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[Home](#) > NBN Virtual School of Emerging Sciences: How to transform the world one scientist at a time...

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### NBN Virtual School of Emerging Sciences: How to transform the world one scientist at a time...

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**TJA - Vol 62, No 5 - November 2012** <sup>[4]</sup>

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#### Abstract

The National Broadband Network (NBN) creates new opportunities for collaborative education. John Monash Science School, Monash University and Pearson Australia have joined together to provide the NBN Virtual School of Emerging Sciences (NVSES), linking together Year 10 students who are passionate about science. The programme provides access to experts in leading fields such as nanotechnology and astrophysics, and gives students the opportunity to be knowledge creators as well as problem solvers. With their experience designing real-world research projects to solve today and tomorrow's problems, graduates of the programme will be well-placed to contribute in their future workplaces.

#### Introduction

The future of Australia's economy lies in well-educated innovators in the knowledge workplace. It is well understood that science plays a key role in the research and development capability of a nation. However, current participation in science in secondary schools is in decline. The National Broadband Network (NBN) Virtual School of Emerging Sciences (NVSES) aims to inspire and equip senior secondary students to be explorers and agents of change, particularly in the "discovery" fields of science.

Modern sciences like nanotechnology, astrophysics and bioinformatics are a source of great interest to many students, but most schools do not have the resources or expertise to explore them. To address this need, John Monash Science School (JMSS), Monash University and Pearson Australia are joining together to provide a world-first programme of emerging science education to schools across Australia.

The NVSES programme will use the NBN to create virtual classrooms of students drawn together from multiple schools. These students will get the opportunity to connect with world leaders in the emerging sciences, exploring the latest insights and designing a research project that applies this knowledge in students' local context.

The NVSES will use a variety of social, collaborative and self-directed learning tools to ensure students are both challenged and supported in their learning experience by peers and teachers. This will include leading cloud-based solutions such as Google Apps for Education and innovative educational technology from leading vendors such as Pearson Australia and Cisco Systems Australia. Open-ended enquiry will be supported with remote access to real and virtual research equipment.

The programme provides broader access to scarce resources; teachers, experts and equipment, which many students across Australia could not otherwise access. The social approach provides an opportunity for the learning experience to be shared beyond participants to their local classmates and their families.

Students will graduate from the NVSES programme with hands-on experience of researching in the emerging fields of science and applying scientific practice, including the opportunity to defend their work to peers and leading academics. Students will learn that science is not a passive learning of formulae and facts, but an active search for new meaning and a deeper understanding of our world.

It is also hoped that a powerful, positive experience of science as a continually emerging field, in their formative years of schooling, will impact students' selection of science in higher education and future career paths.

Teachers from the participating schools also have the opportunity to engage with and learn from the experience, with mentoring and professional development provided by teachers from JMSS and academics from Monash University. This powerful dynamic of teachers learning alongside students and the blurring of traditional roles, spaces and pedagogies will make the NVSES a very exciting "place" to learn.

## Beginnings ? the JMSS Regional Science Exchange

The NVSES builds on a successful 2011 and 2012 'Regional Science Exchange' programme conducted by John Monash Science School (JMSS) in partnership with Monash University Faculties of Education and Science), the Victorian Education Department (DEECD) and 14 regional and rural schools.

JMSS is a specialist science school established by Victoria's Education Department to raise the profile of science education and demonstrate new approaches to exploring science in secondary schools. Working with Monash University, JMSS developed a programme of science electives targeted at Year 10 students. The semester-long electives provide students with a chance to engage directly with Monash scientific researchers and outside experts in fields such as:

- Nanotechnology
- From Cells to Systems (Biomedical Science)
- From Bugs to Drugs (Pharmaceutical Science)
- From Quarks to Quasars (Astrophysics)
- Our Dynamic Earth (Geoscience)
- Bioinformatics
- Imaging Science (imaging and visualisation)
- Marine Science
- From Logic to Magic (mathematical pattern, logic and beauty)
- Computational Thinking

In studying these electives, JMSS students are also exposed to world leaders in scientific research (eg. a recent lecture by Nobel laureate Brian Schmidt on the big bang and the future of our universe).

Students not only learn from experts, high quality resources and experimentation, but there is an equal emphasis put on collaborative research in a real world context. Students explore questions, through a model of scientific enquiry, which are meaningful to them and in many cases are the questions being explored at the cutting of scientific research in labs around the world.

Students share their research findings through an annual science fair where they have to explain and justify their work to peers, parents and academics from Monash and beyond. These projects are the lynch-pin of the programme ? students are not only exposed to these emerging fields of science but are participating in how they can be used to solve current and future problems, becoming knowledge creators as well as knowledge consumers.

### Taking the emerging sciences beyond JMSS

With a mandate to facilitate change in science education across Victoria, JMSS leaders worked with regional directors in Loddon-Mallee and the Grampians to extend access to the programme to students in rural and regional schools. Students visit the JMSS campus for five weeks of on-site participation, and then collaborate with JMSS peers and teachers from their home school for a further ten weeks.

Although the programme has limited participation (as few as one child per school, including one who flew in each week to participate), the continuation of the programme at the student's home school gives both their peers and their teachers an opportunity to share in the experience. Teachers also access professional development around innovative educational approaches in teaching the emerging sciences through enquiry and technology.

The programme has been a huge success in terms of developing links between remote learners and teachers which revolve around a passion for science and a building of capacity to engage in scientific learning which is cutting edge, challenging and critical in developing the skills needed to continue work in scientific research. In addition, the experience of learning in a school so closely linked to a university has changed the aspirations of some students in terms of participating in higher education.

Although JMSS and regional schools will continue the programme, it is necessarily constrained in scale by its on-site nature and the physical housing of students in homestays. The NBN provides an opportunity to massively scale up the approach, providing students around Australia a chance to engage with these emerging sciences, and thereby increase their desire to study science, enter University and become explorers and agents of change in Australia's knowledge workplaces.

Feedback from students participating in the 2011 regional science exchange

Feedback from participants in the programme has been very positive. Comments from participants in the 2011 programme include:

"Going to Uni and seeing what kind of sciences you can do in jobs, it's shown me there are lot more job opportunities than just medicine. I'm now thinking of a career in either orthodontics, geology, zoology or palaeontology.

"I was actually thinking that maybe I wouldn't go to uni, but now I'm thinking that I really want to go."

? M, 2011 participant

I'm thinking [of pursuing a career in] physics, whereas before I came here, I was thinking more towards medicine.

"When you experience all the different sciences first-hand ? not just second-hand information from other people and off the Internet ? it's really good."

? D, 2011 participant

"I definitely want to do stuff in science, which I wasn't too sure about when I first came here. But now I know what I really want to do: I'd like to be a zoologist.

? S, 2011 participant

## Project rationale

Beyond just providing access to scarce resources, such as qualified physics and chemistry teachers and scientific experts, this project is also about changing the way people engage with and think about science. Science should be more than just a history lesson. It should be an active exploration of modern insights to modern problems.

When students are exposed to the emerging fields of nanotechnology, astrophysics and pharmaceuticals, their interest in science and university engagement increases dramatically. The NVSES project equips students as active researchers in these fields in a national network of students and teachers passionate about science. Perhaps most importantly, it provides this opportunity to students regardless of the limitations of geography or local school facilities and resources.

The Victorian Department of Education and Early Childhood Development's strategy, 'Energising Science and Mathematics Education in Victoria' (2009<sup>[7]</sup>), highlights the critical need for young Victorians to engage with higher education studies and more importantly to pursue careers in the enabling sciences: 'The future of Australia and Victoria depends on the next generation being excited by careers that use science, maths and technology. We need a strong pool of talented mathematicians and scientists to push the technological and scientific boundaries of innovation.'

Similar statements and accompanying strategies are published in other states and at a national level. It is publicly recognised that the emerging sciences are the key to economic growth for countries in the developed world. However, student participation in science is in decline (Thomson et al. 2010<sup>[8]</sup>), with particular issues evident in physics, chemistry and mathematics (Office of the Chief Scientist 2012<sup>[9]</sup>).

Despite a number of programmes and an increasing sense of urgency, interest in high school science continues to decline (e.g. Ainley et al. 2008<sup>[10]</sup>) leading to a corresponding decline in university science enrolments (e.g. Scoullar 2008<sup>[11]</sup>, Office of the Chief Scientist 2012<sup>[9]</sup>). Together, these needs are leading most governments to invest more heavily in Science, Technology, Engineering and Mathematics (STEM) education and in the fundamental sciences underlying them.

Unfortunately, the impact of these new opportunities may not be widespread enough and, generally, student exposure to science is from the more traditional applications within curricula that reflect little of the radical developments in the last 20-30 years. Bioinformatics, astrophysics, pharmaceutical science, bio-medicine and nanotechnology are just a few fields that are barely mentioned, if recognised at all in current secondary science education. Not surprisingly, student desire to participate in these sciences wanes well before their exposure to these topics at university.

Furthermore, many schools (especially in rural and remote locations of Australia) do not have access to specialist science teachers in disciplines such as senior physics and maths. As a result, these subjects are often taught by teachers from other disciplines with limited insight or expertise (Panizzon et. al. 2010).

The NVSES will connect students with teachers and academic experts who are well-qualified in these fields and the latest emerging trends. This connection to the human or personal side of science is a critical factor in reshaping the way students think about science, which is clearly demonstrated by the inclusion of the Science as a Human Endeavour strand in the Australian Curriculum: Science and Senior Science (K-12).

## Project delivery

The five partners contributing to the initial design and delivery of the NVSES are the Australian Science and Mathematics School, Gungahlin College, Tasmanian eSchool, Willunga High School and Cisco Systems Australia.

In the first instance, the programme is intended to be select entry, focusing on students who are excited and enthusiastic about a science career and equipped to undertake 8 weeks of active learning and a research project.

Year 10 students from across the country will be nominated by their school to participate in one or two term electives. Teachers from the NVSES will work with local teachers and student mentors (past graduates from the program) to lead participants in an invigorating, application-oriented and research-informed learning experience.

Schools will identify appropriate teachers, support staff and students to participate in the programme who will be supported through the process with online professional development and a thorough change management programme, ensuring that the current needs and capabilities of each school are incorporated into the delivery of the programme.

In addition to the NVSES teacher's availability during online lessons and asynchronously, teachers in situ will support students during the 8-week modules, enhancing their own knowledge of the subject and the mode of learning.

The educational experience

The programme will often adopt a "flipped classroom" approach, with students preparing before each class by engaging with online learning resources, simulations and assessments. In class time, the teacher will review what the students have studied, exploring challenging concepts and supporting students in applying what they have learnt.

The challenge and one of the objectives in designing this project has been to ensure that the art of the classroom teacher in supporting and personalising learning with students is translated into an online environment, synthesising the best pedagogy with the best technology, going beyond best practice into the realm of next practice.

Through a blend of live and asynchronous guest lectures, experts in the field will provide insight into current trends, with an opportunity for students to ask questions about current applications and really understand the challenges and joys of scientific research at the cutting edge.

The burgeoning online community of teachers, experts and most importantly peers will be of invaluable support as learners engage in their own research and inquiry in preparation for the concurrent online and physical science fair. Learners will develop an understanding of themselves as learners in a virtual space and the importance of community, open-mindedness and critique when learning collaboratively at a distance.

## Project schedule

The programme will be run from January 2013 to December 2014. Major project milestones include:

- October 2012 ? Initial project design complete
- February 2012 ? First class commences with partner schools
- April 2012 ? Further schools invited to participate
- June 2014 ? Conclusion of demonstration trial
- December 2014 ? Final report and evaluation complete

The trial starts with an initial teaching programme across four states and territories, and, subject to demand and network-readiness from other states, will expand to support all areas of Australia with appropriate network connectivity (NBN or equivalent). It will integrate secondary, tertiary and corporate educational resources and services to provide a high-quality educational experience for both students and teachers.

Importantly, given that NVSES will be cross-jurisdictional the curriculum used will address components of the three strands of the Australian Curriculum: Science Understanding, Science as a Human Endeavour, and Science Inquiry Skills.

NVSES will develop and deliver four 8-week modules, two for Quarks to Quasars and two for Nanotechnology:

Emerging Science

Leading module

Research module

Quarks to Quasars

Astrophysics

Quantum Physics

Nanotechnology

Principles and Concepts

Applications and Implications

**Table 1** - Two subjects and four modules taught in NVSES.

Each module will be discrete, and the leading modules can be studied independently. However, the research modules (which include a research project) require the prerequisite leading module.

## Potential benefits

The need for increased engagement in science education and its link to productivity and innovation is well documented. Providing enthusiastic students with these kinds of opportunities can lead to "super-engagement" that extends beyond these areas to impact students' other studies, their classrooms and teachers, and ultimately, their school. Students are validated and inspired by peers and educators who are equally passionate about science. This may impact tertiary progression, as students reconsider previously held views about the intimidating nature of universities to one of excitement, intrigue and motivation based upon their positive experiences in the NVSES.

Professional development of teachers is also a crucial component of the project. Teachers will be equipped to support the collaborative and personalised education models this curriculum requires. Support for teachers is critical as they oversee the learning journey of their students. Staff from the Faculty of Education at Monash and JMSS have developed an effective professional development programme that has received strong positive feedback from Regional Science Exchange participants. The NVSES programme builds upon these proven approaches.

In 2011, JMSS' Regional Science Exchange had a demonstrable impact on student interest in Australian Tertiary Admission Rank (ATAR) performance and university studies. Equally importantly, it also affirmed the value of science education by connecting passionate students with peers who validated a continuing interest in science. The NVSES aims to scale up these existing benefits and demonstrate a new model of education ? one that provides distributed access to scarce discipline-specific teachers within an engaging online environment with the opportunity for exposure to leaders and researchers in the emerging sciences.

Several thousand students and teachers will benefit from the deployment trial. The programme also aims to explore the potential development of a sustainable, scalable model that would support delivery to far greater numbers of students. There are also potential opportunities for translating the model to other disciplines. With in-built professional learning for teachers, it is hoped that the approaches and tools used in the programme will influence teacher adoption in other subjects.

These improvements can lead to significant economic outcomes. Teachers better equipped to teach with collaborative approaches will have direct impact on student learning performance; avoiding costs of student failure and resulting in more capable and productive students ready for university and the workplace.

## Evaluation and outcomes

In the short term, the programme will be evaluated by:

- feedback from participating students, teachers and schools;
- changes in student career aspirations and university intentions;
- growth in the programme; and
- the interest generated in extending the model to other disciplines and/or countries.

The ultimate measure of success of the programme is students changing the way they think about science, applying scientific thinking to the problems they face in everyday life, no matter what field they study and work in and developing an outstanding capacity to work collaboratively, virtually and independently, choosing the best technology for their needs.

Modern workplaces face constant and rapid change requiring complex problem solving skills. Students with experience in solving problems that cannot just be "Googled" will be sought after by employers. These outcomes could lead to real economic benefits.

"Establishing a National Centre of Pedagogy" (Loughran et al 2008<sup>[12]</sup>) provides a thorough analysis of the impact of improved teacher capability and improved education on Australia's economy. Based on their most conservative model, a program such as this could deliver tens of millions of dollars in benefits.

Increased participation in science also has direct benefits to the Australian economy. Reports from the Productivity Commission (2006 and 2007), indicate that over \$6 billion is spent by the Federal Government on research and development and nearly twice that by industry, with a return on investment of 13-26%. If this programme can increase that workforce by just 1% (less than the students participating in the deployment trial), it could produce further returns in the tens of millions of dollars.

## Future directions

During the final semester (early 2014), explorations will be underway to determine the ongoing sustainability of the programme, in the hopes that the NVSES might continue after the Government-funded demonstration trial completes. It is hoped that access to the program could be expanded to include a broader selection of students from years 9-12, depending on interest and availability.

## Conclusion

This programme has the potential to kick start significant change in Australia's education system. In such a large country with limited resources, new approaches to education are crucially needed. Beyond this, improvements in education the potential to fuel further growth in Australia's third largest export industry (Education).

Combining a National Broadband Network and all of the benefits that brings in terms of high speed access to rich multimedia resources and platforms for collaboration, with a dynamic curriculum which continually realigns itself with scientific thinking as it emerges will be a model for learning in a new and exciting space.

The NVSES will continue to grow and change ensuring that the best of pedagogy, science and technology combines to enthuse and challenge the next generation of Australian scientists to be amongst the best in the world, with exceptional knowledge, skills and attributes along with a truly connected and collaborative outlook.

## Acknowledgements

This work has been supported by funding from NBN Co; the NBN-Enabled Education and Skills Services (NBN-EESS); and the Department of Education, Employment and Workplace Relations.

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**Cite this article as:** Bailey, Nathan; Harte, Chris; Panizzon, Debra. 2012. ?NBN Virtual School of Emerging Sciences: How to transform the world one scientist at a time??. Telecommunications Journal of Australia 62 (5): 70.1-70.8. Available from: <http://tja.org.au> [16].

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#### Cite this article as:

Nathan Bailey, Chris Harte, Debra Panizzon. 2012. *NBN Virtual School of Emerging Sciences: How to transform the world one scientist at a time....* tja, Vol 62, No 5, Article 374. <http://doi.org/10.18080/tja.v62n5.374> [19]. Published by Telecommunications Association Inc. ABN 34 732 327 053. <https://telsoc.org> [20]



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