THE WINSTON CHURCHILL MEMORIAL TRUST OF AUSTRALIA

Report by Karen Burke da Silva

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The Phyllis Primrose Whyte Churchill Fellowship to investigate methods of teaching science at the undergraduate university level – New Zealand, USA and Canada

Signed: Dated:

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INTRODUCTION AND ACKNOWLEDGEMENTS

For the past 20 years I have been teaching science across multiple universities in Canada, England, the USA and Australia. At Flinders University, South Australia my focus over the past five years has been to increase the profile of teaching and learning and to transform the way science is taught at the university level. The approach I have taken is comprehensive (considering the whole curriculum and the way students from diverse backgrounds learn) and the objective has been to produce a model from which other programs could be fashioned and improved.

Improving Scientific Literacy within Australia is the ultimate outcome of this Fellowship project; however the work being done here is just the first step in that process. Universities around the world have initiated programs to ensure that their students graduate with adequate science knowledge so that they will be better able to make important decisions about their health care, their environment and the society in which they live. In particular Canada and the United States have taken an overarching approach which requires all university graduates to take at least one semester of science. How these non-science students are taught science is of interest, whether courses of this type provide scientific literacy will be questioned. In other words do current practices impart students with factual knowledge only or are they also providing students with the skills needed to interpret critical scientific issues which affect them on a daily basis. By examining various university programs across Canada and the United States I hope to gather information that will be helpful in developing programs within Australia that can inform science teaching and determine most effective practises for the development of scientific literacy within the large non-science cohort of students. Since North American universities have been providing courses for non-science students for many years it will be interesting to determine how Australian universities might be able to learn from their initiative. My fellowship not only allowed me an opportunity to visit various universities within North America but also to attend a First Year Biology Educator's Colloquium in New Zealand which provided me with an opportunity to learn about recent innovations in teaching and learning and to discuss the challenges facing biology teachers at the entry level.

I will be forever grateful to the Winston Churchill Trust and especially Phyllis Primrose Whyte for providing me with the excellent opportunities that the scholarship has given me.

The privilege of representing the Winston Churchill Trust has enable me to study in New Zealand, Canada and the United States and to determine strategies and innovations that will help improve university teaching and ultimately increase scientific literacy of university educated students.

I would also like to thank my two referees, Jim Mitchell and Gus Worby for providing generous encouragement and for supporting me in this endeavour. I have learned a great deal from both of them and hope that my work can live up to their expectations. Martin Westwell and Brent Banham also provided excellent advice and encouragement; I owe them my thanks as well.

Finally, I would like to take this opportunity to thank the staff of the Winston Churchill Memorial Trust of Australia for the amazing opportunities offered by these Fellowships for all Australians. As a relatively new Australian it brought me great pleasure to be awarded one of these prestigious fellowships and to proudly represent the Trust as an Australian citizen. My girls and I will always be very grateful for the opportunity this Fellowship provided and we will look back at the six weeks of travel with very fond memory.

EXECUTIVE SUMMARY

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The Phyllis Primrose Whyte Churchill Fellowship to investigate methods of teaching science at the undergraduate university level – New Zealand, USA and Canada

Project Description:

This project proposes to investigate methods of teaching science at the undergraduate university level in New Zealand, Canada and the United States. From discussing teaching practises with first year Biology coordinators in New Zealand and observing teaching methods in North American universities, where non-science students take a specially designed science course to gain scientific literacy will help me determine best and most effective teaching practises for Australia.

Highlights:

- One week of meetings with First Year Biology Coordinators and lecturers in Wellington, New Zealand
- Visiting multiple academics across Canada and the United States to learn about teaching innovations and pedagogy and
- The amazing generosity offered by every academic staff member who took time out of their very busy schedule, especially during exams and as Christmas approached to talk to me about teaching and to share their own passions about student learning.

Major Lessons Learnt:

- First Year Biology programs require huge investments in time and manpower if they are to engage students and help them with the transition from high school to university
- First Year Biology lecturers require adequate support in terms of teaching staff and funds in order to effectively build programs that can be sustained
- Teaching non-science students science requires a different teaching style and if not done carefully could result in courses that resemble core science courses that are simply taught at a lower level
- Not all courses for non-science students are taught to provide scientific literacy and in fact many lecturers teaching into the courses did not state this as their aim.
- Non-majors science courses are the largest courses being taught in American universities and yet there are little requirements regarding what should be taught and how it should be taught.
- Scientific literacy can be achieved in all university students if it is a requirement of the universities and if it is taught with that objective.

Dissemination and Implementation

- Discuss experience with university colleagues within South Australia
- Meet with all First Year Biology Coordinators from Australia at the First Year Biology Colloquium to be held in September 2012
- Implement various aspects of teaching and learning into a non-major's biology course at Flinders university
- Promote course for non-major's at National Science Education Conference, held in Sydney
- Promote course at the Australian Science Associate Dean's for Teaching and Learning Meeting held in July 2012

PROGRAMME

23 November – 30 November

Wellington, New Zealand

- Attend First Year Biology Educator's Colloquium, Victoria University, Wellington.

1 December – 4 December

Los Angeles, California, USA

- Visited the University of California, Los Angeles

5 December – 10 December

San Francisco Bay area, California, USA

- Visited the University of California, Santa Cruz
- Visited Monterey Bay Aquarium, Monterey Bay

11 December – 16 December

St. Catharine's, Ontario, Canada

- Visited Brock University, St. Catharine's, Ontario

17 December – 2 January

Vancouver, British Columbia, Canada

- Visited Simon Fraser University, British Columbia

MAIN BODY

University educated students should possess at least a basic level of scientific literacy so as not to be disadvantaged in a highly technological global environment. Most, if not all Australian Universities, list the graduate attribute of "being knowledgeable" yet many graduates are potentially unable to make decisions based on scientific understanding. Without a basic knowledge of science, graduates will find it difficult to make informed choices about their health care, their environment and the society in which they live. The ability to critically analyze the validity of a given argument or media presentation in order to come to a logical conclusion should be considered highly valuable in terms of graduate qualities and consequently an important requirement of all university degrees.

University students (both national and international) are our potential future leaders so it is particularly important for them to be able to weigh up ethical, moral, and social implications while maximizing the benefits of a given scientific development. Yet the proportion of students who study science at university is at an alarmingly low level, and in Australia continues to decline. Clearly there is a need to not only attract more students into science-based courses but to ensure that those who do enrol remain engaged with their course. It is also essential that universities provide non-science students with the basic scientific literacy to prevent misconceptions of current issues many of which are on a global scale.

Scientific literacy of students and the population in general is known to be quite poor. An increasing number of reports have documented student avoidance of science courses and the consequential result to national and world economy. The Nobel laureate come science education specialist, Carl Wieman, commented on the need to review science education, observing that far too few students choose to take science at universities and of those who do choose science many are finding science less interesting and relevant than they expected. Therefore, to improve scientific literacy amongst our university graduates, science courses needs to be promoted and taught in a way very different from their current form.

Fortunately, there does seem to be some movement in Australia and around the world to address these problems, primarily in the form of changing the way science is seen and taught. Although still in its infancy, improvement in the quality of teaching and the use of innovative pedagogical approaches can significantly influence students' attitudes toward science, thus

improving their scientific literacy in general. Interestingly, there have been few studies, and very little evidence to support whether either core or elective science courses can improve scientific literacy or whether they are at all valuable in helping resolve misconceptions or misunderstandings of relevant scientific societal issues. The aim of this Fellowship was:

1. To investigate educational pedagogies for best practice in teaching and learning science by both science and non-science students.
2. Determine non-traditional approaches used to maintain student interest and enrolment in science-based courses.
3. Determine whether innovative practise impact on preparing university students for future encounters which require scientific literacy

KNOWLEDGE I HOPED TO GAIN FROM THE FELLOWSHIP

The knowledge gained from this Fellowship will be used to apply best practices within South Australia initially and to disseminate across Australia and in doing so changing institutional practises. As found from projects that I have been involved with, science academics have a greater propensity to accept the findings of other science academics and are more likely to try innovations when they have been shown to be directly relevant to their discipline and presented in a language that they understand. I therefore will carefully plan a strategy by which to promote my findings to my teaching colleagues so that the information I have gained can be of most value.

WHY TRAVEL TO NEW ZEALAND?

Taking part in the First Year Biology Educators Colloquium in New Zealand allowed me to meet other lecturers and tutors to learn about recent innovations for the teaching of Biological Sciences to first year undergraduate students. The colloquium showcased a range of achievements from some of the best teachers and educators from across New Zealand and Australia. It also provided an opportunity to gain 'hands-on' experience in the use of digital technologies that are well known to increase student engagement. The opportunity to participate in a forum to discuss the current critical challenges facing first year Biology instructors at tertiary institutions in the Southern hemisphere provided excellent ideas and mechanisms to affect change.

One of the major challenges faced by first year coordinators is to maintain student engagement in large lecture theatres. Several of the speakers at the colloquium dealt with this issue. Ideas such as the use of personal response devices, colour coded cards to answer multiple choice questions, emphasizing new vocabulary through the use of hand movements, and group learning exercises all contributed to increase engagement. A move toward increasing the relevancy of biology to include real world examples where the theory of biology can be applied had a marked effect on student interest.

A current concern with lack of student engagement is the use of lap top computers in the lecture theatre. Many lecturers believe that students should use laptops in place of note taking; however a colloquium speaker demonstrated that most students who used a lap top in the lecture spent more time on social networking and surfing the internet than they did note taking. It was also found that nearby students were distracted by the computer and often drifted their attention to it rather than to the lecturer. Follow up discussion to prevent this was insightful and indicated perhaps a need for a culture shift away from the use of computers as a primary source for note taking.

A central issue for New Zealand is creating programs that can attract and maintain the interest of Maori students. Several papers were presented with ideas of how to use peer mentors, how to use songs and rituals in learning and how to promote the sciences. These discussions will be very useful for helping develop similar programs within Australia to increase participation of Aboriginal students and to promote an environment which leads to greater interest and success leading toward an undergraduate degree in the sciences. An excellent initiative was presented by peer mentors who discussed a peer mentoring scheme for Maori students that consisted of weekly sessions for discipline specific topics, run by second and third year students who received high grades in previous years. One method of enhancing concept understanding is through song. Within the colloquium we broke into groups and each group was asked to develop a song based on the most difficult concept covered in first year biology. The group that I was part of developed a song to explain Hardy-Weinberg equilibrium which is always known as a stumbling block for first year students. The song is sung to the tune, Old MacDonald had a farm:

Hardy-Weinberg made an equation:

P^2, q^2, 2pq

It is used to study populations

P^2, q^2, 2pq

With a p allele here and a q allele there,

Here a p there a q everywhere a 2pq

Hardy-Weinberg made an equation

P^2, q^2, 2pq

And in the equation there is a p

P^2, q^2, 2pq

That p is the allele frequency

P^2, q^2, 2pq

And q is an allele frequency too!

P^2, q^2, 2pq

Chorus

A significant outcome from the colloquium was the development of a network of Australian and New Zealand first Year Biology educators. We are currently in the process of organising a similar colloquium for 2012 that will be held in Adelaide, SA. All first year Biology coordinators from Australia and New Zealand will be invited to attend and participate in a highly practical session which will not only focus on best practise but also allow for opportunities to form collaborations and research networks.

WHY TRAVEL TO THE U.S.A.

Travel to the United States was important so that I could investigate methods being used to teach non-science students science, in other words how to teach non-majors biology. In this respect I was interested to find out whether scientific literacy can be gained through university courses.

The first university visited was UCLA where I met with Professor Jay Phelan who teaches a life science course in biology to non-majors. Jay has been featured on a variety of television documentaries as well as magazines and newspapers. He has won a variety of awards for his teaching, has written introductory non-majors text book and popular science books and his lectures can found on youtube where they are available to anyone who has interest in this area. http://www.youtube.com/watch?v=xktJl4tqK9E

Jay's unique style of lecturing includes a chalk board with lecture outline, one projector with overheads that he writes upon and one projector that provides photographs illustrating his main concepts. He does not use a power point presentation and refuses to give students his lecture notes, he believes that it is important for students to attend lecture and take their own notes. He also likes to have students draw diagrams with him in the lecture and to take home about 3-5 main messages from each lecture.

The time I spent with Jay showed me his passion for teaching and the time and effort he puts into helping his students learn. He wants students to find the creative side of biology and to

have fun while studying. As his course is specifically aimed at non-majors he wants to provide these students an opportunity to become biologically literate so no matter what area they study they will have some knowledge of biology to help them with their studies and with their life. He asks students to think about these sorts of questions:

- Why are humans one of the only species to have friendships?
- Is DNA fingerprinting foolproof?
- How can it be that almost everyone in the U.S. consumes genetically modified foods regularly without knowing it?
- Why do dieters lose large amounts of "water weight" during the first few days of a diet?
- Why isn't it always wise to take aspirin or other medicine when you have a fever?
- How does caffeine combat fatigue?

Jay is a fantastic lecturer, has a genuine interest in the students he teaches and by bringing in relevant topical issues he engages students in the material being covered.

One area of interest I have in particular is how to assess student learning, especially when looking at scientific literacy. I found it interesting that although this course is clearly aimed at providing scientific literacy, engaging non-science students in science, the assessment still mirrors that which a science student would undertake. A very formal midterm and final exam based primarily on multiple choice questions and short answers are used to test student's knowledge gained through lectures. The text book that Jay has written and uses in his courses is also fairly similar to core science text books and many of the main concepts covered are the same as what is taught in core biology programs. So although the course has a variety of applied and relevant examples it still focuses primarily on core concepts such as photosynthesis and cell biology and it is expected that students learn these in enough detail to be examined on them. Jay has developed a very extensive question bank that students can use to help them with the core material being covered and most of these questions focus on understanding of relevant core material. This finding was surprising and is indicative of the difficulties associated with the development of new innovations in assessment within the sciences.

My next stop within the United States took me to the University of California, Santa Cruz where I met with Professor Gregory Gilbert, director of SCWIBLES GK-12 Training Program. Currently the National Science Foundation is providing funding for 120 programs

across the country to investigate environmental issues and to promote scientific literacy. The aim of these programs is to improve scientific knowledge of the community and to allow voters making decisions to think about the scientific information behind a problem. This program is also aiming to determine methods to enable scientists to speak to members of the public, from primary school children through to high school. The funding opportunities provide up to 5 years worth of financial support, with most of the funds being used to support PhD fellowships.

The program at UCSC is specifically designed to teach science PhD students science education and to improve the scientific literacy of the local primary school children. PhD students while studying their scientific discipline must also develop classroom modules for the primary school children and work with classroom teachers to deliver the science module. In this way the school children get to meet real live scientists, they learn some interesting science, and the PhD science students learn to speak to non- science people, in this case school children. Classroom teachers spend some time in the field or laboratory helping the PhD student collect data thereby attaining professional development and getting firsthand knowledge of the project and scientific understanding that will help them teach the material. The program takes place over a whole year and the PhD students are expected to spend about 15 hours/week on educational activities.

The Monterey Bay aquarium prides itself on education initiatives and its role in increasing scientific literacy of students and the public in general. A two day trip to the Aquarium provided me with many ideas for using a zoo and or aquarium to teach undergraduate students. A particularly nice example at the Monterey Bay aquarium was the emphasis placed on seafood education, what are environmentally sustainable seafood to eat, and how to check labelling in order to obtain this knowledge. They also produced take away cards that people could keep in their wallets as a handy way to check this information first hand. Interestingly, written wall displays had very few people engaged in learning, whereas video displays and more interactive displays seemed to hold students attention for longer and presumably increased their understanding.

WHY TRAVEL TO CANADA

I visited two universities whilst in Canada, Brock University in St. Catharine's Ontario and Simon Fraser University in Vancouver, British Columbia. Both of these universities are similar in age, size and course offerings as Flinders University, which allowed me to make observations that could be directly applicable to my current teaching practises. Both universities offer degrees in Biological Sciences and both teach introductory Biology to students who are Biology majors and another course purposely designed for non-majors. Through observations and discussions I found that core Biology courses tend to be taught in a traditional fashion in Canada, basically three lectures per week with an associated laboratory and tutorial. The topics covered are essentially the same as they are in Australia and the text books used are also the same and these tend to drive the curriculum. I had the opportunity to meet with both lecturing staff and practical teaching staff and was provided with copies of lecture and laboratory teaching materials. Assessment in core Biology courses tend to be through examination at the end of the year and lecturers are focused on providing students with content and understanding of core Biology concepts.

Teaching in the non-majors courses were essentially equivalent as to the way Biology majors are taught, but at a slightly lower level. Interestingly, there was still a focus on learning the content and understanding core Biology concepts. The assessment also mirrored that of the core courses being primarily end of year examinations as well as practical examinations. Upon speaking with various lecturers teaching into the course, some spoke of improving scientific literacy of this group but most spoke about teaching non-Biology students how to think like scientists and about the importance of learning core Biology concepts. Few of the lecturers spoke about making topics relevant to societal issues or designing the course in a way different from the way science students are traditionally taught.

RECOMMENDATIONS

1. Current teaching practises for undergraduate science students should be continually monitored and academics need to seek ways to increase enrolments and student engagement.

2. Australian universities should consider scientific literacy of their non-science students and either mandate a science course for all university students or build scientific literacy teaching into programmes within current course offerings in order to improve scientific literacy of all undergraduate students.

3. Science pedagogy at the university level needs to become more innovative in order to maintain student interest, deal with an increased diversity of students from different backgrounds and determine means of teaching that are outside the traditional approach.

4. Teaching science to non-science students does not need to be done in a traditional fashion, with assessment being focused on examinations. Providing relevant real world examples works well to increase student interest but perhaps using case-based teaching with a critical thinking approach to assessment may improve student understanding of current global issues.

5. Engaging science PhD students with education initiatives can help improve their communication skills with school aged children and the public in general. This type of program can build trust between scientists and the public and can improve professional development of teachers.

CONCLUSION

The Phyllis Primrose Whyte Churchill Fellowship has provided me with an invaluable experience. I feel very privileged and honoured to have made these discoveries through the travel that the fellowship enabled. I have learned a great deal from many science academics who have undertaken tremendous workloads and challenges to create programs of study that encourage student learning and embed a passion for science. I have without – a – doubt gained an international view of teaching undergraduate science which will allow me to improve my own teaching and hopefully the teaching of my colleagues across Australia. This would never have been possible without the generous support of the Winston Churchill Fellowship.