

THE WINSTON CHURCHILL MEMORIAL TRUST OF AUSTRALIA

Report by - Bernardo A. León de la Barra - 2007 Churchill Fellow

“To study methods to improve hands-on science, engineering and technology education from primary school to university”

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Signed Bernardo A. León de la Barra

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Introduction

There is a growing concern in the developed world about the decline both in the number and in the overall quality of preparation of school students who choose a career in Science, Engineering and Technology (SET). A similar concern is prevalent when it comes to the extremely low percentage of female students that choose careers in the Physical Sciences, Engineering, and Information Technology fields. To help reverse this situation it is crucial to know how to encourage from an early age creativity and innovation in children (especially girls) with a focus on SET related areas. This is essential to Australia's success in a global knowledge-based economy.

This Churchill fellowship project involved visiting world-renowned "Hands-on Science and Technology" Educational Centers and Museums in Finland, Norway, Sweden, and the USA. Through this overseas project the fellow gained first-hand experience of how these highly innovative and technologically advanced societies motivate and educate their children through engaging practical activities and experiments in SET. The project also allowed the fellow to identify state-of-the-art SET educational resources and methodologies.

Now that the fellowship has been completed the fellow will continue to engage with Australian schools, colleges, universities, and their communities with renewed knowledge and enthusiasm. The fellow will also use his overseas experience to inspire and encourage Australian students to study SET in primary school, middle school, high school and at tertiary level.

This overseas experience has also proved invaluable in providing the fellow with new knowledge and insight into how to attract competitive funding in the area of SET hands-on education. The fellowship has also enabled him to identify new powerful ways of encouraging school age students (especially female) to consider careers in SET. It is expected that because of the fellowship he will also be able to more positively influence other key stakeholders (including teachers, career counselors, and parents) so that the education, recruitment, progression, and retention of SET students from primary school to University become a shared endeavor.

Executive Summary

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I would like to identify four highlights in the fellowship, one in Sweden and three in the USA:

1. In Gothenburg, Sweden, the fellow visited the "Physics Toys" Laboratory (http://fy.chalmers.se/~perolof/fyslek/index_en.html) at the Chalmers University of Technology. There he met with Professor Per-Olof Nilsson, the Lab founder and Director for the last 10 years. The "Physics Toys" Laboratory was not the typical science center as it was based at a University. Hundreds of hands-on activities and experiments (most of them created using easily available low-cost materials) were available. It became clear to the fellow that the continuing success of the laboratory seemed to significantly rely on Prof Nilsson's enthusiasm, dedication and expertise. In fact, even though he was approaching retirement he seemed to be a bit concerned about passing the baton onto a "younger" person because he was finding it hard to identify someone who shared his same passion for such an endeavor.

Seeing Prof Nilsson's experience was a highlight of the fellowship because it reinforced how important it is to have a team of people who may share similar views on what to do to improve hands-on science, engineering and technology education. Prof Nilsson's experience is important to the fellow as he is also a full time academic who is subject to other demands on his time, namely, research, teaching, and administration.

2. The time spent at the Museum of Science (MOS: <http://www.mos.org>), Boston, Massachusetts, USA, was definitely another one of the highlights of the fellowship. The fellow attended a two-day workshop on "Engineering is Elementary" (<http://www.mos.org/eie/>), a program that introduces the Engineering Design Process (EDP) at primary school level. It does so by integrating numeracy and literacy with SET concepts. During his time at the MOS, the fellow also met people in charge of programs targeted at middle school ("Building Math" <http://www.buildingmath.org/> that integrates the EDP and Algebra) and high school ("Engineering the Future" <http://www.mos.org/etf/>). It was great to get copies of these resources and realize that the associated programs have the potential to be very useful in enhancing the fellow's capacity to improve hands-on SET education in Tasmania. Another important feature of many of the activities and programs at the MOS is that they use the EDP from Kindergarten to Year 12!
3. The time spent at the Lawrence Hall of Science (LHS: <http://www.lawrencehallofscience.org/>), Berkeley, California, USA, was certainly another highlight of the fellowship. Meeting with so many people who were in charge of such a diverse range of quality SET programs was an eye opening experience. For example, the Bay Area Science Project (<http://csmc.ucop.edu/csp/basp/>) is "a teacher leadership network committed to quality science education that is equitable and accessible for all students, and is based on research, sound teaching strategies, and teachers' experience of effective classroom practice".

4. The time spent at the Exploratorium (<http://www.exploratorium.edu/>), San Francisco, California, USA, was definitely another highlight of the fellowship. I was lucky enough to spend time with Dr Paul Doherty (Co-Director of The Teacher Institute <http://www.exploratorium.edu/ti/>) and with Barry Kluger-Bell (Co-Director of The Institute for Inquiry <http://www.exploratorium.edu/ifi/>). The Teacher Institute offers a rich mix of hands-on activities based on Exploratorium exhibits, content-based discussions, classroom materials, web-based teaching resources, and machine shop experiences. On the other hand, The Institute for Inquiry focuses on the scientific process of asking questions and seeking answers as the core element behind a wide variety of workshops, forums, and resources that support an international community of scientists and educators dedicated to developing innovation and leadership in science education.

If the fellow had the chance to (at least partly) re-do the fellowship he would definitely spend more time at the MOS, the LHS and the Exploratorium. In the fellow's opinion, these three institutions have some of the most advanced and comprehensive programs and resources in the area of hands-on SET education from primary school level upwards. Not only the programs are exceptional but the people running them are passionate and knowledgeable experts in their fields. Going back there for extended periods of time would be a great experience!

Program

This Churchill fellowship project involved visits to leading SET educational centers and museums in Finland, Norway, Sweden, and the USA. The program below provides details on the institutions visited and the people met.

Finland

During his time in Finland the fellow visited the following organizations and people:

1. Heureka (The Finnish Science Centre), Helsinki (<http://www.heureka.fi>). Mr Mikko Myllykoski, Exhibits Director.
2. Tietomaa (City of Oulu's Science Centre) <http://www.tietomaa.fi>. Ms Minna Laitsaari, Centre's Director, and Mr Sampo Puoskari (Content Designer).
3. Arktikum (City of Rovaniemi's Science Centre) <http://www.arktikum.fi>. Exhibits officer on duty at the time.

Sweden

During his time in Sweden the fellow visited the following organizations and people:

4. The National Museum of Science and Technology, Stockholm (<http://www.tekniskamuseet.se>). Ms Mariana Back, Science Education Director.
5. "Physics Toys" Laboratory, Chalmers University of Technology, Gothenburg. Professor Per-Olof Nilsson, Lab Director.
6. Universeum, Science and Technology Centre, Gothenburg (<http://www.universeum.se>). Exhibits officer on duty at the time.

Norway

During his time in Norway the fellow visited the following organizations and people:

7. The Norwegian Museum of Science, Technology, and Medicine, Oslo (<http://www.tekniskmuseum.no>). Mr Jan Andersson, Science Centre Director.
8. Vilvite (City of Bergen's Science Centre) <http://www.vilvite.no>. Mr Ove Ødegård, Exhibits Officer.

USA

During his time in the USA the fellow visited the following organizations and people:

9. The Museum of Science, Boston, Massachusetts. Mr Lee Pulis from the "Engineering the Future" (ETF) program; Dr Peter Wang, Director of University Relations and Director of the "Building Math" program; and Dr Yvonne Spicer, Director of the National Centre for Technological Literacy (<http://www.mos.org/nctl>). The fellow also met most of the "Engineering is Elementary" team as he took part in a two day workshop run by them.

10. New York Hall of Science (<http://www.nyhallsci.org>), New York City (NYC). Mr Eric Siegel (Director and Chief Content Officer) and Mr Chris Lawrence (Senior Manager, Digital Learning).
11. Girl Scouts of the USA (<http://www.girlscouts.org>), NYC. Mr Jaime Joyce, Marketing Director.
12. SONY Wonder Technology Lab (<http://www.sonywondertechlab.com>), NYC. Ms Corrine Doron, Program Manager.
13. Educational Equity Centre (<http://www.edequity.org>), NYC. Ms Maryann Stinner (Science Programs Director) and Ms Merle Froschl (Centre's Co-Director).
14. City Technology Program (<http://citytechnology.cuny.cuny.edu>), City University of New York (CUNY), NYC. Professor Gary Benenson.
15. The Tech Museum of Innovation (<http://www.thetech.org>), San José, California. Ms Nancy Robertson, Science Education Officer.
16. Lawrence Hall of Science, Berkeley. Dr Elizabeth Stage (Hall's Director), Ms Erica Friesen (Co-Director of Education), Ms Lynn Barakos (Professional Development Specialist), Mr Claudio Vargas (Co-Director, Bay Area Science Project), Mr Kevin Cuff (Director, East Bay Academy for Young Scientists), Dr Barbara Nagle (Director, Science Education for Public Understanding Program) <http://www.lawrencehallofscience.org/sepup>, and Ms Traci Wierman (Great Explorations in Math and Science Network Director) <http://www.lawrencehallofscience.org/gems/gems.html>.
17. The Exploratorium, San Francisco. Dr Paul Doherty (Co-Director of the Teacher Institute) and Barry Kluger-Bell (Co-Director of the Institute for Enquiry).

Main Body

Finland

The fellow first traveled to Helsinki, Finland, where he visited Heureka (The Finnish Science Centre). There he met with Mr Mikko Myllykoski, Exhibits Director. From Helsinki he traveled north to the city of Oulu where he visited Tietomaa (Oulu's Science Centre), where he met with Ms Minna Laitaari, the Centre's Director, and with Mr Sampo Puoskari (Content Designer). Note that Oulu is a city well known for the high number of start-up companies. Nokia has also one of its major R&D facilities in Oulu. This was certainly reflected in the exhibits available at Tietomaa, a large Science Centre relative to Oulu's population (approximately 130,000 inhabitants on 01 January 2008). The fellow traveled from Oulu further north to the city of Rovaniemi (located near the Arctic Circle) where he visited Arktikum (Rovaniemi's Science Centre).

Visits included meetings with the above people, intensive use of the floor exhibits, attendance to SET documentaries on show at the time, and a careful browsing of the Museums' shops looking for hands-on kits and resources that could be used after coming back to Australia.

Most people in Finland were very good hosts even though it was clear that visiting these institutions in the week before Christmas was not the best timing as it was not possible to observe or attend any professional development workshops for school teachers. The fellow then traveled from Rovaniemi to Stockholm, Sweden, via Helsinki.

Sweden

During his time in Stockholm, the fellow visited "The National Museum of Science and Technology", where he met with Ms Mariana Back, Science Education Director. From Stockholm the fellow traveled to Gothenburg where he visited the "Physics Toys" Laboratory at the Chalmers University of Technology. There he met with Professor Per-Olof Nilsson, the Lab Director. Also in Gothenburg, the fellow visited Universeum, the city's Science and Technology Centre.

As for Finland, visits included meetings with the above people, intensive use of the floor exhibits, attendance to SET documentaries on show at the time, and a careful browsing of the Museums' shops looking for hands-on kits and resources that could be used after coming back to Australia.

Most people in Sweden were very good hosts even though it was clear that visiting these institutions in the days around Christmas and New Year was not the best timing as it was not possible to observe or attend any professional development workshops for school teachers.

Norway

The fellow traveled by train from Stockholm to Oslo. During his time in Oslo he visited the "Norwegian Museum of Science, Technology, and Medicine" where he met with Jan Andersson, the Science Centre Director. From Oslo he traveled to Bergen to visit Vilvite, Bergen's new Science Centre. At Vilvite, he met with Ove Ødegård, Exhibits Officer. From Bergen he traveled back to Oslo before flying to Boston, USA, via London.

All the science and technology educational centers and museums visited in Scandinavia were certainly doing their best to engage with both local and foreign visitors. The fellow

was provided with lots of information (leaflets, brochures, and links to websites). Unfortunately, even though English is widely spoken in Scandinavia most of the printed and online resources were in the local language. Sometimes, brief “executive” summaries were available in English. This certainly detracted from the fellow’s capacity to easily identify programs, activities and initiatives that could be replicated in Australia.

USA

During his stay in Boston, Massachusetts, the fellow visited the Museum of Science. There he attended a two-day workshop titled “Engineering is Elementary” (EIE) that described and presented approaches, resources and methodologies to introduce the EDP at primary school level. The fellow met with Lee Pulis from the “Engineering the Future” program that focuses on high school students. He also met with Dr Peter Wang, Director of University Relations, and project leader of the “Building Math” program that aims to introduce the EDP at middle school level using Algebra as the main vehicle. Finally, he met with Dr Yvonne Spicer, Director of the National Centre for Technological Literacy. As stated earlier in this report, the time in Boston was one of the highlights of the fellowship. The fellow was provided with samples of the ETF and “Building Maths” resources, and he also bought sample units of the EIE program. All these resources and the associated programs have the potential to be very useful in enhancing the fellow’s capacity to improve hands-on SET education in Tasmania. The fellow then traveled from Boston to New York City.

During his time in NYC he visited the New York Hall of Science where he met with Eric Siegel (Director and Chief Content Officer) and Chris Lawrence (Senior Manager, Digital Learning). The fellow also visited the Girl Scouts of the USA in NYC where he met with Mr Jaime Joyce, the Marketing Director. Note that Girl Scouts of the USA conducts outreach and research on how to attract girls to SET related fields (an area of great interest to the fellow). The fellow also visited SONY Wonder Technology Lab meeting with Corrine Doron (Program Manager). Later he visited the Educational Equity Centre where he met with Ms Maryann Stinner (Science Programs Director) and Ms Merle Froschl (Centre’s Co-Director). The Centre conducts research and outreach to implement gender neutral SET education which is also an area of interest to the fellow. Near the end of his stay in NYC the fellow visited the City University of New York where he met with Professor Gary Benenson from the Department of Mechanical Engineering. Prof Benenson has been actively involved with NYC schools and has published extensively on SET Education at school level. The visit to NYC also included some time at the American Museum of Natural History, a great place to encourage curiosity in children and adults alike. The fellow then traveled from NYC to San Francisco.

During his stay in San Francisco, the fellow traveled to the city of San José where he visited “The Tech Museum of Innovation”. At “The Tech” he met with Nancy Robertson, Science Education Officer. He later visited the Lawrence Hall of Science at the University of California at Berkeley where he met with the Centre’s Director Dr Elizabeth Stage, Erica Friesen (Co-Director of Education), Lynn Barakos (Professional Development Specialist), Claudio Vargas (Co-Director, Bay Area Science Project), Kevin Cuff (Director, East Bay Academy for Young Scientists), Barbara Nagle (Director, Science Education for Public Understanding Program), and Traci Wierman (Great Explorations in Math and Science Network Director). The visit to the LHS was another highlight of the fellowship. Meeting with some many people who were in charge of such diverse range of quality SET programs was an enlightening and humbling experience.

The fellow’s activities in San Francisco also included a visit to The Exploratorium where he met with Paul Doherty (Co-Director of “The Teacher Institute”) and with Barry Kluger-Bell (Co-Director of The Institute for Enquiry). As stated before, the visit to The

Exploratorium was certainly another highlight of the fellowship. It was surprising to learn that many Exploratorium staff had Ph.D.'s in SET fields and that formal research was conducted with the participation of postdoctoral fellows and the funding of the USA's National Science Foundation.

It is important to point out that the fellow benefited greatly from being accompanied on this trip by his wife (a primary teacher) and his seven-year-old daughter. They accompanied the fellow on most of his visits to educational science and technology centers and museums and they were able to offer valuable perspectives on what was observed, experienced, or spoken about with the different local hosts.

Conclusions

The list below summarizes some of the major lessons learnt during the fellowship.

1. Close interaction between SET Educational Centers and Museums, Schools, Universities, Research Companies, and Business Corporations provides a fertile ground for SET hands-on education.
 - a. Secondments and sharing of personnel between the above organizations are a key factor in encouraging much needed cross-fertilization.
 - b. In particular, long term relationships between Schools and Universities tend to be better than one-off interactions that in general do not induce nor sustain transformation and improvement.
 - c. The most comprehensive hands-on SET educational programs seem to flourish in cities that have a high concentration of world-class research-intensive universities, for example, in Boston (MIT, Harvard) and San Francisco (UC Berkeley).
2. Primary school children should be exposed to SET as early as possible so that they do not lose their natural sense of curiosity and creativity.
3. After school programs in SET are increasingly popular in the USA as a way of introducing SET in a fun and relaxed way.
4. Professional development opportunities in hands-on SET education are crucial. Teachers can make a huge difference in the classroom.
 - a. Not only teachers and students are part of the equation. Parents and career counselors also play a key role in encouraging students (especially girls) to explore and consider a future in SET fields and careers.
 - b. Volunteers, after-school science clubs, and related community-based efforts can really make a difference when it comes to complementing school-based programs in hands-on SET education.
5. Low school science budgets are not a barrier. Student engagement in hands-on SET education is also possible on a low budget. There are many resources (printed and online) that cater for this.
6. The teaching of Physical sciences at school level could benefit greatly from using Engineering applications to engage teachers and students.

Recommendations

What could **you** do to bring about improvements in Australia?

The fellow will share his experiences and new knowledge through the delivery of hands-on workshops, the presentation of seminars and demonstrations, the publication of journal and conference papers, the sharing of resources via websites and via active leadership in new initiatives and innovative projects that further promote hands-on SET education at primary school, middle school, high school and tertiary levels.

What other improvements **should** be made in Australia?

1. Hands-on SET education should be promoted as a way of engaging students and teachers. Hands-on SET education may also provide students and teachers with clear links to real-world applications and challenges.
2. Teachers should be provided with plenty of professional development opportunities that help them to become confident and self-sufficient in delivering hands-on SET education. This should be done from early primary school level.
3. Parents, career counselors, school managers, and school district superintendents should be made aware of the range of opportunities that a career in SET may bring to school children (especially girls).
4. Faculties of Education (that usually train the future SET school teachers) should work together with Faculties of SET (especially in the areas of Engineering and the Physical Sciences) to provide real-world examples, modern applications, and technology background to trainee teachers.
5. Undergraduate engineering students should be encouraged to get teaching qualifications so that they can become involved in teaching SET at school level.
6. The role of "SET ambassador" should be promoted among undergraduate students so that they interact with schools as part of their degree requirements.
7. Philanthropy is big in the USA. Benefactors regularly donate to SET Educational Centers and Museums allowing programs and initiatives to develop with a long term perspective. This type of culture should be encouraged and facilitated in Australia.
8. Concern about the nation's and the states' scientific and technological literacy should be reflected in Federal and State policies and initiatives.
 - a. Australians should have a clear awareness that SET education, scientific and technological literacy are key factors in the continuing growth and long-term success of our economy.
9. University probation, tenure, promotion and reward systems should value more highly the involvement of academics in school outreach activities. The formal education of a nation should be a continuum that starts early at primary school level and may end with a postdoctoral position at university level. This certainly requires cooperation to be ongoing and long-term.