarton & Ainley 2000: Long & Steinke 1994). Students in middle school years choose senior secondary school science based on their middle school science lesson experiences(Ainley1993: Fullarton & Ainley 2000).

Dr Terence Lyons of the University of New England found also that students with families and parents who advocated or showed interested in science were more likely to select senior secondary science units and consider science as a career(Lyons 2003). Figure one illustrates the congruence between characteristics of family and school science worlds found among science proficient students choosing physical science subjects(Lyons 2003).

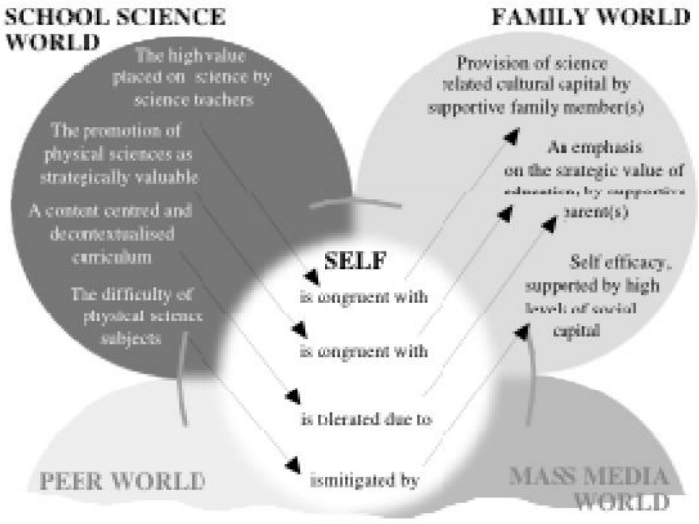


Figure 1.

Increasing the number of tertiary students selecting science and engineering courses is going to be done through ensuring high quality, relevant science throughout a student's schooling. A positive learning culture surrounding science education in schools and in science in the community is likely to assist in creating positive dialogue and interest in the sciences (Goodrum *et al* 2001: Lyons 2003).

Inquiry-based learning, also referred to as science by doing, is an engaging, motivational and relevant way for students to develop an understanding of scientific concepts and the skills necessary for them to be able to formulate their own questions and inquiry to seek answers. A number of studies have shown that students prefer to learn science through scientific investigation rather than learning science as a series of facts through theory (Osborne *et al* 1998: Woolnough 1994). Studies have also identified the importance of science as an extra-curricular entity, through science clubs, science competitions and involvement of community-based science industry(Woolnough *et al* 1995).

Why Travel to the United States of America?

At CONASTA57 I attended the presentation of a keynote speaker from the National Sciences Resource Center (NSRC). I was inspired by her passion for science education and the programs organised by the NSRC at that time. I also become very aware of the televised science competitions coming out of the USA, there appeared to be significant coverage of science-based programs. From these observations and experiences I came to recognise a positive culture surrounding science and science education in the USA.

I also witnessed a program that introduced the top ten science education centers in the USA. The science centers shown on the program had features that I had not witnessed before and I noted that the centers were geographically widespread across the USA. I researched science centers across the USA and was surprised and impressed by how significant in number they were. It was my

impression that there is a positive learning culture surrounding science education in the USA.

In 2009 I joined a team of NASA scientists on a program called Spaceward Bound. On this program science teachers are able to witness and be involved in the scientific research of NASA scientists and work collaboratively to formulate ways to take this research into the classroom in inquiry-based lessons. I was inspired again by the work of the scientists and teachers from the USA.

The positive culture surrounding science witnessed through the publicity given to science-based state and national competitions, publicity and quality of science centers across the USA, materials produced by the NSRC and outreach programs such as Spaceward Bound all contributed to the formulation of The Northern Districts Education Centre (Sydney) Churchill Fellowship to study innovative practices that improve engagement of students in science and promote a positive learning culture in the USA.

National Science Teachers Association Conference for Science Education

PDI – Professional Development Institutes–Biological Sciences Curriculum Study, Elizabeth Edmondson and Connie Hvidsten

"Inquiry into Inquiry Based Learning"

Writing an Explanation

During the professional development sessions scaffolding for writing scientific explanation was demonstrated, modelled and then completed by participating teachers. Teachers had to brainstorm what they believed the components of explanation are. The teachers present were all from the United States of America, though from varying states and districts. All brainstormed components of an explanation similar to those, though differing in name, suggested in the modelled scaffold. Teachers in the USA seem very comfortable with the writing of scientific

explanation in their classrooms, even at a middle school (year 5 – 8) level. In Australia explicit scaffolding of scientific explanation seems most evident in senior years and in my experience and time as a science teacher I have not witnessed explanation writing as explicit as was demonstrated at this professional development workshop.

Teachers were asked to write an explanation for the phases of the moon prior to the demonstration and modelling of the scaffold. The appropriate structure for an explanation was then introduced. A student sample of an explanation was viewed and a critique of the components of the explanation provided and read through. Teachers then worked in groups to write an explanation for a complex question provided by the professional development providers.

Teachers were then asked to review their explanation and check the structure. Following this there was peer review of group explanations and feedback provided by peers. Teacher participants then reflected on the day's process.

Participants finished by being walked through the explanation scaffolds and considered as groups the importance of ensuring students consider explanations as a whole text, not as individual sections stuck together. The need to ensure student review, descriptive feedback and that component's of the explanation structure can be introduced and practiced gradually.

As a teacher I have not witnessed scaffolding in my university studies on science education or during teacher professional development to this extent. I would recommend that scaffolds like the one offered at this professional development day be modelled and made available to science teachers in Australia.

Day 2 NSTA Conference

Earth Sciences Experiments

Magnetometer - this was the demonstration of an excellent activity for students to model how iron deposits are discovered using magnetism. Map on one side of a cardboard box and sticky-tape magnets to the inside. Students use the magnetometer (made from a pin tied to a length of string threaded through a half a drinking straw) they have made to establish where the "iron" deposits are. Teachers can use this activity in forces units and to introduce the concept of magnetism and its use for a variety of purposes.

Teaching Open-ended Inquiry Presentation

The message given during this presentation on open-ended inquiry was to gradually increase the degree to which investigations are open-ended.
This is rather than having the "cook book" experiments where teachers tell students the equipment, method and outcome. Investigations can become gradually more open-ended by firstly removing the result, not telling students what is going to happen. The teacher can then remove the procedure and have students develop their own methods. The final step in increasing the degree to which an investigation is open-ended is to remove the inquiry question. This is very difficult to do as teachers feel that they have little to no control over the questions that students may ask. This issue was addressed during this workshop. The way of overcoming this issue is very simple, yet will be very effective in the classroom.

Introduce topic, stimulation or content of an investigation to students (e.g. have students take their own fingerprints and classify their own fingerprints as whirl, spiral or curve) and then have students develop questions. Ongoing use of this method is likely to result in students being able to develop questions in more

and more open-ended situations. Questioning is key to the inquiry process, if students can formulate questions then they can investigate.

Middle School in Arizona and Professional Development Project
Barbara Reinert

Middle school teachers from a district in Arizona have all been provided with professional development and training on the use of science kits. This is to assist them with the teaching of inquiry and to ensure they are confident and competent teaching in a "science by doing" way. Full-time, part-time and regular casual teachers are all provided with professional development. Pre-service teachers are also given this professional development during their practicums at these schools. Teachers complete this PD in the week prior to term, they also complete PD during school term, and in this way taking teachers private time is avoided. Money has been access through Indian Gaming Funds.

Another individual at the presentation recommended a method used in New York where teachers work an extra half an hour throughout term on Mondays, Tuesdays, Thursdays and Fridays so that PD can be accessed every Wednesday. This is a large sacrifice of time from teachers, but the benefits of having PD every Wednesday from lunchtime onwards would be significant.
Day 3 NSTA Conference

Teaching inquiry to students of all levels
Mr Jeff. D Thomas Assistant Professor of Science Education

A very high quality scaffold was explained and provided to participants to assist students to follow and write scientific method. Particular emphasis was placed on students brainstorming variables at the beginning of the inquiry and using this brainstormed list to help them choose an independent variable (the thing they change) and to help them keep the other variables the same (constants). This scaffold ensures that the variables are explicit to students. The scaffold

includes detailed instructions on writing a scientific method and clear assistance to students for selecting an appropriate graph for their tabulated results.

The presenter also suggested that students present their question, data table and graph and a conclusion (explanation) on a poster to display in the classroom for other students to display. I would suggest that this might be an ideal opportunity for teachers to hold in-class symposiums, which may gradually become across year groups, stages (NSW) and perhaps schools.

I would suggest that this scaffold be modelled and given to teachers in Australia, I see it as a valuable resource.

NASA - Earth from Space Lesson Resources

Activities on modelling the height of various space vehicles in the atmosphere and in outer space. This activity was done by marking out a scale on the carpet in the room, a piece of masking tape was placed at each metre working out from a globe of the Earth and then individuals stood at the distance their vehicle/object was from Earth.

Activities in modelling the layers of the atmosphere and their distance from Earth were discussed. The presenter recommended that teachers also complete this activity as a scaled model working up the wall in the classroom.

Relating Experiments Back to the Work of NASA

I find these activities particularly interesting and potentially useful in Australian science lessons. Students have a natural fascination and curiosity of space. The following activities are common to many Australian science textbooks and across different areas of science, but all have important relationships with and demonstrate concepts important for space travel.

Film canister rockets – rocket propulsion and current research
Black/White Absorption (Radiation Prac) – Space Suits, why they are white.
Water Filtration Experiment – Water Filtration on board the shuttle, cost of carrying items into space, people need a lot of water.

NASA Robots for Less than a Penny

Important lessons learnt:

- Need for students to alter their perception of robots as humanoids. Robots are any devices that have a sensor.
- The presenter outlined the possibility of having students bring toys into the classroom, as many of these are robots.
- Presenter also suggested students walk from one end of a classroom to the other and consider what sensors they required to move from one side to the other. They could attempt this blindfolded etc. Students could also be programmed by other students to walk from one side of the classroom to the other, doing only what they have been programmed by their group to do.

Participants created two different model robot structures that students would be able to create in the classroom. Participants discussed how these tasks could become inquiry-based tasks. Changing materials and basic patterns etc. These are excellent resources and can be accessed at:

http://www.nasa.gov/pdf/179225main_ISS_Poster_Back.pdf on the 6th page.

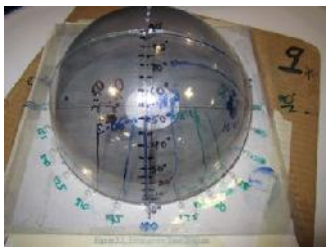
And
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/I_Want_to_Hold_Your_Hand.html

Sun Dome Lab Lesson Resource

Ms Ardis Herrold

I was shown an excellent experiment for demonstrating movement of the Earth using clear plastic hemispheres. Teachers write the degrees of a compass on the marked edges of the hemisphere. Students mark the position of the Sun on the dome by standing outside in the Sun with the cardboard base pointed North. The student passes a pen over the outside of the hemisphere until the point of the pens shadow is at the point where the North-South and East-West lines meet. Students mark a dot at this point to indicate the Sun's position in the sky. The time of day is written next to each dot. Students are able to repeat this task over a period of a lesson or a day and observe the movement of the Earth, they will be able to note that the Sun does not "pass directly over head" and is not directly overhead at midday.

Students are then able to use a second hemisphere with altitude marked on it to determine the altitude of each of the marked points. Students are able to graph the 2 lots of data against each other. Midday may be calculated by looking at altitude at 180degrees or by looking at the altitude when the marked dot passes the east-west line. Data collected can be compared to an online site to check the validity of the findings.



The lady who showed me this experiment is keen to have my Science students in Australia complete this experiment and share their results via Skype with her students in the USA. This will be a great opportunity for students to communicate scientifically with students from another country and feel that they are collecting relevant data for a purpose.

iSeismo and Quake Seeker, iPhone applications, were also demonstrated. These are excellent applications that can be used in Earth Science topics.

NSTA Presidents Banquet

Listened to a speech by and then met retired NASA astronaut and physician Dr Bernard A. Harris Jr. His speech was very inspiring as he shared his background in a low-socio economic region, broken and drug affected home. He spoke of how his Mother always encouraged him to be the best that he could be. Dr Harris also talked about how his teachers inspired him to follow his dream of becoming astronaut.

Another speaker from Yorkshire, in the UK spoke of the importance of having science teachers who encourage creativity in their students, through creative and innovative teaching. Both of these speeches outlined the importance of having passionate and innovative science teachers.

NSTA Aerospace Educators Luncheon
NASA Aerospace Education Services Project

At the luncheon I listened to a speech by Dr. Vinton G. Cerf, VP and Chief Internet Evangelist for Google. Dr Cerf spoke of technology and its impact on education. He talked about the need to teach students how to check the validity of sources and ensure that they know how to make their searches on the internet explicit. At the conclusion of his speech he had question and answer time. Mr Peter Russo, CEO of the Australian Science Teachers Association asked Dr. Cerf whether he felt that content or process was more important in regard to the development of new Australian science curriculum. Dr. Cerf stated that process was always going to assist students in accessing their answers.

This supports the need for inquiry-based learning in the science classroom and the importance of students knowing how to formulate questions.

Science Centers - Galleries/Exhibits, Outreach Programs and Teaching Resources

The Tech Museum

Ms Julie Smith

The Tech Museum has many amazing exhibits, which have been provided to the centre through partnerships with science and technology providers. One example of this is the partnership with Microsoft, which has enabled the Tech to provide an exhibit where students teach visiting students through short film clips. On these clips students of varying ages introduce and describe a specific concept through modelling and example. Close to 25 different scientific concepts are introduced and described through this process. Each concept has its own toy to encourage students to interact and LCD screen with between 2 and 4 students presenting their explanations one at a time. The explanations are approximately a minute in length.

Explore your World has been provided through a Google partnership. Students and visitors are able to view any part of the Earth (including their home), the Moon and Mars at this exhibit on a series of 8 screens. The exhibit creates a very 3D sensation!

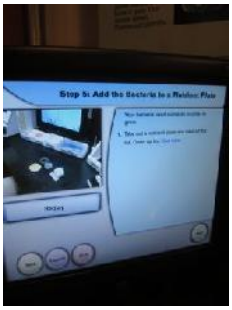
NASA has provided a jetpack chair and an exhibit that allows students to view the Earth from space. Students are able to access views of hurricanes, ocean currents, the Earth by night and various others. Each view includes commentary to assist students in understanding the concept involved.

The Tech has a vast number of student-oriented activities. There are 5 science laboratories at the centre, 2 wet and 3 dry, where school groups are able to be involved in authentic rich science inquiry. These labs are targeted at grades 5 through to 12. The dry lab on rollercoasters is one of the most popular interactive lab lessons.

The Tech also runs an engineering competition for students from grades 5 to 12. This year the competition is modelled on the plastic pollution that has been found in San Francisco Bay. Students are to design and build an object to remove plastic bottles from the model version of a bay, complete with fictional endangered fish. There are two areas set up in the Tech for students to test their designs and make improvements prior to the competition day. Approximately 1200 students are involved in the competition.

On the floor of the Tech amongst the interactive exhibits there are university students and post-graduates with tables of scientific equipment who complete science experiments with students as they pass through the center. School students and visitors benefit by being able to be involved in authentic scientific inquiry and university students are provided with the opportunity to teach and present science to the wider community.

The genetics wet lab, positioned on the general floor of the Tech was one of the most innovative exhibits I have ever seen. Students are able to complete their own genetic work placing jellyfish DNA into bacterium. Each workstation is equipped with a touch screen computer monitor and fully labelled equipment ready to use. The computer monitor walks students through the experiment method, providing written instruction as well as filmed examples of each individual step. Students/visitors can choose to watch each step as many times as they like and a Tech education officer is always present to assist. The instructions are concise and precise. Students are able to access photographs of their incubated agar plates online from home the following day.



The tickets handed to visitors/students as they enter the Tech have details of a website and every ticket has its own webpage. Students can only access their

own webpages, but are able to add to their webpages by simply passing the barcode of their ticket under a scanner at the exhibits where a scanner is present. In this way they build their own science-based webpage.

The exhibits are relevant and contemporary and the inclusion of an exhibit on astrobiology was particularly impressive. The exhibit gave students evidence for the possibility of life on Mars and asked them to provide their own opinion.

One exhibit in the space science area that relates well to materials collected at NSTA was a magnetometer exhibit where students had to use a magnetometer to locate areas of magnetic activity on the Moon, just as astronauts will. This could be easily recreated for the classroom using the simple magnetometer model and a lumpy, coloured dome with magnets under it.

The Lawrence Hall of Science

Ms Erica Friesen Barrueto

The Lawrence Hall of Science consists of an immense number of fully resourced science laboratories, 9 in total! These laboratories are used to run laboratory workshops with visiting school students. Visiting classes range from kindergarten right through to year 12 and entry is free. The Lawrence Hall of Science services an area with a radius of approximately 100 miles. The staff at the museum is available to travel to schools in outlying areas to share science and do workshops with students.

There is also a program run whereby teachers are trained and these teachers then train other teachers within their region.

After school science programs also run, the focus being on providing science to elementary school students who may not be doing a lot of content and process rich science at school. University students from the University of California Berkeley volunteer and run activities during these afternoon sessions. Summer

camp programs are also run at the Lawrence Hall of Science with students able to apply for scholarships to cover the cost of the camps.

Publications linking literacy to science are currently being developed through the Lawrence Hall of Science. I shared information on Primary Connections, produced by the ASTA and Erica recorded information about this publication. Erica shared an older publication developed by the centre for elementary (primary) teachers that focuses on ensuring elementary school children are engaging in inquiry and critical thinking.

California Academy of Sciences

Ms Lindzy Bivings

The California Academy of Sciences has a number of science kits available for teachers to hire. The kits are large and very comprehensive. Teachers are required to complete professional development programs at the Academy to ensure they use the kits correctly and are able to get the most out of the equipment they hire. This is an immensely good idea, once teachers have received training on the use of the various science kits they are able to hire them year after year, or until they are able to gain resources similar to those contained in the kits.

The CAS also offers teachers professional development on how to make the most of an excursion to the CAS. Rather than have teachers equipping students with workshops that may not be suitable or relevant, they are walked through the exhibits and their content and provided with rich tasks for students to complete during their time at the CAS. Students take activity cards home with them to complete with family members, the back of the activity card contains a voucher for family entry to the CAS. It has a 15% success rate and 60% of families who attend the CAS on one of the family vouchers have not visited the centre on a previous occasion.

There are online lesson plans offered by the CAS that are extremely comprehensive, providing precise materials lists, preparation and lesson time, links to the curriculum and background information to assist teachers.

The CAS also completes laboratory workshops with students, focused on the specialty areas based at the CAS and linked to California state curriculum and local teaching programs. The displays at the centre are interactive, stimulating and rich in content, people, children in particular have a natural fascination with animals and the museum have used this natural curiosity to engage visitors in scientific concepts of zoology and ecology.

Exploratorium

The Exploratorium is not like any of the other science centres visited so far. The focus of the Exploratorium is problem solving and scientific questioning. The floor of the centre is littered with engineering type games and challenges. These pieces of machinery are non-threatening and are each accompanied by simple instruction, which include a problem and/or question, which can only be answered by interacting with the equipment. The result is a HUGELY interactive science centre. Everywhere I looked students, children, adults and families were totally engaged in scientific concepts as they focused on solving the problem posed to them. The equipment is all sturdy, effective and safe. The objects are set up related to theme, but not in the same context as the exhibits in the other Californian science centres.

There is a book available through the Exploratorium bookshop and website which allows teachers to build simple versions of the engineering/science challenges present at the Exploratorium. The book is called the Exploratorium cookbook.

Programs are offered at this science centre for both teachers and students. Excursion workshops are available to visiting class groups, a new program is now available for students who are home schooled in the California Bay area and Exploratorium also completes school visits.

Programs for teachers are in the nature of programs for beginning teachers, particularly elementary teachers who may not have had a lot of exposure to the sciences during their training. Programs are also offered to experienced teachers and often teachers who complete these professional development opportunities become mentors at the beginning teacher education programs.

NASA Spaceward Bound Expedition Mojave Desert

I travelled to Spaceward Bound at Zzyzx Desert Research Center in the Mojave Desert. I presented programming and lesson scaffolding ideas to the 30 attending university students, NASA scientists and NASA science education officers on the night that I arrived. The presentation included programs and activities I had developed myself following Spaceward Bound Australia, ways of building student knowledge about a topic using Bloom's Taxonomy and collaborative team building through a fun science-based task. I received large amounts of positive feedback from the university students. NASA Spaceward Bound programs are an incredible experience for teachers and I would recommend them to all teachers.
http://quest.nasa.gov/projects/spacewardbound

I was involved in discussions on how to implement astrobiology content into lessons. I offered my programs and materials to students and these have been added to the NASA website and students set up a drop-box so that they could access the materials whilst they were still involved in Spaceward Bound.

On the days that followed I observed experiments being conducted by NASA scientists with the assistance of pre-service teacher university students. One experiment involved the use of equipment and chemicals that may not be easily

accessed by schools and teachers. This experiment involved identifying living components of soils using a spectrometer rather than having to grow microbes on count plates, which involves significant risk of contamination. This is important in astrobiology because contamination can destroy the viability of data from microbial investigations and when investigating life on Mars it is important to remove any risk of contamination from Earth. The dye, LB and spectrometer are not all going to be available in schools, I would recommend teachers use equipment and materials at local university campuses with the assistance of academics or that a simulated laboratory be set up on the internet so that students may interact with this investigation.

Mud batteries were also being developed and tested on Tuesday the 22nd of March. This activity has immense potential in the classroom and would tie in with a number of areas of science in the New South Wales and Australian science curriculum. The mud batteries use big sheets of carbon fibre, this is thought to increase the surface area in contact with the surrounding environment. The cathode is buried under ground, at an anaerobic level and the anode is above ground in oxygenated air. Wire is weaved through the carbon fibre. The voltage created by the battery can be measured using a voltmeter. These and other battery related experiments are able to be located at www.r2labs.org

Arizona Science Center

Ms Dianne McKee and Ms Caroline Starr

The Arizona Science Center (ASC) runs a quite unique science education program for students in years 4 through to year 8. The program is an after school inquiry-based program run by staff from the ASC at the participating school. All equipment required by the program is provided by the ASC and the school needs only to provide a teacher as a supervisor, these teachers are urged just to relax and have fun by the ASC staff. Input from the supervising teacher must be limited.

The major emphasis on the program is engagement of students in two-hour sessions of inquiry-based learning, where students develop their own understandings of scientific concepts and processes. The after school program is written in conjunction with the curriculum outcomes and based on interesting themes. The activities are connected to standards once they have been developed.

Recently the ASC has run a pilot program which gave teachers in the after school program the opportunity to actually run the after school program themselves. The pilot program involved 40 hours of professional development that aimed to train teachers to allow students to complete inquiry-based learning. Teachers were trained through a series of interactive workshops that modelled inquiry-based learning. One activity involved teachers being told to build a rollercoaster out of piping protector cut in half and a marble. Teachers could be told to make the marble go faster or slower, to add turns etc. Another idea for this activity would be to have students or teachers build a rollercoaster and aim to have the marble travel from a height of 2m to the floor the slowest. A variety of materials should be provided to open up the inquiry further.

Carolyn Starr explained that some teachers have trouble with inquiry-based learning, as the teacher needs to limit the structure of the lesson. Good inquiry-based learning looks chaotic from the outside in and some educators have problems with this. An inquiry-based classroom is very active. Carolyn described how she assists teachers in making the transition from totally structured to inquiry-based. She advices teachers to count to 25 in their heads when they feel like they need to give a student the solution to a problem and she encourages teachers to use peer-mentoring for students who are really struggling. If a fellow student approaches a student with advice about a solution they are more likely to question the reason for the advice than if it came from a teacher. If a teacher advises a student to add something to a project/solution they will rarely question the information. Using peer mentoring encourages students to learn through questioning and explaining.

"Add foil to your oven"
"Why should I?"

The materials for running workshops on inquiry-based learning have been offered by Carolyn Starr and I intend on facilitating these workshops upon my return to Australia.

The ASC also runs an extensive professional development program once a year. The program involved between 500-600 teachers from across the USA. The ASC did attempt to cater for everyone by running a survey to determine the best dates for the program, but the results were not consistent and it was decided that not everyone's needs in terms of timing could be met. The program is run during the autumn, as many teachers are returning back to school after a long summer break refreshed.

There will be 20 school holiday camps run at the ASC during the 2011 summer and this is going to be increased to close to 45 holiday camps in 2012.

The ASC has an impressive human body floor exhibit, which explains everything from the circulatory system to the Elements of the Periodic Table involved in the functioning of the human body. Medical students from Arizona State University volunteer on the floor around this exhibit, answering questions and explaining human body processes.

Georgia Aquarium

The aquarium offers numerous professional development programs to assist teachers in educating and mentoring their students in a variety of sciences all with an aquarium/marine/freshwater basis. Descriptions of each of the workshops is available online.

Further resources are available to teachers who may be at a distance from the aquarium. These resources are all available to teachers online.

http://www.georgiaaquarium.org/education/teachers/lesson-plans.aspx

The aquarium has large and interesting species to engage and inspire students and visitors of all ages. Many of the animals are responsive and engaged with the public.

World of Coca Cola

Teaching resources are limited at this stage, mostly they relate to social science, art and African/American history. However, more science teaching resources will be made available now that a "factory" exhibit has been included in the museum. The factory exhibit takes visitors through the process of producing and packaging Coca Cola, there is an immense amount of scope for relating this exhibit to quality testing and investigation, engineering and chemistry. I aim to contact the World of Coca Cola and discuss with them how they will go about producing these resources.

http://www.worldofcoca-cola.com/TeacherToolkit/TeacherToolkit.aspx

Fernbank Science Center

Mr Douglas Hrabe

Very different to the science centers visited so far in that this science center is run and owned by the schools system. The center is more about providing students with rich learning opportunities to assist in meeting the state science standards. The students receive tuition from teachers at the center who have significant specific expertise in their chosen teaching area. The 9 laboratories at the center are each designed, furnished and equipped to teach specific lessons and scientific content.

There are also outdoor learning opportunities by way of a large pond, substantially equipped vegetable garden, chicken coup and a 64-acre forest. There are learning areas within the forest where students are able to receive

lessons on ecology. Another larger pond also exists in the forest for students to observe and learn about.

The exhibits are varied and numerous at the FSC. The scientific experts at the center have each been able to provide authentic learning materials for the exhibit hall. This includes a large variety of reptiles, a large taxonomy collection of a variety of different animals from this region of the United States and an amazing space education exhibit that includes meteorites and the Apollo 16 lander.

The center also possesses an incredibly sophisticated space science education lab, where students are able to be involved in experiments utilising a wind tunnel and a drop shaft, which simulates microgravity. The FSC has significant connections to NASA and NASA Education, who have funded the Space Learning Center. The center also has regular visits from astronauts and has been able to provide opportunities for students to ask astronauts questions.

The planetarium and observatory are open to the public every Thursday and Friday night. The planetarium shows cost the public only $4. Entry to the FSC is free and students are not charged an entry fee either.

NASA conducts the Science, Engineering, Mathematics and Aerospace Academy www.semaa.com out of the Fernbank Science Center and the Lockheed Martin Aviation Camp http://fsc.fernbank.edu/aviationcamp.htm is also conducted at the FSC.

Schools are able to borrow taxonomy exhibits, small exhibits can be borrowed short-term and the large exhibits borrowed on a long-term basis.

Teachers are able to apply to be part of the Master Gardner program which takes place during school holiday time. Teachers completing this program must agree to return to their schools and set-up their own school vegetable garden.

Coca Cola Space Science Center

Ms Mary Johnson

The Coca Cola Science Center is a Challenger Space Learning Center that offers a variety of education programs for teachers and students. Students on excursions are able to visit the planetarium where shows cater for varying age groups. Teachers who may be teaching students about the universe and specific areas of the solar system are able to have the planetarium show customised to fit the needs of their students. Other shows include animations that have been developed by employees of the science center.

The planetarium also holds shows for general public. Other activities and interactive days are held regularly to engage the general public, the next being a comic strip day!

Visiting students are also provided with hands-on learning experience in the mission simulator. Students are places into two groups. One group is in the mission control room, each student has a different responsibility and contributes to the group. The other group is on the space station and again each student is given a different role during their time in the simulator. Various mock emergencies and challenges arise during the simulated mission and students need to complete their role, follow instructions and work together as part of a large team (space station and mission control) to complete the challenges and solve emergencies.

The floor exhibits at the center are all interactive and are all aligned with the state science teaching standards. The solar system exhibit provides students with insight into what each planet looks like and doing so shows students the extend of the knowledge scientists have on the planets in the solar system. In this way Pluto appears quite plain in colour, as it has not been mapped as may of the other planets have.

Teachers are able to access professional development through workshops conducted at the CCSSC. These workshops are focused on space science standards and information can be located on the CCSSC website.

The CCSSC website also includes activities for teachers to do with their students in their classrooms. These are easily accessed. Are series of further activities that are traditionally completed during excursion days can also be found in the online Teacher Handbook. Activities include experiments that can be conducted with UV beads.

New to the CCSSC website is podcasts which take students through a variety of scientific concepts. Currently there are twelve available, by the conclusion of summer this number will have increased to 50 and by the end of the year to 75. These podcasts include audio, visual and text to assist students with their understanding of scientific concepts.

Students and teachers are able to access the CCSSC seismograph via the internet and view current readings as well as readings from events such as the Earthquake which affected Japan.

Soon to come to the website will be links to the CCSSC observatory, students and teachers will be able to observe the characteristics of the Sun as recorded at the observatory from across the world!

Columbus High School
Mr Luther Richardson

Hosted two lessons conducting inquiry-based learning where students made rollercoasters for a ball bearing. Students were in groups of 3 and given specific roles according to the day and month that they are born. Students who celebrated their birthday first in 2011 were the materials managers, second were the group scribe and third were timekeepers. Each member of the group had a specific role.

Students were given the task of building a rollercoaster out of piping insulation for a ball bearing. They were given height criteria, maximum of 1.5m, told they had to have 2 loops in their rollercoaster and they had to include a free fall for their ball bearing. There was no limit on the length of insulation they were allowed and this was not an issue, however having students limited to the same amount of insulation may eliminate any issues.

Students were engaged and motivated and utilising scientific concepts to build their rollercoasters. They were extremely motivated, particularly given that it was the last day before spring break!

WEATHER BALLOONS

Hints for using weather balloons to complete scientific experiments at the edge of space – from Luther Richardson

http://hilton.columbus2space.org/
http://dreams.columbus2space.org/D10/

- Weather Balloon
- GPS Tracker
- Hydrogen gas – cheaper than Helium
- Parachute – from hobby store for rockets
- Payload – box - cover in cameras or place data loggers on experiments within.
- Check weather conditions – other weather balloons that have been sent up in the region
- Permission to use airspace

Balloons travel to a height of 95000ft, vast amount of data can be collected.

Zoo Atlanta

Zoo Atlanta runs workshops for teachers that provide teachers with recognised professional development hours. There are a variety of workshops available for teachers to attend, depending on the needs of their students and school context. http://www.zooatlanta.org/home/book_a_program/educators_lounge/teacher_workshops

Activities/lessons are available at http://www.zooatlanta.org/home/book_a_program/educators_lounge/educator_activities_guides these are supposed to be used as pre and post visit activities, but may have good ideas for teaching ecology and zoology based topics.
http://doubleknot.com/openrosters/DocDownload.aspx?id=86866
This is the year 7 page.

Around the zoo there were interactive signs/displays to engage students in the field trip experience, one of the signs that I found interesting was the flight sign. This sign and its information would enable teachers to connect the zoo experience across scientific disciplines, increasing engagement in physics for students who may be more comfortable with biological content/concepts.

An outreach program is also run out of the zoo for schools that may not be able to get to the zoo due to financial hardship or distance.

Orlando Science Center

Ms Heather Norton

Orlando Science Center (OSC) has a varied education program for students involved in field trip experiences. They cater for students from Kindergarten through to Year 12 and are even able to provide lessons for pre-kindergarten students upon request. The science laboratories were spacious and well lit. Laboratory lessons are each taught in a series of workstations, where students work mostly independently in small groups and move from activity to activity.

This is different from science centers visited previously. Each work station has very clearly explained instructions, elementary school student instruction includes photos and pictures to assist them with understanding.

All workshops and activities are closely aligned to state standards. Teachers are able to access pre and post visit activities online, to ensure students are able to make the most of their OSC experience. Teachers in Australia may be able to use these lessons and activities as ideas for teaching specific topics.
http://www.osc.org/index.php?option=com_content&view=category&layout=blog&id=85&Itemid=51
The K-8 workshops and pre/post activities have been linked across the curriculum for elementary (primary) schoolteachers. This enables science to be linked through other key learning areas, including mathematics, English and art.

The OSC caters for a huge 7 surrounding counties.

The OSC offers a huge number of summer camps, which range in length from weeks to single day activities. All summer camps are day camps only students who are attending longer camps must have private accommodation.

Teachers are able to bring their students to the OSC overnight, by sleeping in the hallways of the science center. Dinner and breakfast is included in the overnight package.

OSC has an amazing number of offsite programs on offer. These include outreach workshops, shows and science night activities. The science night program provides schools with the opportunity to host a community based science evening where OSC runs a variety of science workstations aimed at engaging students and parents in science. Included in this experience are “passports” sheets of paper that students have signed by each workstation facilitator once they have engaged in and completed the science activity at that station. Students who complete all workstations are able to have their name put into a competition to be drawn at the end of the evening. Other reward ideas may be to

provide students who complete all tasks with a small piece of scientific equipment.

At the conclusion of the evening parents are able to access online science activities to complete at home with their children. Some of these activities may also be useful classroom ideas. Each of the activities can be accessed through the family night flyers and all include website resources for further information and engagement. Go to this site and then access each of the Family Night Flyers for the Take Home Activity files.

http://www.osc.org/index.php?option=com_content&view=category&layout=blog&id=26&Itemid=44

All workshops and outreach programs are described and can be accessed at: http://www.osc.org/index.php?option=com_content&view=category&layout=blog&id=26&Itemid=44

Kennedy Space Science Education Center

Dr Patricia Gillis

Observation of 2 groups of elementary (primary) school students was made whilst they were on a field trip to the Space Science Education Center. Students were completing interactive workshops.

In the first workshop students built and tested a stomp rocket. Questioning was used to get students brainstorm prior knowledge of rockets. Students gave answers that the instructor then verbally categorized for them; these included the shape, size and function of rockets, how dangerous rockets were and the types of rockets. Students were then shown a diagram of the forces acting on a rocket and through questioning walked through each of the forces. Students were then asked whether they had any prior knowledge on Newton's Laws and some did, despite being in year 4! Students were walked through each of Newton's three laws and taught how they relate to how a rocket works.

Once this introduction was complete students were shown how to construct the first part of their rocket. Thin cardboard was made into a cylinder by wrapping it around a thin piece of PVC piping. Students were then directed to create a cone shape out of a semi-circle piece of cardboard. The size, shape and way they attached the top of their rocket was left up to them. Students were then told to create fins for their rockets out of scrap cardboard, again they were encouraged to consider the concepts discussed and make these any size or shape they felt would make their rocket most successful in launching.

Rockets were launched by being placed on the end of PVC piping and connecting an empty 2-litre soft drink bottle to the other end. When the bottle is stomped on air is released through the pipe and into the rocket, causing it to launch. In this instance there was only time and opportunity for students to have a single launch. In school lessons it would be ideal to allow students opportunity to make changes to their rockets and encourage the to discuss what went wrong/right in terms of scientific concepts. Older students could be given the freedom of constructing their rockets out of any material they liked, as long as it launched from the same structure, using the same sized soft drink bottle. See the following website for more information:

http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html

The second activity observed was the construction of a model of the solar system out of beads and string. Students were taught about Astronomical Units and why they are used in space measurements and then these units were used to develop a scale model. Students simply multiplied the AU by 10 to work out how many cm their planets were from the Sun. This was completed as a class group. Students then marked on their screen with a felt tip pen each of the planets (including the asteroid belt) and then added the Sun and the planets one at a time by knotting them onto the string in the correct position. Labels can be added to the model. The activity would also be suitable for older students in

Australia, particularly year 6 or year 7. Extension students can be asked to display a scale bar with their model, showing km as well as AU. String needs to be at least 3m in length. Students will need 10 beads of differing colours.

http://solarsystem.nasa.gov/docs/Solar_Sys_Beads.pdf

For other great activities on the Solar System and Universe go to:
http://solarsystem.nasa.gov/educ/resources.cfm

Each of these activities went for an hour, the second activity would not take any longer than this in a classroom situation. The first activity could definitely be extended to ensure true inquiry-based learning and to support development in understanding of the design process.

Students then explore a variety of mini-hand on activities set up around the education room. Including an activity where they are required to trace the shape of a star by only looking at its mirror image. Rather than drawing onto the star, as I have seen this done in the past, the star is made out of electrical tape and on a metal surface. When students failed to trace the star an alarm was set off through an electrical circuit. I like this interpretation of this activity as it allows the activity to involve electrical circuits and reflection and be based in space science. Astronauts are required to work with mirrors in space.

Students were also shown a gyroscope and given the opportunity to use it. A tray was also set up at the end of the room containing sand and pebbles. The tray had water running through it from a tube at one end, the water was then filtered through at the opposite end and re-used. Students are able to experiment with land formations as a result of weathering.

This is a great robotics/rover lesson sequence online:
http://robotics.nasa.gov/edu/rover.php

National Museum of Crime and Punishment

Workshops run for groups of school students on forensic science. Students are motivated and engaged in the science involved in solving crime and are encouraged to consider a job as a forensic scientist. Teachers receive free entry to the museum at any time, with appropriate identification. The museum recommends teachers use the following website to assist in teaching forensic science in the classroom. The how to part of the website would be particularly useful to teachers.

http://theforensicteacher.com/how_to.html

National Museum of American History

Ms Tanya Garner and Ms Tricia Edwards

SparksLab at the National Museum of American History is an interactive science and invention area for children up to the age of 12. There is a small area developed specifically for children up to the age of 5. Museum education officers engage students in a series of science and engineering activities. The activity observed required children to design their own robot. They had to first decide what their robot was going to do and then decide what parts it would need to have.

In another part of the SparksLab there was a robot with basic circuitry boards on top, this was to assist children in understanding the electronic nature of robots and to allow them have a turn at operating a basic robot. A father and daughter combination built and rebuilt the circuitry boards and experimented with the robots for approximately half an hour while I was at the lab.

Education officers will also do demonstrations that run for 10-15 minutes at a time. The demonstrations are aimed to cater to young visitors and their parents.

The SparksLab does not do specific school group activities anymore. The lab is open to members of the public and if school groups are passing through on a field trip to the museum they are able to join in. In this way children are able to engage in the activities with their families, they don't have to be with a school group to be involved.

This section of the museum engaged children, young adults and adults in the process of design and invention. The displays are very interactive and the individuals observed in the exhibit were very engaged. People are more engaged in learning materials in museums when they are able to manipulate and become immersed in the displays, this happens well when individuals are asked to answer a question or solve a problem.

The National Museum of American History also has lesson plans and activities. The following link is to an online game for linking body parts to a Jerome, a full size anatomical model from the Smithsonian.
http://americanhistory.si.edu/anatomy/bodyparts/nma03_bodyparts.html

Website on polio
http://www.americanhistory.si.edu/polio/virusvaccine/index.htm

The following is a make a constellation activity suggested for K-year 4, but could be altered to be appropriate for NSW year 7 and year 8. Obviously it would be more appropriate for Australian students would be encouraged to create a constellation of an Australian woman.

http://americanhistory.si.edu/ourstory/pdf/telescope/telescope_maker.pdf

The following is an Edison website:

http://invention.smithsonian.org/centerpieces/edison/

National Museum of Natural History

A museum that has everything! Many of the museums displays are interactive and encourage viewers to learn through feeling. Evolution and adaptation were key themes in the animal displays, significant elements in the USA science standards are a significant part of the NSW curriculum in Australia. Teachers would be able to use this museum to assist in meeting all of the biology outcomes.

There was a display that showed early multicellular life forms. It was set up as a diorama, this would be an excellent way to engage students in how the early Earth looked, have them research multicellular organisms and create their own detailed dioramas.

The Invention at Play display that showed comparison of a prokaryotic a eukaryotic cell was engaging in the way it was set out. The cells and their labels were 3 dimensional and very large, such that they were eye catching and easy to read. This comparison is a specific outcome of many state's science curricular in the USA.

The rock display walks visitors through the different types of rocks and how they form. The displays were again very interactive.

The insect exhibit includes a butterfly dome, where visitors walk through hundreds of butterflies. The museum also has an insect zoo, with live insects and an insect petting zoo, children are able to touch and hold various insects including caterpillars, cockroaches and beetles. All of these displays have resulted in a hugely engaging exhibit.

The National Museum of Natural History has websites for educators. The following link is to lesson plans in a variety of biological areas
http://www.mnh.si.edu/education/lessonplans.html

The National Air and Space Museum

Mr Michael Hulslander

The How Things Fly gallery at the National Air and Space Museum is focused on engaging and immersing visitors in understanding what enables flight. The gallery takes visitors through the characteristics and concepts behind gravity and air, thrust, drag, lift and high speed flight through interactive exhibits. The physics involved is at an early college level, but is explained at a middle school level to ensure it is accessible to all who visit.

This type of gallery is unusual for a museum, but it is the most visited gallery in any Smithsonian museum and probably the most visited gallery in the world. There are a variety of educational programs that run out of the How Things Fly gallery. Schools are able to book into a number of interactive demonstration sessions, these sessions are also open to the public and run at different timetabled times throughout the day.

The gallery also has a program that gives college and high school students the opportunity to work part time on the museum floor as "Explainers". The benefit of Explainers is that they ensure visitors are taking the right information from museums galleries and exhibits, by providing additional explanations.

The Explainers learn how to explain scientific concepts on a variety of stages, including providing interactive demonstrations to crowds of up to 100 people. The museum also provides these students with leadership, resume and public speaking training. Once students finish High School or College they complete their program of work at the museum and other students are given the opportunity to be Explainers.

Explainers also provide Discovery Stations throughout the museum, particularly in the How Things Fly gallery. Explainers use stimulating and thought provoking

objects to explain concepts of flight and tie the concept in with the displays in the gallery.

The Moving Beyond Earth gallery is on the verge of a massive expansion with the shuttle "Discovery" on its way from NASA. The gallery includes an interactive quiz and has the Presentation Center, camera facilities that enable astronauts, scientists and leaders in the field of space science to provide lectures and demonstrations to people from across the world. Go to:
http://www.nasm.si.edu/exhibitions/gal113/mbe/index.cfm

Online resources are available from the National Air and Space Museum website and the Museum itself is able to provide teachers with details and transcripts of the displays. Contact the museum for more information.
http://www.nasm.si.edu/education/teaching_resources.cfm

Online activities:
http://www.nasm.si.edu/education/onlinelearning.cfm

Videoconferencing:
http://www.nasm.si.edu/education/classroom_videoconf.cfm

National Science Resource Center
Dr Thomas Emrick

Dr Thomas Emrick was able to share the National Science Resource Center's latest research project. The NSRC has received 33 million dollars in funding to facilitate a study that focuses on literacy in science. Approximately 1500 teachers at 500 schools are involved in this 5-year intensive study. This is the largest study of its kind ever conducted. A series of books, illustrated with photographs and diagrams have been produced to stimulate young readers. The books are formatted to engage and stimulate the reader, the images occupy most the pages. The text in the books in the series is predominantly question-based, modelling the questioning process to students.

When a child learns at a young age they learn through modelling and practicing the new skill, in the same way these small texts, model questioning, such that students will learn how to formulate questions. Learning how to formulate good questions, basis of the inquiry process. If students know the process they will always be able to seek answers.

Students who have this skill of questioning and beginning the inquiry process (and repeating it to answer new questions) will be able to more effectively learn and utilise the full scientific inquiry process at a higher level. They will also have the skill necessary to locate information as it is needed.

Questioning is viewed as key in good teaching practice. Teachers who are able to question well in the classroom are both stimulating inquiry and modelling effective questioning technique. This is the focus of studies by Dr. Ali Sammel who is based at Griffith University in Queensland Australia.

Dr Thomas Emrick also expressed the necessity for science students to appreciate that inquiry doesn't provide scientists with conclusive answers, often it enables them to formulate new questions. Students need to see inquiry as an ongoing process.

Society for Science and the Public
Ms Michele Glidden

SSP is the organiser and facilitator of the International Science and Engineering Fair (ISEF) and also facilitates an online directory of national USA science camp programs.

SSP has published all student abstracts from ISEF entries since 2003. These abstracts would be a good resource for science teachers. The abstracts would help in stimulating students to come up with their own ideas for open-ended

inquiry. The abstracts are also useful to students wishing to check the authenticity of their investigation idea.

The website also has a "Rule Wizard" which assists students in assessing the safety and suitability of their project for the ISEF competition and helps them to ensure that their study is legal in the USA, Australian students would need to check with local authorities, however the rule book wizard is still a valuable resource.http://www.societyforscience.org/

The SSP releases a magazine that contains scientific studies and research that is aimed at a student audience. The magazine, due to the accessibility of its content, it read and enjoyed by adult audiences also. This is another resource that would assist in stimulating students to be involved in inquiry.

The Intel Science Talent Search is a competition that is also organised and facilitated by the SSP. This is a prestigious competition where senior secondary school students are able to submit a scientific report that is of high quality. Often these are reports from investigations that students have completed on science summer camps, where they have been involved in authentic inquiry in tertiary facilities. The competition provides its winning students with cash prizes, first prize recipients receive $100 000. The other specific cash prize values can be found at:

The Intel Science Talent Search is a highly prestigious competition and one that would be immensely motivating for students requiring extension and enrichment in the sciences.

National Museum of the American Indian

The National Museum of the American Indian has galleries and exhibits that aim to educate visitors on American Indian culture. The galleries engage visitors in American Indian history, the varying tribes, their customs, beliefs and values. As well as the galleries the museum offers mini educational workshops. American

Indian museum education officers teach visitors through hands on workshops. The workshop I participated in was on the different types of canoes built by American Indians, how they were made and the science behind the success of the materials used.

The information offered in this workshop was an American Indian science perspective. Teaching science from this perspective is engaging and relevant and is how I would like to deliver science from an Indigenous Australian perspective in Australia. However, I do not have the Indigenous Australian knowledge to be able to teach science from this basis.

CONCLUSIONS:

The Northern Districts Education Centre (Sydney) Churchill Fellowship to study innovative practices that improve engagement of students in science and promote a positive learning culture has provided me with a once in a lifetime opportunity. I have been able to access resources and cutting-edge information into teaching inquiry-based learning from some of the best science educators in the world.

I hope that my report provides Australia's science educators with the resources and inspiration that are able to assist them in engaging and motivating Australian students and communities in science.

RECOMMENDATIONS:

- Interactive professional development opportunities for primary and secondary teachers to learn how to teach open-ended inquiry.
- Professional development opportunities for primary and secondary school teachers on questioning. Teachers may need assistance in ensuring they are modelling quality questioning techniques in their classrooms.

- The outreach programs offered by science education providers in Australia (including science centres and museums) are of high quality. I endorse and support these programs, however I would recommend that these providers regard the programs being organised and facilitated out of the science centres in the USA and consider implementing these programs.

REFERENCES:

Aikenhead, G. 1996, 'Science education: Border crossing into the subculture of science', *Studies in Science Education,* 27: 1-52.

Ainley, J. 1993, 'Participation in science courses in senior secondary school', *Research in Science and Technological Education,* 11(2): 207-223.

Lyons, T. 2003, 'Decisions by science proficient Year 10 students about post-compulsory high school science enrolment: A sociocultural exploration', unpublished PhD thesis, UNE School of Education.

Fullarton, S. & Ainley, J. 2000, *Subject Choice by Students in Year 12 in Australian Secondary Schools,* LSAY Research Report Number 15, ACER, Camberwell Vic.

Goodrum, D., Hackling, M. & Rennie, L. 2001, *The Status and Quality of Teaching and Learning of Science in Australian Schools,* DETYA, Canberra.

Long, M. & Steinke, J. 1994, 'Images of science and scientists on children's' educational science programs', paper presented at the 77th annual conference of the Association for Education in Journalism and Mass Communication, Atlanta GA, August 10th -13th.

Osborne, J., Driver, R. & Simon, S. 1998, 'Attitudes to science: Issues and concerns', *School Science Review*, 79 (288): 27-33.

Woolnough, B. 1994, 'Factors affecting students' choice of science and engineering', *International Journal of Science Education*, 16(6): 659-676.