Title: Growing Tall Poppies in Secondary School Science

Dr Eroia Barone-Nugent Science Domain Leader and Growing Tall Poppies Program Manager at Santa Maria College, Northcote

BACKGROUND

'Growing Tall Poppies: an authentic science experience for secondary school students' (GTP) is a collaboration between Santa Maria College Northcote (SMC), the Australian Research Council Centre of Excellence for Coherent X-ray Science (CXS) and AKORN Educational Services. GTP is supported by the Catholic Education Office Melbourne (CEOM) and the National Australia Bank (NAB) Schools First program.

SMC is a Catholic girls school in the inner-north of Melbourne. The College has a vision is to ensure that students are fully able to realise their potential in all areas of academic endeavour.

CXS is a multi-university and interdisciplinary science research organisation that is based in the School of Physics at the University of Melbourne. It has an imperative to share the interdisciplinary research they conduct and to encourage students to pursue careers in the sciences. CXS is composed of six research programs across four Melbourne universities (University of Melbourne, La Trobe University, Swinburne University of Technology and Monash University) and one in Queensland (Griffith University). AKORN Educational Services is an educational provider. It facilitates partnerships between schools and industry organisations. AKORN matches school groups with GTP projects and it provides leadership training for students and supports them during the projects.

The GTP program is focused on giving secondary school students, especially girls, an authentic experience of the physical sciences. Students are expected to collect first hand data from experiments and then to analyse and publish the results on a public web site. They are encouraged to contribute original ideas and propose lines of investigation. Through this enquiry-based experience students are given the opportunity to use their curiosity by being placed in a real scientific research environment so as to get a genuine feel for how interesting and relevant the physical sciences are to their world and their future. It allows young women and men to exercise not only their curiosity but also to create knowledge and to practice team-building and leadership skills.

"Tall Poppies" is an expression used to describe people who rise conspicuously above the norm in achievement. The purpose of the GTP program is to help young Australians, who have the potential, to become "Tall Poppies" in science. It is genuinely about growing new Tall Poppies for Australia.

GOAL OF THE GROWING TALL POPPIES PROGRAM

The last two decades tells a grim story with a low number of students studying science. There has been a decrease in the number of high school students choosing the sciences, especially the physical sciences. Girls have particularly shied away from physics.

The goal of the Growing Tall Poppies program is to increase the number of students, especially girls, interested in studying the physical sciences to Year 12 and beyond.

I have led the development of the GTP curriculum-based program to engage year 10 science students in authentic enquiry-based research projects where the focus is on ‘why science is meaningful and why we should care about it’. This was in response to the literature and anecdotal evidence, which strongly indicates that girls need to see the connectedness of the subjects they choose with the real world. This goal is shared by the CXS members and through this shared goal a strong partnership has developed. Furthermore, the support from AKORN Educational Services allows participation by year 10 students from many schools across metropolitan Melbourne.

This project has received pilot funding from CEOM, funding and in-kind support from CXS, and a seed-grant from the Knowledge Transfer Department at the University of Melbourne. The excellence of the GTP program was recognised when the partnership won the 2009 NAB *Schools First* State award of $100,000. These funds are allowing us to grow the program in new directions and widen its reach.

THE GROWING TALL POPPIES PROGRAM

The GTP program is an innovative context-based curriculum that creates an authentic science environment for students aged 15 – 17 to promote enduring learning of science content by relating its meaningfulness to society, community and individuals. The program focuses on how the scientific process is a way of building knowledge to improve the quality of life and to solve problems, which confront society today. It connects students and the science community to explore science knowledge, the process of its formation and its relevance.

Students are mentored by professional scientists and participate in current experiments to obtain first hand data that is, in some cases, the first collected in the world. Students are immersed in labs that are working at the forefront of science. Students formulate questions and search for the solutions together with the scientists. Students experience meaningful learning by linking the science content to experimental process and also to the relevance of science to every day human life.

In summary, GTP has the following key features:

1. It takes students out of the classroom and immerses them in world leading science laboratories with world-class scientists and cutting edge technology

2. It provides context-based projects to relate science content to a broader contextual meaning

3. It allows an inside look at world leading science projects in Australia

4. It expects students to gather results that contribute to scientific knowledge

5. It expects students to present their work to the scientific community and publish their work online, and to reflect on the meaning and importance of science

6. It develops student expertise and knowledge that is shared with their school community

The outcomes of the project are aligned with the VELS and the International Baccalaureate Middle Years Program curriculum. These encompass knowing the cutting edge technologies used in science including the Australian Synchrotron, formulating investigation questions. Furthermore, the interdisciplinary strands of connecting to community and industry, communication and reflection are also included. This method of learning connects the learner to many aspects of the curriculum that are inaccessible through conventional models. The GTP curriculum outline and student projects can be viewed on the GTP web-site http://www.coecxs.org/index.php?mod=Dynamic&id=32.

I have designed the GTP curriculum to allow students to focus on the interconnectedness of science to other facets of life and society. It provides opportunities to enquire into science with self generated questions. This builds an understanding of the interdisciplinary nature of science, as well as society's dependence on scientific knowledge and understanding.

Each of the Melbourne-based CXS programs host a groups of six students who work for a period of one week with scientists on current research projects. The students are actively involved in the projects in an authentic manner to promote questioning and enquiry to foster enduring knowledge and understanding of science. Each project is interconnected with all CXS programs and students provide input to future student projects.

The student projects are designed to guide, but not limit, students' participation in the research conducted by CXS physicists, biologists and chemists. The enquiry-based projects provide students with the opportunity to follow their own line of enquiry and test hypotheses.

With access to a number of special scientific research facilities, the GTP program allows students to see and or use equipment that would otherwise be unknown to them, such as the Australian Synchrotron, 3-D Tomography Machines, Ultra-Fast Lasers, Cry-Electron Microscopes, Fluorescence Microscopes and spectrophotometers. These technologies are underpinned by high power computer analysis technology. Through experimental investigation and reflective discourse with experts, students learn the issues associated with science and they get the chance to synthesise individual opinions and critical thinking. The confidence students gain from working in this environment arms them with skills for future learning as well as developing them as global citizens for the challenges of a new Millennium.

PROGRAM EXAMPLES

Project Title: What are we all 'wining' about?

Students worked in the CXS Attosecond Laser Lab based at the University of Melbourne, where they investigated the breakdown products of wine due to light. This was especially interesting because the wine industry is considering dispensing with green glass bottles in favour of clear glass bottles because it is more energy efficient to recycle clear glass. Consequently this would reduce costs and reduce the carbon emissions that contribute to climate change. Using clear glass however, may have an effect on the taste and shelf life of the wine, which is very important to the sellers and consumers.

The students collected first hand data using light spectrometry to investigate the break down products of wine under different light conditions. They made no conclusions so far of the effects excessive light can have on wine quality but they were excited about the Australian scientists taking the lead in reducing carbon emissions by investigating the use of clear glass wine bottles rather than coloured glass. These students have participated in cutting edge science that will contribute scientific knowledge to inform decisions about storing wine that can lead to reducing carbon emissions and so safe guarding the future.

Project Tile: Jurassic Park in Miniature

Using 3D Tomography machine students imaged an insect fossilised in amber believed to be over one million years old. Prior to the experiment it was unclear whether such an image could be reconstructed using this method. The students collected excellent first hand data that has contributed to uses for this type of imaging technique. Their findings have been used to demonstrate the importance of 3D X-Ray imaging techniques with this instrument to biological investigations, and will appear in a peer reviewed scientific journal.

The students' investigation of the fossilised ant in amber raised two questions, which they further investigated. From their own reading on the topic they noted that the amber specimen appeared too soft to be true amber which cast into doubt the age of the fossil ant. The students followed this line of investigation and measured the hardness quotient of the amber and concluded that it was most likely closer to several hundred thousand years old rather than one million.

Further more the students were not satisfied that some of the structure they observed was not an artefact of the fossilisation process and suggested that a control specimen of an extant (currently living) ant could serve to substantiate the results of the structures of the fossil ant. They followed this line of investigation by analysing a 3D X-Ray image of a garden ant and concluded that the structures were most likely physiological rather than artefacts. This data also allowed the students to compare the anatomy of the fossilised and recent ant to determine possible evolutionary changes that may have occurred over several hundreds of thousands of years.

The participants were able to use scientific method to follow their own line of investigation and to provide evidence to substantiate their findings.

FUTURE DIRECTIONS

The program is also providing a unique opportunity for scientists to reflect on their role as advocates of science in the community. Furthermore, teachers have been inspired to experience this authentic science experience to stimulate and invigorate their classroom teaching practice. This extension of the Growing Tall Poppies program that places groups of teachers with scientists to investigate cutting-edge technology and the relevance of the scientific research will be continued in 2010.

Future directions for the program is to develop a variety of delivery models including an on-line learning environment to utilise the modern mode in which students communicate. This will allow students and scientists to work on projects via web-based forums and to link into scientific facilities, for example the Australian Synchrotron, to perform experiments remotely (consistent with the way scientists are currently performing experiments).

THE ‘GROWING TALL POPPIES’ EXPERIENCE

Student and Mentor responses to the program are as follows:

“An experience that you wouldn’t get elsewhere, it was challenging, exciting and different.” – Amelia Hamer, Age 16 years.

“The Growing Tall Poppies was an important program. Not only did it help me explore my own capabilities, explore new interests in the field of Physics and explore science outside the classroom but it also has demonstrated the importance of working collaboratively in a team. The Growing Tall Poppies program revealed the importance of science in today’s society and has inspired me to continue to study science.” Tess Kirkinis, Age 16 years.

“The best part was learning how the three sciences (physics, chemistry and biology) complement each other. This program showed the practicality of science, which is completely different to classroom science.” Sharon Lee, Age 16 years.

“I enjoyed working with other classmates independently as well as learning about how applying physics and biology can make a difference.” Natalie Ng, Age 16 years.

Associate Professor Trevor Smith stated that, *“The Growing Tall Poppies program provides a great mechanism through which students get to see behind the scenes of a working science laboratory. It helped us to identify ways of communicating and highlighting what we do to students who are (currently) non-specialists. Participation in this program reinforced the importance of science education and invigorating interest in science. It also helped to illustrate how our (sometimes apparently esoteric) scientific investigations are directly applied to real world problems”.*

REFERENCES

Providing Hands-On, Minds-On, and Authentic Learning Experiences in Science http://www.ncrel.org/sdrs/areas/issues/content/cntareas/science/sc500.htm

Bulte, A.M.W., Westbroek, H. B., de Jong, O., & Pilot, A. (2006). A research approach to designing chemistry education using authentic practices as contexts. *International Journal of Science Education*, 28(9), 1063-1086.

Cumming, J. J. 1997, 'Attracting girls and women students to non-traditional areas', *Queensland Journal of Educational Research,* vol. 13. http://education.curtain.edu.au/lier/qjer_13/cumming.html

Girls are underrepresented in physics despite curriculum and pedagogical initiatives to make physics more appealing. VCE data(Cumming, 1997; IUPAP, 2005; Kelly, 1982; Parker, 2002).

Hart, C., Fry, M., & Vignouli,V. (2002). What does it mean to teach physics 'in context'? a second case study. *Australian Science Teachers Journal,* 48(3), 6-13.

Hudson, H. T. & Liberman, D. 1982, 'The combined effect of mathematical skills and formal operational reasoning on student performance in the general physics course', *American journal of Physics,* vol. 50, no. 12, pp. 1117 - 1119

IUPAP 2005, *Women Physicists: Progress?,* International Union of Pure and Applied Physics, 12.

Kelly, A. 1982, 'Why girls don't do science', in Kelly, A. (Ed.) *Science for Girls?,* Open University Press, Milton Keynes, pp. 12 - 17.

Kelly, A., Whyte, J. & Smail, B. 1984, 'Girls into science and technology: final report', in Kelly, A. (Ed.) *Science for Girls*, Open University Press, Milton Keynes

Lyons, T. 2005, 'The Puzzle of Falling Enrolments in Physics and Chemistry Courses: Putting Some Pieces Together', *Research in Science Education,* vol.

McKenzie, J. 2006, *Extended Inquiry,* Extended Inquiry - Melbourne 2006, From Now On, Melbourne, <http://www.fno.org>

Parker, K. 2002, 'Men are not from Mars', *Physics Education,* vol. 37, no. 1, pp. 12-17.

Smail, B. 1985, 'Organizing the curriculum to fit girls' ineterests', in Kelly, A. (Ed.) *Science for Girls?,* Open University Press, Milton Keynes, pp. 80 - 88.

Smail, B. 1987, 'Encouraging girls to give physics a second chance', in Kelly, A. (Ed.) *Science for Girls?,* Open University Press, Milton Keynes.

Stage, E. K., Kreinberg, N., (parsons), J. E. & Becker, J. R. 1985, 'Increasing the participation and achievement of girls and women in mathematics, sciences and engineering', in Kelly, A. (Ed.) *Science for Girls*, Open University Press, Milton Keyes, pp. 119 - 133.
Stokking, K. M. 2000, 'Predicting the choice of physics in secondary education', *International Journal of Science Education*, vol. 22, no. 12, pp. 1261 - 1283.
Walkington, J. 1998, 'Girls selecting mathematics and science: Making choices and having expectations', *Queensland Journal of Educational Research*, vol. Vol 14
Williams, C., Stanisstreet, M., Spall, K., Boyes, E. & Dickson, D. 2003, 'Why aren't secondary students interested in physics?' *Physics Education*, vol. 38, no. 4, pp. 324-329.
Victorian Curriculum and Assessment Authority, V. 2004, *Physics: Victorian Certificate of Education Study Design*, Victorian Curriculum Authority, Melbourne.
Victorian Curriculum and Assessment Authority, V. July 17, 2006, 'VCE Statistical Information', http://www.vcaa.vic.edu.au (September)
Victorian Tertiary Admission Centre, V. Course Search: Major search', http://www.vtac.edu.au/courses/searchmajors.html (September)