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Learning about Science: The Australian Academy of Science Experience

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You will note that I have changed the title of my address from that previously announced. I have dropped 'Learning about a Green Planet', not because I consider this to be not important but because as I started thinking about the education needs in science I realised that a Green Planet is one part of the larger issue of education needs to solve a multiplicity of major issues that Asia and the world is faced with. I return to this towards the end of my address.

As in nearly all countries, education in general and science education in particular has been and continues to be a matter of great concern in Australia. This is not so much because it has not been possible to find the right system but because the requirements constantly change with time.

How does an education system respond to the changing social, technological and economic make up of the country? How does it adapt to the changing social aspirations of its people, and how does it change with the evolution of science and technology itself?

The Australian Academy of science has over its brief 50 year history been involved with science education. Its first major efforts were with the 'Primary Investigations', a program that had some success in introducing science into primary school education in some of the States, that established in the minds of some teachers and education authorities that this was an area where the Academy had something constructive to offer, and that gave the Academy the confidence to develop the present program '*Primary Connections*'

Primary school science education and the Australian Academy of Science.

Traditionally, science education, especially in the primary school, has not been a core priority of school education in Australia and teachers have received very limited training in how to teach science as part of the school curriculum. This has been of

concern to the Academy because it is at this critical stage of the primary school that good habits can be cultivated, or where bad habits often start: of children, innately enthusiastic and curious, not being encouraged to develop a questioning mind, not encouraged to develop a desire to understand and explain the world around them, and of loosing interests in science by the time career-shaping decisions have to be made.

To have education programs that develop this curiosity, that develop young minds to use their innate enthusiasm and abilities to understand, and to contribute to the understanding of the world around them, is one of the main reasons why the Academy is involved with school science education.

Why is it important to do this? It is because:

- The future will depend increasingly on science and technology to resolve societal issues, and because education underpins the wise use off and creative development of tomorrow's technology, we need a national education system that meets the continuously evolving requirements for the future.

- Future issues will also become increasingly complex such that they cannot be addressed by science alone.

Thus it is important that the sciences become part of the general education program, not an isolated part that is taught from 2 to 3 PM on a Thursday afternoon. Hence the importance of the subtitle of our *Primary Connections* program *'Linking Science with Literacy'*.

- It will be important to train not just the next elite scientists, our Nobels of the future, but equally important to educate a population that understands how science works so that they can make intelligent contributions to the debate on the technological issues with which society is faced and make effective and creative use of the products flowing on from science and technology advances.

Perhaps nowhere is this more important at present than in the public debate on climate change. Hence our emphasis is on a program that is accessible to all students, not just tomorrow's scientific elite. Going down the latter path, without training a much broader community that has some understanding of the science and technology issues involved, of the ethics that may be involved in the applications of science and technology, and unable to seize the opportunities generated, is not something we care to contemplate.

This quote on education, attributed to Alan Greenspan, a former head of the US Reserve Bank, says it all.

"If you get that right (almost) everything else will be alright. If you get that wrong then nothing else much matters."

In our own Academy words prefacing the *Primary Connections* instructional units, "All citizens need an understanding of science to make sense of their world, to make decisions about health and well being and to engage with an increasingly scientific and technological world. Quality primary school science education provides the foundation for a scientifically literate society. Children are naturally curious and we need to support and nurture their sense of wonder and develop their passion for discovering how the world works."

But why should an Academy of Science, a nations elite scientists, get involved in education issues at school level? And why at primary school in particular? The latter question is the easier to answer since there have been several studies that show that students' general interest in science and their thoughts of a career in scientific fields are developed before approximately 11 – 14 years of age. Hence the importance of getting science education right at the earliest stage.

The first question raises the related question. Why do the existing teacher training institutions not suffice? I do not have the complete answer and I suspect that the answers will vary from country to country. But in Australia a void had developed for various reasons which was not being filled by the existing education training programs. Hence the Academy stepped in. It is not always wise to jump into voids but in this case it resulted in some significant success. I will turn to some of the features of the program in a moment but some of the reasons for the success include:

- The Academy backing of the program with the guarantee of quality of the contents through the use of its membership to provide rigorous scientific content.
- The independence of the Academy from Government agencies and educational training institutions has made the intervention acceptable to the different school systems across the country.
- That the Academy is seen to be concerned enough to do something about teaching provides an unmeasurable incentive to teachers!
- That an Academy can often initiate programs quietly and at relatively modest costs allows confidence to be built up in the evolving product, through frequent feedback and evaluation of its components and of the training methods.
- That at appropriate times the profile of the Academy can be instrumental in making successful approaches to Government to provide funding to develop cutting edge approaches.
- The *Primary Connections* approach is comprehensive including professional learning as well as quality curriculum resources. It meets the needs of the students and of the teachers.

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- That the Academy can uprovide long-term backing to ensure continuity, improvement and evolution of the program.

Primary Connections

What is *Primary Connections*? This is not the place to go into details about the program and, in any case, I am not the right person to talk about the details.[1] But it has a number of features that I believe are quite universal:

- The *Primary Connections* approach is comprehensive in that it includes both professional learning and quality curriculum resources.
- It is based on research into how students learn and how teachers can be supported to change the way they teach.

That is, it aims to help teachers and students alike. In Australia's case the former is important because the teaching of science has not been an important aspect in the training of teachers, many of whom are uncomfortable about teaching science topics in the classroom. Furthermore:

- The teaching of science is linked to literacy by providing a meaningful and engaging way for students to develop their basic literacy skills.

This has two linked consequences. First, the student is encouraged to read about the topic, to discuss it in a group environment and to write about it. That is, to develop their reasoning skills and in the process to develop deeper learning and understanding. Second, as shown by follow-up research, the general literacy of students is improved through the *Primary Connections* program and this has resulted in enthusiasm for the program also from non-science teachers.

- Developing evidence-based arguments when discussing science topics is at the heart of the teaching approach – ie building hypotheses, presenting evidence and reasoning and testing conclusions.
- Students carry out investigations in the classroom where ever possible because that is more powerful than providing information to remember.
- A professional learning approach is designed to help teachers to use the inquiry-based strategies in the classroom.

These are also skills that go beyond the immediate confines of the science class.

- Alignment of the resources to the curriculum documents of the various educational authorities.

[1] http://www.science.org.au/primaryconnections/index.html

In the case of Australia this is important in that education is still largely a State responsibility and within each State there are different public and private jurisdictions. A new and recent development has been the development of a national curriculum and the challenge for *Primary Connections* continues to be to develop our instructional units at a time when the national curriculum is still evolving. A measure of the significance of *Primary Connections* is that significant alignment is being maintained throughout the development of the National curriculum for science. I mention this because it illustrates that if Academies are to be successfully involved in improving science education in their countries they have to be able to work with the relevant authorities at all levels.

- A continuous feedback and evaluation of the components of the program and of the training methods that engage the teachers and the relevant authorities alike.

There are now some 20 research reports[2] on the website showing evidence of the success of the *Primary Connections* approach. In terms of success as reflected in the school performance of children, these reports have demonstrated:

- Improvement in student learning and increased student interest in science.
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- Improvement in teachers' confidence and competence to teach science.
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- More time spent teaching science in schools.
- .
- A higher profile of science in schools.
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- That, importantly, the approach has been very effective in improving the learning outcomes for indigenous students.

The Academy has trained over 1000 school-based leaders of science who have introduced PC into our schools and who provide support to other teachers in their schools. In addition over 500 professional learning facilitators have been trained to support regional clusters of schools and classroom teachers to ensure continuing development of the program. *Primary Connections* is now used in ~ 54% of Australian primary schools. This uptake will continue to increase as the national curriculum is implemented.

What after primary school: Science by Doing.

A most important outcome is that the success of the *Primary Connections* approach has led to the question: what happens after Primary School? What happens to the children who have become enthused about science when they enter into the more

[2] http://www.science.org.au/primaryconnections/research-and-evaluation/irr.html

rigorous programs of secondary school? Here, in Australia at least, the problems are somewhat different. At secondary school science is part of the curriculum and the teachers are usually qualified to teach its component subjects of physics, chemistry and biology. But it is also a time when students are exposed to many social pressures and the challenge is how to maintain their enthusiasm for learning in the face of these other competing demands on their attention and time.

It is also a more difficult area for an outside body to influence because, as just mentioned the teachers are more skilled, and the emphasis on science teaching methodology in the teachers training institutions is greater at secondary than primary level. Nevertheless, buoyed by success with *Primary Connections*, the Academy, with the support of the Federal Government, is developing a junior secondary program called '*Science by Doing*'.[3] This follows on similar principles as the primary program with the purpose to improve science learning through:

- Engaging secondary students through an inquiry-based approach.
- Supporting high schools' science departments that acknowledge and build upon teacher expertise.
- Working together with both the teachers - including heads of departments - and State education authorities, to develop programs that meet national needs as expressed in the newly evolving national curriculum for science.

The program has a number of components that include:

- A professional learning approach that includes establishing professional learning communities with an emphasis on leadership.

This involves, for example, the development of 'clusters' in which science teachers work collaboratively in a science department to improve student learning and which emphasize the importance of shared leadership. It includes the development of both

- Curriculum resources that are inquiry-based and also use digital technology in innovative ways, to help students and
- Professional learning resources that use digital technology in innovative and effective ways to help teachers.

Subsets of the program *Science by Doing* are presently being trialled in 28 schools throughout Australia in 2010, with the full trialling awaiting the outcomes of the

[3] http://www.science.org.au/sciencebydoing/

present National Curriculum development and on future funding for this program from our Federal Government.

Lessons learnt?

What are some of the lessons that we have learned so far from our experience in a highly contested area of school education where, possibly, there are as many views on what constitutes a good education system as there are educators:

- That from small, well designed and independent, pilot projects major national outcomes are possible.

And that this can sometimes occur, if the climate is right and opportunities are grasped, in a surprisingly short time. Nevertheless:

- That there has to be recognition that these are long-term commitments: that change in teaching practice takes time.

In fact one has to be prepared for continuing involvements if the benefits are to be maintained as educational needs and methods evolve.

- That the credibility of an independent Academy can enhance the profile off, and leverage support for, science education initiatives.

Academy backing of the program provides a guarantee of quality of the contents of the program as well as of its independence and this has made it acceptable to most of the different partners and jurisdictions involved in school science education. That the Academy is seen to be concerned enough to do something about teaching provides an unmeasurable incentive to teachers!

- That there is a need to establish strategic and early partnerships with government education ministries, with teacher training institutions and professional associations, and with school principals and teachers.

This has been one of the most difficult things to achieve and perhaps there has to be a sense that a system is in real trouble before there is recognition that these diverse agents have to work together to find a solution.

- That national or regional collaborative and integrated effort is more effective than disparate individual projects.

- That curriculum materials need to align with national or district curriculum requirements, syllabuses and standards.

Or, that the curriculum materials are such that they can influence these requirements and standards.

Science Education for One Sustainable Asia

So far I have not addressed the real theme of this meeting 'Science Education for One Green Asia'. This is partly because I very much adhere to the Greenspan dictum mentioned earlier, that if one gets education right then everything else will be all right. He did insert (almost) and possibly what he meant was that success also depends on being able to direct the products of an effective and creative education system to societally important problems.

A 'Green' Asia is one such. But this cannot be separated from other issues: population, water, food, health, social and material welfare, energy, security etc. and, as I think about it now, a better theme for this meeting may have been 'Science Education for One *Sustainable* Asia'.

Elements of the science part of such an education would include:

- Programs that bring an understanding of some of the basic underpinnings of science to the vast majority of the population through engaging all students to explore, explain, elaborate and evaluate what they observe, what they read and what they are told.

These would be programs that allow them to begin to understand the world around them so that, later in adult life, they can contribute constructively to the important issues of the day without being totally bewildered by the often contradictory debate that flows over them and that leaves them feeling disenfranchised and further withdrawn from the public debate.

- Programs that at the same time as meeting these broad objectives encourage students with particular talents and interests to develop these in a creative and questioning environment and to give them the opportunities to become tomorrow's leading scientists.

One of the features of growing old is that I spend more time reading obituaries of scientists and other intellectuals. One of the features I have noted is that outstanding scientists very often have come from unprepossessing and unexpected backgrounds. Spreading the net wide in a search for talent and then nurturing that talent is, with some provisos, an important element.

- Programs that while they include the core elements of the science disciplines also emphasise the multidisciplinarity of science: that we use science to address certain big problems, be they in basic or applied

science, that do not know of the boundaries that we have created between disciplines.

Many of the exciting new discoveries are occurring at the interfaces of the science disciplines, most notably between physics, chemistry and biology, and nowhere is this more important than in addressing the scientific underpinnings of achieving a sustainable planet. Who has not seen decisions made about the development of a particular source of energy, scientifically and technologically sound within a narrow framework, but without consideration of the impact on regional water, agriculture or environment.

- Programs that do not treat the science in isolation of other areas of human knowledge, particularly in the social sciences and humanities.

Many of the major issues that we are faced with require science and technology for their resolution but alone will not resolve them. Being able to communicate the science to the broader community, being able to deal with the ethical, social and economic consequences of the science, will be at least as important as the science itself. This is perhaps the most difficult challenge that we have and how it is best achieved is no doubt a matter for its own research. But it also brings us back to the first point: the importance of having a community that has some understanding of science and of scientific methods.

- Programs that convince the wider community that science and technology education is important and that investment in it is not a drain on the public purse but a sound long-term investment.

The *Primary Conections* and *Science by Doing* programs attempt to provide these elements but it is still early days and it will be a long time before any lasting benefits of these approaches will be felt by the community as a whole. This leads me to my last point. That the time to reform an education system and to retrain the teachers, and the time for the new students to become leaders, is long and greater than the timescale required for tackling the pressing problems that the world is faced with.

What is required in addition to enhancing our education programs is the science education of our present makers and executors of policies that affect our nations and the world. This is where national science academies and groupings of national science academies have a role to play. One example is through the provision of authoritative statements on the science issues that underpin policy decisions[4] and there are many more avenues. But that is another topic for another time.

[4] A recent example from the Australian Academy of Science is on climate change available at http://www.science.org.au/publications/research-projects-and-policy.html