An integrated, industry-linked approach to developing a nanotechnology curriculum for secondary students in Australia

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ABSTRACT

St Helena Secondary College, Bridge 8 Pty Ltd and Nanotechnology Victoria Ltd have formed a partnership to develop a curriculum that will be implemented in Victorian high schools from 2007. The approach taken by this collaboration is distinctive for three reasons. First, the curriculum is specifically focused on nanotechnologies for secondary schools. Secondly the partnership between Government, education, and industry has ensured the involvement of the broader nanotechnology community. Thirdly, the curriculum covers the science, its breadth of applications and implications for the community. It is this unique approach that delivers valuable skills for the Victorian and Australian community and positions these to capture the benefits of nanotechnology.

Keywords: nanotechnology, education, industry, society

1 INTRODUCTION

Nanotechnology is an emerging driver of industry development. It requires scientists and industrialists to integrate across traditional boundaries to exploit its full potential. It also requires open engagement of a skeptical public to debate and decide on its place in society.

The Government of Australia's major manufacturing State, Victoria, has recognized this challenge and invested in education to address these needs. St Helena Secondary College – one of Australia's foremost high schools; Bridge 8 – a leading foresight and communications consultancy for new technologies; and Nanotechnology Victoria – an industry investment vehicle for the commercialization of nanotechnologies; have formed a partnership to develop a curriculum that will be implemented in Victorian high schools from 2007.

2 NANOTECHNOLOGY AT ST HELENA SECONDARY COLLEGE

St Helena Secondary College is a government school providing education for students from year 7 to 12. The school runs an accelerated program for advanced students, compressing their required curricula needs for years 7-10 into three years, thereby allowing for extended learning.

St Helena Secondary College is a recognized for its approach to excellence in the sciences. In 2006, a team of seven teachers – Francesca Calati, Christine Willocks, Juha Ruuska, Hong Tay, Huwi Mak, Jenny Russell, and Amanda Clarke - applied for a Teacher Professional Leave (TPL) Grant from the Victorian State Department of Education and Training (Northern Region). The grant was successful and enabled these teachers to take leave from the classroom in order to research nanotechnologies and develop a specific nanoscience and nanotechnology program.

This program is positioned as a flagship program for the school. Its purpose is to excite and support science students pursuing careers in the emerging nanotechnology industry. The program also engages other students, parents and the community, creating knowledge and recognizing many different perspectives and concerns about a new technology.

The nanotechnology program is important because it provides training for the next generation of nanotechnologists, giving these students an advantage for future careers. More broadly, it engages all students in an exploring new applications of science.

2.1 Nanoscience & Nanotechnology Elective

The main part of the nanotechnology program at St Helena Secondary College is a nanoscience and nanotechnology elective aimed at year 10 students. The course structure is unique because the theory incorporated in it is driven by the applications of nanotechnology.

The program provides plenty of content for teachers to choose from to meet the needs of their class. In addition, the content has been designed to be engaging and thought provoking. Topics include 'what if' statements that examine the potential of nanotechnology to solve problems and innovate. The program examines cutting edge applications of nanotechnology and also investigates the potential of future applications such as the 'space elevator' concept. The outcomes of the program are adjusted according to the group and this in turn drives the approach to assessment.

There are seven flexible modules in this program that can be adapted to suit any middle school science course from year 7 to year 10. These are described in Table 1:

Module	Course Content
Module 1	Introducing the metric system; understanding the nanoscale; comparing size; using scientific instruments; using scientific methods.
Module 2	Revision of bulk properties (classical effects); introducing properties at the nanoscale (quantum effects); investigating nanoparticles, EMS, magnetism and ferrofluids; memory alloys; investigating the effect of particle size - surface area, reaction rates, diffraction patterns.
Module 3	Investigating performance materials - bonding in carbon, graphite, and diamond; buckyballs; single and multi-walled carbon nanotubes; nano capsules; polymers; applications of these technologies for industry, sport and leisure
Module 4	Investigating nanotechnology in health – understanding DNA, proteins, and microbiology; considering examples such as for transdermal patches; looking at disease diagnosis and treatment
Module 5	Investigating textiles and glass in the home – discovering surface chemistry; applying nanolayers to alter properties; looking at applications in textiles and glass
Module 6	Introducing consumer science – looking at applications of nanotechnology in food and cosmetics (including sunscreens), learning how to read and interpret consumer product labels.
Module 7	Taking a broad view and looking at issues associated with use of nanotechnologies – critical analysis of media articles; guest speakers with a range of perspectives; participating in the 'utility fog' workshop to consider the social impacts of nanotechnologies.

Table 1: Learning Modules for Nanoscience and Nanotechnology Elective.

For the purpose of this program, nanotechnology is defined as processes that occur at one-billionth of a meter and where the properties are different to those found in bulk quantities of the same material. The combination of both scale and properties make nanotechnology meaningful.

Module 1 introduces the concept of nanotechnology by considering the nanoscale world and comparing size on the metric scale. This module enables students to use scientific instruments such as rulers and micrometers to measure size and get an appreciation for the nanoscale. A sorting activity featuring a range of objects in power of ten increments also allows students to appreciate scale.

Module 2 discusses properties in bulk materials and the different properties that can arise at the nanoscale. Specific properties investigated include conductivity magnetism and color. Simple experiments such as one using sugar cubes and crystals can be undertaken to demonstrate the effects at different particle sizes.

Module 3 examines applications in performance materials and uses these applications to introduce Buckyballs and carbon nanotubes. It asks 'what if you could knit a car?' and 'what if you could play golf like Tiger Woods?' and then uses potential applications of carbon nanotubes and other performance materials to address these questions.

Module 4 examines the applications of nanotechnologies to health issues. It asks 'what if you could cure cancer?' and looks at the use of gold nanocapsules as delivery agents. It also looks at the development of transdermal delivery patches and disease diagnosis.

The next two modules look at consumer products. Module 5 looks at textiles and glass applications and then delves into surface chemistry to explain the mechanics. Module 6 is devoted to food and cosmetics and looks at the chemistry involved in the manufacturing process, and also includes a section on understanding product labels.

The final module opens up the study of nanotechnology to consider its effects on society. It includes the innovative 'utility fog' workshop developed by Bridge 8 (discussed further in section 3.3). Other activities suggested for this module include the critical study of media articles on nanotechnology, and visiting guest speakers. Some of these activities were trialed with students prior to implementing the entire program. It was observed that the more students knew about nanotechnology prior to tackling these issues, the better they were equipped to handle the complexity of the technologies and the complexity of possible responses.

2.2 What Color is Gold?

Another component of nanotechnology at St Helena is a year 11 chemistry module on gold. The module is framed by asking the question 'what color is gold?' and then investigates the properties and uses of nano-gold particles.

Central to this gold module is three experiments that were developed by St Helena students during work

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experience at RMIT University. The experiments include the synthesis of gold nanoparticles, electrophoresis to determine the size of the nanoparticles and a final experiment that looks at the plasmon effect occurring when gold nanoparticles are coupled and how this can be used for medical diagnostics.

This is an exciting outcome as the VCE (Victorian Certificate of Education) Curriculum has recently included a study module on nanotechnology for year 11 Chemistry. Many science teachers are looking for interesting and simple ways of introducing nanotechnology to the classroom and there has been much demand for this package. A recent science teachers' conference in Melbourne (STAVCON) saw over 200 teachers attending the nanotechnology presentation by St Helena Secondary College, and leaving their contact details in order to receive the program for inclusion in their chemistry classes.

3 AN INTEGRATED APPROACH TO LEARNING

These nanotechnology curricula are ground-breaking in Victoria, not just for the development of nanotechnology content for the classroom, but also because of the approaches to learning in developing and delivering the curricula.

3.1 An Industry-Linked Approach

The teachers developing this program have not acted alone – it has been and industry-linked integrated approach to developing robust curricula that meet the needs of industry in Australia. This has been achieved through the partnership between Bridge 8 Pty Ltd, Nanotechnology Victoria Ltd and St Helena Secondary College.

Bridge 8 Pty Ltd is a foresight and communications consultancy with a special interest in new technologies and has contributed to the curriculum development by coordinating many of the activities and providing back-up for teachers' research. Nanotechnology Victoria Ltd is an industry investment vehicle for the commercialization of nanotechnologies. These organizations have assisted teachers' learning about nanoscience and nanotechnology and the field of nanotechnology in Australia. The expertise of Nanotechnology Victoria Ltd in commercializing research initiatives has provided in-depth learning and demonstrations that are able to be used in the classroom. Nanotechnology Victoria Ltd has also contributed funds towards the establishment of a dedicated nanotechnology laboratory at St Helena Secondary College. The on-going collaboration between these organization have also led to important relationships with the broader nanotechnology community in Victoria.

Teachers have attended nanotechnology undergraduate degree programs including a lecture series at La Trobe University that features the latest research and views on nanotechnology from guest speakers. La Trobe University students have been involved in a peer mentoring program that has seen them assisting science teachers at St Helena Secondary College to run nanoscience experiments involving specialized equipment for the year 10 science classes. These tertiary links are important as La Trobe University is a major catchment institution for the students from St Helena Secondary College.

There has also been close involvement with RMIT University. Three students from St Helena Secondary College undertook work experience in one the of RMIT laboratories and used their time to assist in the development of experiments investigating gold nanoparticles. This was a productive experience resulting in outcomes for the St Helena Secondary College curricula, and challenging and fulfilling work experience for the students. Staff at RMIT University were also impressed by the level of enthusiasm and skills of these secondary school students.

St Helena Secondary College students have also undertaken excursions such as the visit to the Monash University Science Centre to learn about biotechnology applications of nanotechnologies. The teaching team developing nanotechnology curricula also attended a three day Annual Cosmetic Conference in Geelong, Victoria, giving them additional background in skin care and sunscreen applications for Module 6 of the year 10 program.

The St Helena Secondary College teaching team has also provided input into a nanotechnology kit being developed with the assistance of Nanotechnology Victoria Ltd. This nanotechnology kit provides a number of simple, yet useful nanotechnology experiments that could be performed in the home or classroom.

Finally, the teaching team has approached members of the nanotechnology community to present their perspectives to students. Topics under consideration include research initiatives, toxicology, ethics, environmental group viewpoints and commercialization projects.

3.2 An Student-Focused Program

The breadth and complexity of nanotechnology sometimes makes it difficult to develop a curriculum that does justice to the basic science and the understanding of the possibilities. After much consideration, the St Helena program gets this balance right by focusing on the interests of students.

Specifically, the program focuses on the applications of nanotechnologies and then uses these to delve into the

supporting theory. This gives students something tangible to identify with immediately.

In addition, the program delivers learning through a variety of media including PowerPoint presentations, videos, animations, worksheet activities, experiments, demonstrations, research projects and discussion topics. Through this approach, the content appeals to a variety of learning styles and engages different students in different ways.

The student-focused approach also means it is easy for teachers to take and adapt for their own classrooms. The interest from science teachers in the program has been overwhelming. Bridge8 Pty Ltd and St Helena Secondary College are now working with the Victorian State Department of Industry, Innovation and Regional Development to engage the services of a design team to help make the year 11 'What Color is Gold?' curriculum accessible and adaptable for schools through Victoria.

3.3 A Multidisciplinary Program

Thirdly, the nanotechnology program is multidisciplinary. It covers basic biology, chemistry and physics as required by the secondary school curriculum, but it also engages other disciplines.

The program presents an integrated approach to the teaching of nanotechnologies building on underlying sciences. Nanoscience and technology cover a complex range of interdisciplinary sciences and it can be difficult to approach the teaching of nanotechnology by focusing first on the basic science. Where the St Helena Secondary College nanotechnology curricula have been so successful is by focusing or applications of the nanotechnologies and then exploring the basic science that provides knowledge and understanding underneath. In doing so, the program ensures that the fundamental science required by a general science class is covered. Students gain a detailed and competent knowledge base in science.

Nanotechnologies are also considered in the broader view of the impacts on society. This is achieved through a speaker program, research reports and an innovative workshop developed by Bridge 8 that encourages students to think about the future of nanotechnologies and society by considering the potential impact of molecular manufacturing technologies, in particular utility fog. The workshop introduces the concept of utility fog as invented by J. Storrs Hall [1]. Small groups think about its implications in five different perspectives including society and culture, the environment, technological innovation, behavior and belief systems to develop an understanding of the critical issues associated with the introduction of utility fog. These critical issues are often the same for the introduction of any new technology and include questions around health and safety, governance, environmental impacts and creativity and expression.

The program can be adapted to introduce sections at younger year levels. Furthermore, the program can be expanded into other subjects. Year 8 art students will be trialing the use of shape memory alloys in jewelry-making and sculpture as a component of their visual arts program.

4 CONCLUSIONS

The approach taken by the Victorian collaboration is distinctive for three reasons. First, the partnership between Government, education, and industry has ensured the involvement of the broader nanotechnology community the curriculum. Secondly, the nanotechnology program is specifically focused on nanotechnologies for secondary schools and is designed to meet the needs of teachers and the interests of students. Thirdly, the curriculum covers basic science while also including the breadth of applications and implications for the community. It is this unique approach that will deliver valuable skills for the Victorian and Australian community and position these to capture the benefits of nanotechnology.

REFERENCES

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