Productive partnerships: Advancing STEM education in Western Australian schools

Supporting volume

The supporting volume to the report to the Science Education Committee of the Western Australian Technology and Industry Advisory Council (TIAC):

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Professor Lyn Beazley, Western Australian Chief Scientist; and
Winthrop Professor Shaun Collin, Western Australian Research Fellow, The University of Western Australia.

with support from the Science Education Working Group:

Mr Alan Brien, CEO Scitech;
Mr John Clarke, CEO, Science Teachers Association of Western Australia;
Professor Vaille Dawson, Science and Mathematics Centre, Curtin University;
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Ms Louise Nielsen, Principle Consultant, Department of Education; and
Mr David Wood, Management Consultant, Public Sector Commission.

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17 December, 2011

This supplementary volume to the main report provides an overview of the three sources of data used to underpin the main report:

- A ‘snapshot’ of WA STEM education;
- A directory of STEM education reports; and,
- A directory of STEM education support providers.

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Context and approach

the possibility that a more effective education in science and technology will enable more and more citizens to delight in, and feel a share in the great human enterprise we call Science

(Fensham, 2008, p. 5)

The new Western Australian Technology and Industry Advisory Council (TIAC) was established on 8 December 2010. TIAC provides advice to the State Government and delivers recommendations and activities that support the development of industry, science and innovation in Western Australia.

TIAC commissioned a study into the STEM (science, technology, engineering and mathematics) education initiatives currently supporting science education in Western Australia's primary and secondary schools.

Leading the study is TIAC's Science Education Committee: Chairman of Earth Sciences Western Australia (ESWA), Dr Jim Ross; the Chief Scientist of Western Australia, Professor Lyn Beazley; and Western Australian Research Fellow, Winthrop Professor Shaun Collin.

The Science Education Committee convened a reference group for this project - the Science Education Working Group (SEWG), chaired by Dr Jim Ross:

- Mr Alan Brien, CEO, Scitech;
- Mr John Clarke, Chief Executive Officer, Science Teachers Association of WA (STAWA);
- Professor Vaille Dawson, Science and Mathematics Education Centre at Curtin University;
- Dr Pamela Garnett, Dean of Curriculum, St Hilda's Anglican School for Girls and member of the Australian Science Council;
- Ms Louise Nielsen; Principal Consultant, Policy and Advice, WA Department of Education; and
- Mr David Wood, Management Consultant, Public Sector Commission and former head of the Curriculum Council.

The primary aims of the study were to:

- Map and analyse the key existing STEM education support programs/initiatives in Western Australia and assess their impact and effectiveness;
- Present the findings of the analysis to TIAC for consideration; and
- Propose suitable strategies for further action to support and strengthen STEM uptake, teaching and literacy in Western Australia's primary and secondary schools.

Three sources of data used to underpin the main report:

- A ‘snapshot’ of WA STEM education;
- Directory of STEM education reports; and,
- Directory of STEM education support providers.

The ‘snapshot’ was based on a pilot project which sought the views of STEM teachers about STEM education offerings. Additional evidence was provided by an evaluation of existing STEM education reports, and key STEM education providers.

The researcher for this project is Associate Professor Renato Schibeci, Murdoch University, with the assistance of the Graduate Research Assistant Alice Williams.

The researcher initially met with SEWG members on 4 August, 2011 to agree on a method for this project. Subsequently, the method was refined through a number of discussions, either face-to-face or by telephone with SEWG members.

Arising from those discussions, there was agreement that the project would incorporate the following elements:

(1) a directory of STEM education reports;
(2) a directory STEM education support initiatives;
(3) key stakeholders would be interviewed; and
(4) a survey of teachers and others would be conducted using the discussion lists of the two professional associations, STAWA and the Mathematical Association of Western Australia (MAWA), together with the contacts from the Department of Education, the Catholic Education Office and the Association of Independent Schools of Western Australia.

To facilitate (1) and (2), the SEWG provided an initial list of reports and initiatives, respectively. To facilitate (3), SEWG organised a meeting with key stakeholders at Scitech on 26 August, 2011.

The project team then began the tasks of reviewing STEM reports, interviewing stakeholders, and refining a survey.

The survey went through a number of iterations to improve the questions which formed the basis of the survey. The software Survey Monkey was used to generate and administer this survey.

Readers should note that the acronym STEM is not universal; in this report, it means science, technology, education, and mathematics. There are instances where the ‘M’ in STEM represents *medicine* not *mathematics*, and there are instances where the acronym is SMET: science, mathematics, engineering and technology.

What do published STEM education reports tell us?

Whether motivated more by a desire to improve the human condition or to remain at the forefront of other industrialized nations, there is a strong press among policymakers, industry leaders, and educators to improve the quality of mathematics, science, and technology education at K–12 levels and to increase the number of students who are interested in STEM fields, particularly among groups who have not traditionally chosen STEM careers: women, ethnic and racial minorities, and persons with lower socioeconomic status. The persistent lack of diversity in science classrooms and laboratories not only is socially unjust but also compromises the vitality and creativity of STEM endeavors. Many inventions, breakthroughs, and significant leaps in science-related understanding and applications are less likely to happen under conditions of homogeneity of thought and perspective.

(Greene et al, 2006, p. 53)

Formal STEM education for students is the responsibility of the Government, Catholic education system and the independent schools sector which, together, constitute the *formal* education system. In addition, there is a wide range of STEM education providers *external* to the formal education system. They include Federal and State Government agencies, statutory bodies, professional organisations, universities and private companies.

There is an abundance of reports and activities relevant to STEM education, both in Australia and overseas. The SEWG provided and initial list of reports to review.

A search for more recent reports revealed that there was a substantial body of additional literature. Indeed, the UK has a national STEM centre (http://www.nationalstemcentre.org.uk/) and an online STEM resources database (http://www.stemdirectories.org.uk/). The US has recently conducted a national workshop on STEM education, under the auspices of the National Academies (www.nap.edu/catalog/13230.html). The European Commission has set up a 'Maths, Science and Technology Cluster' to develop STEM education (Kearney, 2010). In 2010, 67 national STEM educators from 15 countries were brought together to develop action plans to support STEM education in Asia (http://www.intel.com/cd/corporate/csr/apac/eng/news/news26/465256.htm).

The various reports can be categorised according to the focus of the report:

(1) many reports, understandably, deal with the science education of students in early childhood, primary and secondary settings;
(2) another group of reports deals with STEM teachers, either teachers in preparation or practicing teachers;
(3) the third group includes those dealing with a variety issues, such 'informal' science education, as well as, for example, the preparation of science laboratory technicians; and,
(4) the last group of reports deal with the evaluation of one or more STEM education support activities.

Part B of this supporting volume contains a directory all the reports which were briefly reviewed for this project. For each report, there is a brief background statement followed by a *verbatim* summary of findings and/ or recommendations; finally, for each report, there is a concluding comment. The reports provide a rich source of guidelines and pointers, and, consequently, the possibility of using STEM resources more effectively. The directory may form a useful resource for STEM educators and other stakeholders.

The summaries cannot provide the full context, and so readers are urged to access the original reports, most of which are available online.

Primary and secondary students

A major report dealing with science education primary and secondary schools in Australia was that by Goodrum, Rennie and Hackling (2000). This report set the scene for many future science education efforts in this country. Not only was there a review of existing research; the authors also conducted research which included a telephone survey of 505 teachers, a survey of 4023 students in Years 5 to 11. The report thus has a strong empirical evidence base; indeed the volume had the sub-title' 'A research report'. This report noted some of the problems associated with science teaching and learning in schools at the time: 'The actual picture of science teaching and learning is one of great variability but, on average, the picture is disappointing' (p. 9). The first of its nine recommendations was as follows: 'It is recommended that the Commonwealth and educational jurisdictions promote the importance of science education in schools, particularly its fundamental role in developing scientific literacy.' (p. 10)

The authors believe that the stages of science education in schools needed to be developed especially in the context of developing a more scientifically literate group of students. The recommendations were based on five premises:

- The purpose of science education is to develop scientific literacy which is a high priority for all citizens, helping them to be interested in, and understand the world around them, to engage in the discourses of and about science, to be skeptical and questioning of claims made by others about scientific matters, to be able to identify questions and draw evidence-based conclusions, and to make informed decisions about the environment and their own health and well-being.

• The focus for change is closing the gap between the actual and ideal pictures of school science education.
• Teachers are the key to change.
• Change takes time and resources.
• Collaboration between jurisdictions is essential for developing quality science education resources. (p. 10)

This major report was published 2000, and provides a benchmark for science education more than a decade on. Two of the authors subsequently, in 2007, produced a national action plan for science education: for curriculum, assessment and resources; for teacher education for science and professional learning, and for systemic relationships and community sources of learning (Rennie & Goodrum, 2007).

As we move into the second decade of this century, what can we say about the quality of science education? The report by Tytler (2007), unfortunately, suggests that they situation has not improved. The title of the report was, *Re-imagining Science Education: Engaging students in science for Australia's future*. This title suggests that we have yet to engage all students in science.

This theme of engaging students in science is a recurring one in STEM education reports.

STEM teachers

A number of STEM reports focus on teachers. As indicated above, teachers are the key to change.

The preparation of STEM teachers has been reviewed a number of times in Australia. An early inquiry into science and mathematics teacher education was conducted by Speedy et al (1989). Recent reports have examined the science discipline content knowledge and science pedagogical content knowledge of STEM teachers. Some reports have also analysed the issues of attracting students, and retaining those students, in STEM teaching careers.

There is a move to national standards in teacher preparation, including STEM teacher preparation (http://www.aitsl.edu.au/), which will provide the state government with the opportunity to improve STEM teacher preparation, and to lead the nation in this effort.

Supporting STEM education

Some STEM reports focus on supporting initiatives, sometimes called 'informal' science education, as well as reports dealing with science communication broadly, such as the *Inspiring Australia* (2010) report.

Many of these reports have very useful guidelines for STEM education providers, such as advice about exhibitions.

Evaluation Reports

An important group of reports deal with the evaluation of various STEM education support initiatives.

Some of these reports deal with major national evaluations, such as the evaluation report of the Australian School Innovation in Science, Technology and Mathematics project and the Australian Science Teachers Association *Awareness Raising Model*. There have also been evaluations of local initiatives such as the *Primary Science* Project of the WA Education Department. Evaluations of other initiatives have also been undertaken, such as evaluations of Scitech programs, and the Water Corporation education initiatives; this latter report, however, is not yet available. The SPICE program has recently been evaluated, but the evaluation report is not yet available.

The evaluation of STEM education initiatives is crucial. Indeed major evaluations should include a budget component for a formal evaluation; many evaluators recommend that 10% of the total budget be required for a formal valuation. Initiatives with a limited budget can conduct an internal evaluation, while major initiatives should have an external evaluation so that stakeholders can be confident of the value or otherwise of the initiative.

However, it maybe that what 'evaluation' involves is not well understood. That is, some of those who offer STEM programs may not be aware of the complexity of evaluations and subsequently produce evaluation reports which are not as useful as they could be. Evaluations are classified in many different ways; STEM education providers, however, should be aware of at least two kinds of evaluation. The first could be called an *internal* evaluation; that is, the evaluation focuses on the achievement (or non-achievement) of the program's goals. Many evaluations are of this type. A second type of evaluation examines the program from the outside. Such an evaluation might not only assess the achievement of the program's goals, but also makes some judgment of the worth of the goals themselves.

For example, one issue which could be considered in the evaluation of a STEM initiative is: *To what extent are the STEM provider initiatives contributing to the state government vision for STEM education in WA?*

The STEM education literature

The body of literature represented by these various reports is substantial, and provides many useful guidelines for STEM teachers, STEM providers as well as policy makers. The directory in Part B of this supporting volume will be a useful resource for those who wish to examine international, national and local trends in STEM education.

What do STEM education providers currently offer?

I am not aware of what STEM support initiatives are currently available (Survey respondent).

Our study shows that a diverse range of organisations is providing a broad spectrum of STEM projects or programs throughout WA. However, these are, for the most part, limited to offering science-based programs, with technology, engineering and, in particular, mathematics being under-represented, certainly within the sample identified by the SEWG.

STEM providers can be as diverse as ‘Phiggles The Flying Scientist’ who ‘takes science to the outback’ (http://auspost.com.au/education/primary-phiggles-outback.html), to the ‘Planting seeds of science’ resource (http://www.altc.edu.au/resource-planting-seeds-science-second-edition-2010) for ECE students, to the CSIRO’s *Science by email* (www.csiro.edu.au/services/Science-By-Email-Main.html) and *Mathematics by email* (www.csiro.edu.au/resources/pchnf.html).

Of those organisations and programs explored in some detail in this report, the majority provide opportunities for the application of *Science inquiry* skills – usually in the forms of competitions or research based project work. *Science inquiry* skills form a key strand of the national science curriculum.

Biology featured most commonly as the area of *Science understanding* being promoted followed by chemical, earth and space science and physical science being equally represented within the sample.

Over half of the sample examined provided links to “other” areas of *Science understanding* and “other” most commonly referred to ‘sustainability’ and/or ‘conservation’.

None of the nine STEM providers we examined tackled *the nature and development of science* but all provided programs that featured the *use and influence of science* in some measure. Just under half the sample offered career-related programs or information but careers tended to be just one of many programs offered within a STEM provider i.e. no STEM provider was dedicated solely to offering information or programs related to careers in STEM.

All providers offered STEM programs for secondary school students, and just over half offered programs specifically suited to ECE. Where "other" was selected, this mostly referred to providers that offer STEM education for the general community as well as for schools.

All STEM providers offered programs for a metropolitan target audience, and just over half of those examined provided for a remote target audience. Where regional or remote target audiences are being provided for by a particular provider, it is usually because the provider offers some sort of outreach program and/or the website contains information which, theoretically, can be used by remote or regional schools.

It is worth mentioning at this point that the Australian Science Communicators (WA) and the Department of Commerce is compiling a list of providers of 'science outreach program for schools' (see Attachment 1). This compilation would be a useful resource to include in a revised directory.

What did the interviews tell us?

Programs work that maximise students engagement – need to be projects that can't be delivered in the classroom or through a textbook anywhere near as well as seeing it 'for real'…

Initiatives that have people "on the ground", making contact with and visiting the school have the most impact.

The onus should be on the organisation to take the initiative(s) to the schools to deliver the message, answer questions, generate interest and explain how what they have to offer links to the curriculum that the teacher is delivering. This enables the school to follow up afterwards. The organisation needs to act as a kind of 'broker'.

Knowing your students' needs and the program you are teaching and balancing those helps to decide what would make a suitable STEM project. Programs that are well resources, well funded, well backed-up by industry and professionals and include mentoring (like scientists in schools or chemists in the classroom) will work well.

Projects that don't work are the ones where you get there and realise that you could have done it yourself.

(Sample of comments made by interviewees)

Process

Stakeholders suggested by the Science Education Working Group were contacted by telephone.

Each stakeholder was emailed an information letter about the project, and a consent form to sign and send back. The following questions, which formed the basis of the interview, were also sent to interviewees.

- What are the main STEM education support initiatives that your organisation provides?
- How did you choose/decide which STEM education support initiative(s) to implement?
- What do you consider to be the major barriers preventing teachers from participating in STEM education support initiatives?
- What additional STEM education support initiatives would you consider/are you considering offering and why?
- Are there any STEM education support initiatives that may not be known to us, which you consider to be of particular interest/success? (Which may not necessarily be offered by your organisation/area).
- Do any of the STEM education support initiatives you provide specifically support any of the three cross-curriculum priorities of the Australian Curriculum, *Aboriginal and Torres Strait Islander histories and cultures*, *Asia and Australia's engagement with Asia*, and, *Sustainability.*?
- Is there anything else about STEM education support initiatives we should be aware of?

Interviews lasted 20-30 minutes each.

Representatives of the following STEM providers were interviewed:

- Water Corporation
- STAWA
- Perth Zoo
- Catholic Education Office
- Scitech

- AISWA
- Curriculum Council
- DEC
- MAWA
- ESWA
- SPICE

Findings

The main themes to emerge from the interview were as follows.

Interviewees stated a variety of influences and considerations when deciding which STEM education support initiatives to implement and these included (but are not limited to):

- Consideration of and loyalty to WACE (especially science and SOSE), matching programs to curriculum requirements;
- Results of evaluation forms from previously implemented programs;
- Consultation with stakeholders and formation of partnerships and direct consultation with schools and teachers;
- Links with strategic direction (of organisation);
- Identification of need by teachers/schools themselves and/or subsequent direct requests from schools to make changes/create new program that meets new curriculum requirements; and,
- Availability of funding for specific programs.

On the whole, the interviewees considered the main barriers preventing teachers from participating in STEM initiatives to include time and cost of programs. Timetable restrictions are a large barrier especially for secondary schools. There is little room/time for teachers to enrich the learning of students. Teachers are unable to take students out of school for any period of time – subsequent complications with other teachers of other subjects across school. Interviewees also nominated the cost of some programs and the transport for excursions as a major barrier.

In addition to these two factors, the following were nominated as barriers (especially in secondary schools).

- New WACE/NAPLAN testing: this year the focus has been on measurement/assessments rather than learning processes. Teachers are too busy reporting on new WACE to participate in (new) STEM initiatives.
- Conflict with other teaching areas – difficult to get students out of school for a day.
- Mapping all excursions onto a calendar can be difficult to fit in with all other student groups.
- Difficulty in justifying excursions or incursions where the links to the syllabus are unclear, especially with senior courses where delivery of the curriculum is often considered more crucial.

Another important factor was teacher knowledge and understanding of the subject area**,** notably within primary school science. In primary schools, teachers often have lack of confidence in their own knowledge of subject.

Also mentioned was the availability of information. Interviewees noted that there is an overabundance of programs to choose from making it difficult to sift through large amounts of information. Some teachers are simply unaware of what is available. Finally, programs and initiatives are not always clearly linked to curriculum.

One barrier nominated specifically in relation to excursions was the requirement for documentation, including: legal requirements/ insurance/ health and safety; parental consent forms; and, associated 'bureaucratic' requirements.

Barriers to teachers participating in Professional Learning (PL) for STEM subjects may include: changes within the school with regard to funding for PL; professional demands placed on teachers are too high; and, the ageing teacher population where enthusiasm for development generally has waned over last 10 years.

Additional STEM initiatives/organisations that interviewees listed as being of particular interest to them included:

- SPICE

- STAWA
- AuSSI-WA
- National Science week
- CSIRO labs
- Inspiring Australia
- PEP network
- Association of Perth Attractions
- UWA Maths enrichment program
- Free Choice Youth Program
- Planting the Seeds of Science book and PD workshops
- Labnet West: website
- Labtech
- Regional technicians Group
- CSBP in Kwinana
- BP Energy Package
- Tammin Land Care centre
- Mundaring Hills Forest project
- Perth Zoo – bush tucker projects
- DEC (sustainability)
- Primary Connections
- Science by Doing.

Few interviewees were able to make clear links between any of the STEM education support initiatives they provide and any of the three cross-curriculum priorities of the Australian Curriculum: Aboriginal and Torres Strait Islander histories and cultures, Asia and Australia's engagement with Asia, and, Sustainability.

What did the survey tell us?

Science *Primary Connections* training - excellent - I have been able to help teachers within our school community become more comfortable with teaching of science and technology use has improved in this area.

Most knowledge of STEM ed. support initiatives come to me via email as I am on a number of lists relating to science and science teaching.

Workshops would be most effective if STEM education representatives came to the school and ran a workshop during a designated learning area meeting.

By far the greatest constraint is time.

Too busy teaching.

More information on research projects. As part of the new physics course students have to conduct their own investigations - perhaps case studies of projects run at Murdoch to help students to see how to plan and perform investigations.

(Sample of comments made by survey respondents)

Process

A survey was developed based on discussions with the Science Education Working Group and, more specifically, a meeting with stakeholders held at Scitech on 26 August, 2011.

The survey was revised a number of times; the text of the final version, together with the email inviting participation in the survey, is shown in Attachment 2.

Results

The first question sought the number of years respondents had been teaching; the data are summarised in Figure 1.

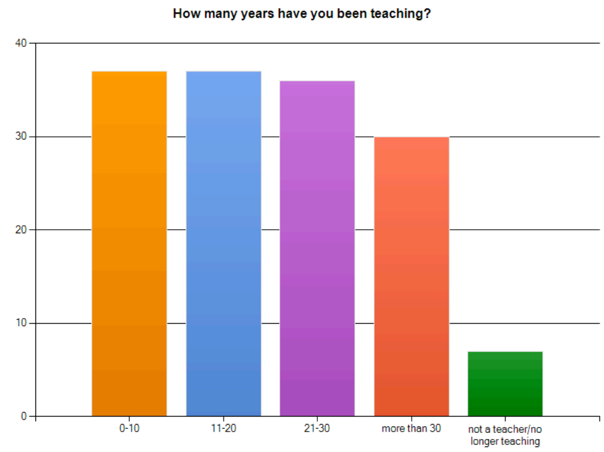

Figure 1
Respondents' number of years of teaching

Next, we sought respondents' main teaching area; the data are summarised in Figure 2.

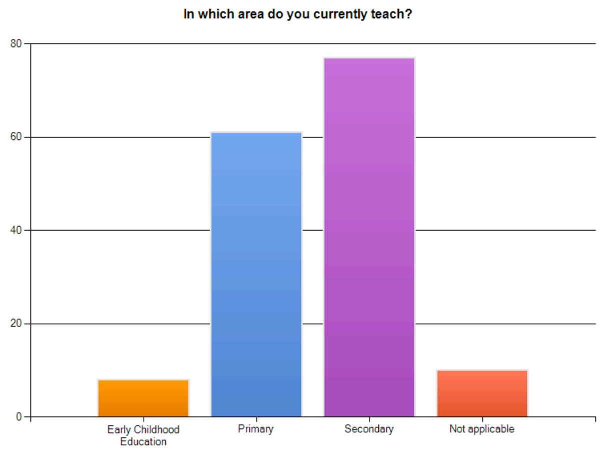

Figure 2

Main teaching area of respondents

The location of respondents' schools was sought, and the responses summarised in Figure 3.

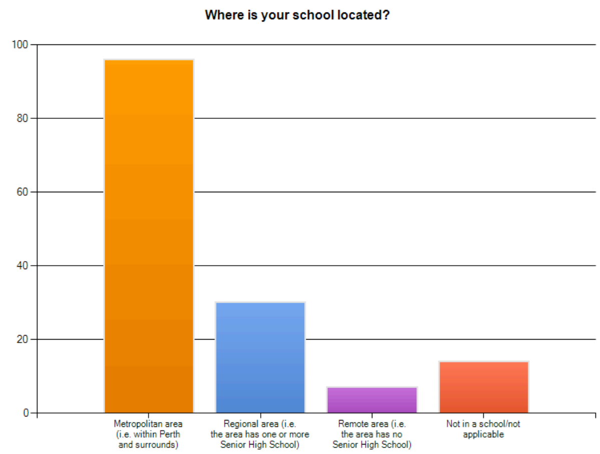

Figure 3

Location of respondents

Respondents were asked to rank various aspects of STEM education support initiatives. These eleven characteristics were derived from a meeting of stakeholders at Scitech and follow up discussions with the SEWG.

Respondents were asked to rank the eleven characteristics resulting from this process from 1, "most important" to 11, "least important". Figure 4 shows ranking averages in order of priority for all respondents (not just teachers), as well as separately for primary and secondary teachers.

Findings

Clearly, for respondents, the two most important characteristics of STEM education initiatives are: *be linked and relevant to the curriculum*; and, *update and develop teachers' knowledge of the topic*. This is consistent with interview data.

For respondents, the least important characteristic of STEM education initiatives is, *either provide or encourage "champions" and supporters within the school*. This is somewhat surprising, given its importance shown in other initiatives, such as the Education Department's *Primary Science Project*.

Primary and secondary teachers generally agreed on the rankings, although there were some differences. For example, *integrate learning across different school subject* was ranked a little higher by primary teachers; this is to be expected, perhaps, given primary teachers teach across different learning areas.

It is a little unexpected that *have an online component* was ranked as being among the least important characteristic, given the current emphasis on ICTs in education.

Of the 102 respondents who chose to specify their area of teaching in Question 2, a majority of 22 responded *"Science"* and five responded *"maths and science"*. None of the respondents specified Technology or Engineering as their area of teaching.

Characteristic	*Overall rank (n =128)*	*Primary (n =50)*	*Secondary (n =72)*
be linked and relevant to the curriculum	1	1	1
update and develop teachers' knowledge of the topic	2	2	2
be the result of a need identified by schools/teachers	3	5	3
have teacher and student activities which work in parallel and are complementary	4	6	4
encourage sustainable teaching practices beyond the life of the STEM support initiative	5	3	6
be relevant to everyday life	6	4	5
make a visible impact/difference	7	7	=7
fill a specific niche (i.e. the initiative offers something that is not provided through any other means)	8	9	=7
integrate learning across different school subject	9	8	10
have an online component	10	10	9
either provide or encourage "champions" and supporters within the school	11	11	11

Figure 4

Respondents' ranking of characteristics of STEM education initiatives

For Question 5, about *STEM education support initiatives relevant to any of the three cross-curriculum priorities of the Australian Curriculum* of 74 responses, 32 responded with either *N/A* or *don't know of any/don't know what they are* offering responses such as:

1. I am not aware of what STEM support initiatives are currently available
2. Unable to answer
3. None
4. Unsure
5. Have not heard of any of these initiatives

A factor that may be operating here is lack of awareness of the acronym, STEM, even though it was spelled out in the survey. Many teachers would be unfamiliar with the term, and this may have contributed to these comments quoted here.

Other responses included reference to STEM programs related to 'sustainability' and 'water conservation'. A few specific initiatives were suggested in response to this question but the links to any of the three cross curriculum priority areas specified in the question are unclear.

Question 6 sought information regarding STEM education support initiatives respondents had recently engaged in. Of 74 respondents, 42 responded with *N/A* or *I am unfamiliar with any STEM education support initiatives*.

However, of those that specified STEM initiatives they have recently been involved in, over 30 initiatives were specified (often more than one by the same respondent) and all respondents considered the initiative(s) in which they had been involved to have been highly effective.

With regards to how respondents become aware of existing STEM education support initiatives, responses included: Catalist, self-initiated within the school, Curriculum Council, STAWA, flyers, emails through school, networking, colleagues and meetings (internal and external).

When asked to specify the barriers to participation (Question 7), 17 out of 74 of the respondents specified time as being a barrier to participation in STEM education support initiatives. Additionally, 15 out of 74 specified lack of awareness of what STEM education support initiatives are available as a barrier.

Only 6 participants responded to Question 8 (*Please list STEM education support initiatives that are unique to your school/area/region)* with a specific initiative and it could be argued that only two of those mentioned are in fact unique to an area or region or school. A large majority of 68 out of 74 responded with either: *N/A, None, Not heard of any/don't know of any or what they are/unsure/no idea.*

Question 9 asked, "What additional STEM education support initiatives would you like to see offered and why?" Responses included:

> These workshops would be most effective if STEM education representatives came to the school and ran a workshop during a designated learning area meeting. As soon as people have to go off campus or are expected to follow up development individually, I believe there is less effective uptake of development opportunities.

> More hands-on engagement and modelling as well as funding for student participation

> More information on research projects. As part of the new physics course students have to conduct their own investigations...

> ...all should be available in large country centres in WA

> Support for year 7 science

> Continuation of Projects like the Primary Science Project....This project provides the 'best of the best' Science resources from around the world.

> Any initiative that encourages WA students to study science is welcome and needed.

The following responses, also to Question 9, relate to the need for support for new national curriculum:

> development of online resources linked to the Australian Curriculum, with enough depth and structure to support graduate teachers and teachers delivering content from outside their area of training
>
> I would like to see a lot more focussed on the National Curriculum.
>
> More relevant and useful links of resources to the Australian curriculum. Current offerings are meagre and their usefulness is difficult to determine.
>
> There is a great need for support for new Physics teachers like myself and even existing Physics teachers with the new curriculum and getting resources.

It is worth noting here that some respondents made specific reference to “in-house” or “internal” programmes within their schools which have not been included in this report.

One interviewee had previously mentioned that she was unsure whether “internal” STEM programmes or initiatives were included or covered by the definitions and parameters we have provided. This may suggest that there are many more programmes and initiatives in which the survey respondents are involved, but they may not consider them to fall under the umbrella term of “STEM education support initiatives” in this instance.

Empirical support for report findings

The pilot STEM survey provided valuable data which supported key findings of both the STEM education reports summarised in Part B, and the STEM education providers in Part C of this supporting volume.

The findings provide supporting evidence for the recommendations enunciated in the report to TIAC.

Attachment 1

[ASC-list] WA - compiling a directory of Science Outreach Providers. Email posted 26/9/11

Are you involved with a science outreach program for schools?

Australian Science Communicators in WA and the Department of Commerce are putting together a central directory of science outreach providers for teachers.

All science education and outreach providers in Western Australia, whether large or small, regional or metropolitan, incursions or excursions, are encouraged to participate.

If you'd like to be included, please fill out the following information and email to Miriam.sullivan@gmail.com. Please feel free to forward this email to any of your colleagues or contacts who may be interested in being included in the directory.

Name of Organisation:
Location:
Incursions/Excursions/Both (Delete as applicable)
Age range: Primary/Secondary/Both
Contact Name:
Phone number:
Email:
Website:
Short description of services (<75 words):
If you wish, you can also attach a logo (saved as a .jpeg or .gif).

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Attachment 2

(a) Post to MAWA and STAWA discussion lists (25/9/11)

Dear

The WA Technology and Industry Advisory Council (TIAC) has commissioned a study into the STEM (science, technology, engineering and mathematics) education initiatives currently supporting science education in Western Australia's primary and secondary schools.

Leading the study is TIAC's Science Education Committee: the Chief Scientist of Western Australia, Professor Lyn Beazley; Chairman of Earth Sciences Western Australia (ESWA), Dr Jim Ross; and, Western Australian Research Fellow, Winthrop Professor Shaun Collin.

The primary aims of the study are to:

• Map and analyse the key existing STEM education support programs/initiatives in Western Australia and assess their impact and effectiveness; and

• Present the findings of the analysis to TIAC for consideration and propose suitable strategies for further action to support and strengthen STEM uptake, teaching and literacy in Western Australia's primary and secondary schools.

The Science Education Committee of TIAC requests ten minutes of your time on about a survey on this topic at http://www.surveymonkey.com/s/VHY3DFD.

The answers and information that you provide will contribute to a broader and current understanding of STEM education support in Western Australia. The objective is to apply this feedback to the development of further action and strategies by TIAC to support and strengthen STEM education in Western Australia.

Many thanks, in anticipation, for completing the survey (if possible, before this Friday). If you have any questions or information you would like to discuss with me, please email me off-list at the email address below (hitting the reply button will go to everyone on the list!).

Regards

Renato Schibeci
Murdoch University

On behalf of the Science Education Committee of TIAC
R.Schibeci@murdoch.edu.au
Ph: 9360 2168

(b) Follow-up post to MAWA and STAWA discussion lists (28/9/11)

Dear

Many thanks to those who completed the STEM (science, technology, engineering and mathematics) survey so promptly. Your views are crucial in determining what makes STEM education support initiatives effective.

If you have not done so, please take ten minutes to complete the survey at
http://www.surveymonkey.com/s/VHY3DFD before the school holidays.

Regards

Renato Schibeci
Murdoch University

On behalf of the Science Education Committee of TIAC
R.Schibeci@murdoch.edu.au
Ph: 9360 2168

(c) Text version of survey

STEM Education Support Initiatives

Dear Colleagues

The Technology and Industry Advisory Council (TIAC) has commissioned a study into the STEM (science, technology, engineering and mathematics) education initiatives currently supporting science education in Western Australia's primary and secondary schools.

Your responses will help to improve STEM education in WA.

Please note that individual results are confidential; aggregated data only will be made available. Completion of this survey is taken as consent to be involved. This study has been approved by the Murdoch University Human Research Ethics Committee (Approval 2011/173).

Thank you for your participation.

On behalf of the Science Education Committee of TIAC,
Renato Schibeci, Murdoch University
Tel: 9360 2168
Email: R.Schibeci@murdoch.edu.au

Q1. How many years have you been teaching?

- 0-10
- 11-20
- 21-30
- more than 30
- not a teacher/no longer teaching

Q2. In which area do you currently teach?

- Early Childhood Education
- Primary
- Secondary
- Not applicable

Please specify any specialist area (e.g. maths, biology, science etc)

Q3. Where is your school located?

- Metropolitan area (i.e. within Perth and surrounds)
- Regional area (i.e. the area has one or more Senior High School)
- Remote area (i.e. the area has no Senior High School
- Not in a school/not applicable

Q4. STEM (Science, Technology, Engineering and Mathematics) education support initiatives include professional learning activities, excursions, incursions, field trips, competitions and awards.

Please RANK (not rate) the aspects of STEM education support initiatives below, from 1, "most important" to 11, "least important".

STEM education support initiatives should:

- be linked and relevant to the curriculum
- fill a specific niche (i.e. the initiative offers something that is not provided through any other means)
- update and develop teachers' knowledge of the topic
- be relevant to everyday life
- integrate learning across different school subject
- encourage sustainable teaching practices beyond the life of the STEM support initiative
- either provide or encourage "champions" and supporters within the school
- be the result of a need identified by schools/teachers
- make a visible impact/difference
- have teacher and student activities which work in parallel and are complementary
- have an online component

Q5. Please list any STEM education support initiatives that you believe are especially relevant to any of the three cross-curriculum priorities of the Australian Curriculum: Aboriginal and Torres Strait Islander histories and cultures; Asia and Australia's engagement with Asia; and Sustainability.

Q6.

a) What STEM education support initiatives have you recently engaged in, and for what purpose?

b) Were these STEM education support initiatives effective? If not, why not?

c) How did you first hear about these initiatives?

Q7. What are the major barriers that limit or prevent your participation in STEM education support initiatives? Do you have any suggestions for overcoming these?

Q8. Please list STEM education support initiatives that are unique to your school/area/region.

Q9.What additional STEM education support initiatives would you like to see offered and why?

References

Education and Training Committee, Parliament of Victoria (2006) *Inquiry into the promotion of mathematics and science education.* Melbourne: Government Printer.

Greene, J. C., DeStefano, L., Burgon, H., & Hall, J. (2006). An educative, values-engaged approach to evaluating STEM educational programs. In D. Huffman & F. Lawrenz (Eds.), Critical issues in STEM evaluation (special issue). *New Directions for Evaluation*, 109 , 53-71.

Fensham P. J. (2008) *Science Education Policy-making: Eleven Emerging Issues*. Paris: UNESCO.

Goodrum, D., Hackling, M., &, & Rennie, L. (2001). *The Status and Quality of Teaching and Learning of Science in Australian Schools*. Department of Education, Canberra: Commonwealth of Australia

Goodrum. D. & Rennie, L. J. (2007) Australian School Science Education National Action Plan, 2008-2012. Canberra: DEST.

Inspiring Australia: A national strategy for engagement with the sciences (2009). A report to the Minister for Innovation, Industry, Science and Research. Canberra: Commonwealth of Australia.

Osborne, J., and Dillon, J. (2008) *Science Education in Europe: Critical Reflections*. London: Nuffield Foundation.

Tytler, R (2007). *Re-imagining Science Education: Engaging students in science for Australia's future.* Australian Education Review No. 51. Australian Council for Education Research, ACER.

Kearney, C. (2010) *Efforts to Increase Students' Interest in Pursuing Mathematics, Science and Technology Studies and Careers: National Measures taken by 16 of European Schoolnet's Member Countries*. Brussels, Belgium: European Schoolnet.

B: Directory of STEM education reports

- Primary and secondary students
- STEM Teachers
- Supporting STEM Education
- Evaluation Reports

B: Directory of STEM education reports

STEM education reports and support initiatives need to be considered in the light of the national curriculum. Both science and mathematics have developed frameworks in the Australian Curriculum

Mathematics

The mathematics curriculum is organised around the interaction of content and proficiency strands.

Content strands. The three content strands in the national mathematics curriculum will be:

- Number and algebra
- Measurement and geometry
- Statistics and probability

Proficiency strands. The four proficiency strands in the national mathematics curriculum will be:

- Understanding
- Fluency
- Problem solving
- Reasoning.

(http://www.acara.edu.au/verve/_resources/Australian_Curriculum_-_Maths.pdf)

Science

The Australian Curriculum: Science has three interrelated strands:

- Science Understanding,
- Science as a Human Endeavour, and
- Science Inquiry Skills.

Together, the three strands of the science curriculum provide students with understanding, knowledge and skills through which they can develop a scientific view of the world. Students are challenged to explore science, its concepts, nature and uses through clearly described inquiry processes.

(http://www.acara.edu.au/verve/_resources/Australian_Curriculum_-_Science.pdf)

B: Directory of STEM education reports:

Primary and secondary students

Goodrum, D., Hackling, M., &, & Rennie, L. (2001). ***The Status and Quality of Teaching and Learning of Science in Australian Schools.*** **Department of Education, Canberra: Commonwealth of Australia.**

http://www.dest.gov.au/NR/rdonlyres/5DF3591E-DA7C-4CBD-A96C-CE404B552EB4/1546/sciencereport.pdf

Background

This is a significant report on science teaching and learning in Australian schools. Not only was there a review of existing research; the authors also conducted research which included a telephone survey of 505 teachers, a survey of 4023 students in Years 5 to 11. The report thus has a strong empirical evidence base.

Recommendations

Recommendation 1

It is recommended that the Commonwealth and educational jurisdictions promote the importance of science education in schools, particularly its fundamental role in developing scientific literacy.

Recommendation 2

It is recommended that incentives be provided to attract larger numbers of quality students into science teaching and to retain experienced teachers in the classroom.

Recommendation 3

It is recommended that funding for preservice teacher education, and in particular for preservice science education, is increased to rejuvenate a diminished and ageing university staffing profile and to make possible a pedagogy that models best practice.

Recommendation 4

It is recommended that educational jurisdictions provide teachers with the support of ongoing professional development to help them teach science in ways that promote improved learning outcomes that contribute to scientific literacy.

Recommendation 5

It is recommended that the Commonwealth and the States/Territories continue to support the development of professional standards for science teaching and the national implementation of these standards.

Recommendation 6

It is recommended that educational jurisdictions provide teachers with conditions and resources necessary to teach science in ways that promote scientific literacy.

Recommendation 7

It is recommended that the Commonwealth assist educational jurisdictions to reform assessment practice so that assessment more effectively serves the purpose of improving learning. Assessment must focus on the learning outcomes associated with scientific literacy.

Recommendation 8

It is recommended that a national focus be encouraged to promote collaborative approaches to research and data collection, innovation, and development of curriculum and professional development resources for science education.

Recommendation 9

It is recommended that, in five years time, there be a review of the quality and status of science teaching and learning, assessing the impact of a range of current and emerging initiatives in this field, including the actions arising in response to this report.

Comment

This report is now a decade old, and it is possible that the situation in Australian science teaching and learning in schools has changed. More recent reports, such as that by Tytler

(2007) suggest that the situation has *not* changed significantly. Thus, the authors' exhortation appears not have fired the imagination or will of policy makers;

> As we commence the third millennium, a greater priority must be given to building the scientific literacy of our people if Australia is to experience social and economic well-being. At this time, the greatest priority is to improve the quality of school science in the compulsory years of secondary schooling so that **all** students can experience a science education that will make a difference in their lives, and attract our best young minds into science research and careers to make Australian industry internationally competitive. (p. 184)

Prime Minister's Science, Engineering and Innovation Council (2003). ***PMSEIC Working Group on Science Engagement and Education: Equipping Young Australians to Lead Us to the Future.*** **Canberra, ACT: Prime Minister's Science, Engineering and Innovation Council, Canberra.**

www.chiefscientist.gov.au/.../20031128-Science-engagement-and-education

Background
This was an early report presented to the Prime Minister's Science Council.

Summary

Recommendations

1. National framework – local action

To support schools and their communities by nationally coordinating the outreach programs of science providers[3] with sufficient resources to reach all Australian school students.

2. Science through literacy

To introduce a collaborative national program in primary schools that links the teaching of science with the teaching of literacy.

3. Science by doing

To develop and implement a national program in junior secondary schools to engage students in learning science through greater emphasis on investigation.

4. Science means business

To strengthen links between business and science education institutions so as to increase the opportunities for science-based careers and improve the performance of both large and small Australian companies.

5. Teachers – the key to success

To strengthen the professionalism and skills of Australian science teachers, providing them with the contacts, support and resources to keep pace with the advancements of knowledge in modern science.

Comment

Some of the recommendations have now been taken up.

Garnett, R. R. (2003). ***Reaching all Australians: A report on delivering STEM education and awareness programs to regional, rural and remote Australia.***

http://catalogue.nla.gov.au/Record/3097686

Background

This is a report on an Australian STEM effort. Some 57 STEM programs from 48 providers were surveyed

Summary

Recommendations

1. That a national framework of action be developed as a way forward to bring together national, state and local resources for the greatest impact and efficiency in addressing the gaps being experienced by regional, rural and remote schools and communities across Australia.
2. That the national framework of action provide a 'national strategy/ local delivery' implementation plan …
3. That a National Working Group – with broad-based representation from SMET outreach program providers and school systems across Australia – be established and resourced to develop a national framework of action. (p. xi)

Comment

This is a significant report, as it was national in scope. It has, also, a focus on students outside metropolitan areas.

Haste, H. (2004). *Science In My Future* (Vol. 1): Nestle Social Research Programme.

http://www.spreckley.co.uk/nestle/science-in-my-future-full.pdf

Background

A UK report of values and beliefs in relation to science and technology amongst 11-21 year olds.

Summary

The overall picture:

Young people feel that science is beneficial to our health and quality of life, and they would like to see more money being spent on a number of developments - particularly finding a cure for AIDS and making environmentally friendly products. Over half trust scientists to make responsible judgments about the dangers of their work. Around four out of ten would like to see more money spent on genetic research for food production, more research for national defence, and research to find out what makes people aggressive. They are less enthusiastic about nuclear power, developing robots, space exploration, and trying to find evidence of life on other planets. The stereotypical image of the scientist - iconically, the wild-haired man in the white coat – appears to be differentiating amongst these young people. Given the cue of a cosmologist, a medical researcher and an art historian, they see the medical researcher as more accessible, less isolated and much more likely to be female, than the cosmologist.

Young people question science and technology in a number of ways:

The ethical concern about animal experimentation is one issue – six out of ten agree that it is morally wrong. A second issue is how far 'scientific' approaches can be applied to human and social problems, or whether science should be trying to change the world; over a half questioned this. Over a third agree that scientific advances are going too far too fast. Trust in the government to make appropriate laws to control any dangerous developments in science is low – only a third trust the government, and a third do not.

Four distinct constellations of values, or value sets, emerge:

The “ Green” value set links ethical concerns, the environment, and scepticism about interfering with nature. It also includes propensity to being involved with the community and feeling able to make one’s voice heard. It is particularly associated with younger girls (under sixteen) and especially with those who would be interested in a job related to science. The three other value sets reflect contrasting patterns of values around science and technology. The set we call the “ Techno-Investor” links enthusiasm for investing in technology (especially space-related) and in science research, with beliefs about the beneficial effect of science, and trust in both scientists and government. It is particularly associated with boys under sixteen and also with young men over sixteen in the workforce. The “ Science-Oriented” value set reflects interest in science programmes on television, and science fiction, and a belief that a ‘scientific way of thinking’ can be applied widely. It is associated with boys over sixteen both in fulltime education and in the workforce. The fourth value set we call “ Alienated from Science”. It reflects boredom with science, and scepticism about its limitations. It is associated with younger girls and with young women over sixteen in the workforce who are not interested in a job related to science.

Comment

This is an interesting report, as it was commissioned by business, not a government or academic group.

Garnett, P. J., Parker, L., Robson, A., Owens, R., &, Chennell, K., Cook, C., & Brien, A., (2006). ***Creating a Future with Science*** **(Final Report). Perth: Western Australian Science Council, Science Education Working Group.**

Background

This study was commissioned by the WA Science Council, and is the precursor to the present report.

Recommendations

That the State promotes and advances science, mathematics, engineering and technology education in schools

Strategy 1.1 Provide primary school students with high quality curriculum materials and teachers with associated resources and professional learning opportunities

Strategy 1.2: Provide secondary school students with high quality curriculum materials and teachers with associated resources and professional learning opportunities

Strategy 1.3 Increase the supply and quality of teachers of the physical sciences and mathematics by enhancing the attractiveness of the profession.

Strategy 1.4 Support enrichment activities for STEM learning to enhance learning outcomes in primary and secondary schools

Strategy 1.5 Increase the participation of under-represented groups in Science and mathematics

2. That the State promotes and advances the support, resources and programs needed to increase the number and quality of university, and vocational and educational trained (VET) graduates in science, mathematics, engineering and technology

Strategy 2.1 Increase the number of students participating in STEM programs at universities and TAFE institutions

Strategy 2.2 Develop the quality of university and TAFEWA graduates in STEM by recognising, encouraging and disseminating excellent teaching and learning practice.

3. That the State works to position Western Australia as a world class provider of science, mathematics, engineering and technology capability in areas of comparative advantage

Strategy 3.1 Increase the critical mass of people with STEM skills

Strategy 3.2 Position WA as a world leader in areas of comparative advantage through developing programs such as the Major Research Facilities Program, the Centres of Excellence in Science and Innovation Program, the Premier's Collaborative Research Program, and the Premier's Research Fellowship Program

Strategy 3.3 Grow capacity by ensuring financial stability for researchers employed on short term funding arrangements

Strategy 3.4 Monitor progress towards Western Australia becoming a world class provider of STEM capability in areas of comparative advantage

Strategy 3.5 Maximise students' participation in and achievement of STEM education, by establishing mechanisms to enhance collaboration between the providers and stake holders of STEM education.

Comment

An implementation plan was developed following the report.

Thomson, S., & De Bortoli, L. (2006). ***Exploring Scientific Literacy: How Australia measures up: the PISA 2006 survey of students' scientific, reading and mathematical literacy skills.*** **Melbourne, Victoria: Australian Council for Education Research, Ltd (ACER).**

http://www.acer.edu.au/documents/PISA2006_Report.pdf

Background

It is not possible to summarise succinctly the major findings of this major, international study of science literacy and engagement. Below is a series of brief findings, which will be useful in analysing the achievement of Australian students.

Summary

Overall, Australian students acquitted themselves very well in PISA 2006. The following are some highlights. Differences are only mentioned if tests of statistical significance showed that the differences were highly likely to indicate real differences.

In terms of country averages:

- Australia's results were above the OECD average in each of scientific, reading and mathematical literacy.
- Australia was significantly outperformed in scientific literacy by three countries – Finland, Hong Kong-China and Canada. Australia's performance was not significantly different from that of Japan or Korea or to that of five other countries.
- Eight countries outperformed Australia in mathematical literacy in PISA 2006, compared with seven countries in PISA 2003 and one in PISA 2000.
- Australian students scored significantly higher than the OECD average in both science knowledge domains, scoring 533 points for knowledge about science and 528 points for knowledge of science, compared to the OECD averages of 500.

In terms of results for the Australian states and territories:

- In scientific literacy, the Australian states and territories all performed, on average, at a level in each domain that was either at or above the OECD average.
- In scientific literacy, the average performance of students in the Australian Capital Territory was significantly higher than that of all states other than Western Australia. The scores of students in Western Australia were statistically similar to those of students in New South Wales and South Australia but higher than those of the other states. These findings were similar to those reported for PISA 2000 and PISA 2003.
- In mathematical literacy the score for the Australian Capital Territory was not significantly different to that of Chinese Taipei, the highest scoring country. The score for Western Australia was not significantly different to that of the Australian Capital Territory, and was also significantly higher than the Australian average.
- In both the Australian Capital Territory and Western Australia, around 20 per cent of students were performing at the highest two proficiency levels in scientific literacy, 40 per cent of students were performing at the highest two proficiency levels in reading literacy, and more than 20 per cent were performing above Level 5 in mathematical literacy.

In terms of Indigenous students′ results:

- Altogether, 1,080 Indigenous students were assessed in PISA 2006. On average, the performance of Indigenous Australians in scientific literacy was 88 score points lower than that of non-Indigenous students. That is, Indigenous students scored around one proficiency level lower than non-Indigenous students.

In terms of the results for males and females:

- Internationally there were gender differences in scientific literacy in 20 countries: 12 in favour of females and eight in favour of males. In Australia there was no significant gender difference on the overall scientific literacy scale.
- There were, however, some gender differences in scores at the level of content areas and competencies. Australian female students performed at a significantly lower level than Australian male students in both Earth and space systems and physical systems but at a similar level in living systems. In Earth and space systems and living systems the average scores for Australian females were significantly higher than the OECD average, but in physical systems the average score for females was not significantly different to the

OECD average. In the science competencies, Australian males outscored females in explaining phenomena scientifically, and females outscored males in identifying scientific issues.

Comment

The PISA data suggest that WA students are among the highest science achievers in the nation. Readers interested in 2006 PISA comparisons of Indigenous and non-Indigenous students in Australia and New Zealand might like to consult the following:

McConney , A., Oliver, M. C., Woods-McConney , A., Oliver, M. C., and Schibeci, R. (2011) Bridging the Gap? A Comparative, Retrospective Analysis of Science Literacy and Interest in Science for Indigenous and Non-Indigenous Australian Students. *International Journal of Science Education*, *33*(14), 2017-2035

Woods-McConney , A., Oliver, M. C., McConney , A., ., Maor, D. and Schibeci, R. (2011) Science Engagement and Literacy: A Retrospective Analysis for Indigenous and Non-Indigenous Students in Aotearoa New Zealand and Australia. *Research in Science Education*

Goodrum, D., & Rennie, L., J. (2007). ***Australian School Science Education National Action Plan 2008-2012,*** **The National Action Plan. Department of Education (Ed.), Vol. 1 & 2., Canberra.**

http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/Australian_School_Education_Plan_2008_2012.htm

Background

This report sets out a national plan of action for school science education in Australia.

Summary

The National Action Plan is set out in three clusters of action areas. … The first cluster of action areas relates to students and the science curriculum and foci for action are described for curriculum, assessment and resources. The second cluster relates to teacher education for science and professional learning, and the foci for action relate to initial teacher education, professional learning and teacher supply and demand. In the final cluster, broader, systemic and community issues are addressed, with actions suggested for systemic relationships and community sources of learning. (p. 8)

Cluster 1 priority actions

1.1 Resolve issues relating to, and develop, a common science curriculum that builds upon the Statements of Learning and retains sufficient flexibility to accommodate local needs.

1.2 Encourage teaching and learning approaches that promote the outcome of scientific literacy.

2.1 Embed the effective use of diagnostic, formative and summative assessment approaches in curriculum resource development.

3.1 Develop national quality resources, including Primary Connections for the primary school years and a comprehensive, inquiry-based science programme for the early to middle secondary school years, and ensure adequate funding for their field-testing and implementation.

Cluster2 priority actions

4.1 Increase funding for initial teacher education to ensure quality training experiences.

4.2 Develop a national video databank of best practice in science pedagogy to enhance professional learning, both in pre-service and in-service environments.

5.1 Explore the provision of financial incentives for teachers to engage in professional learning activities during "stand down" periods.

6.1 Re-examine the various pathways via which people may train (or re-train) to become teachers, particularly those pathways relating to career change, with a view to increasing options and removing barriers, whilst maintaining quality of entrants.

6.2 Examine the components of teachers' work with a view to decreasing nonteaching duties to allow more time for lesson preparation, teaching, professional learning and reflection. 6.3 Continue to explore avenues to make teaching more financially attractive and to retain science teachers in the profession.

Cluster3 priority actions

7.1 Establish a National Council for School Science Education. The Council could be established under the auspices of MCEETYA.

8.1 Promote linkages between science at school and community resources by establishing supporting networks to enhance opportunities for collaboration.

Comment

Those actions nominated as 'priority' actions only are given above. The additional 'actions' will be found in the original document, which is quite detailed and elaborate.

Tytler, R. (2007). *Re-imagining Science Education: Engaging students in science for Australia's future.* ACER Press.

http://www.acer.edu.au/documents/AER51_ReimaginingSciEdu.pdf

Background

This report focuses on how me might re-engage students in STEM.

Summary

> What is needed is the development of a coherent national vision around which a future direction can be clearly charted. Over the next short time period, important decisions will need to be made concerning the future directions of science education in this country. Australia has the opportunity to establish science education as a leading plank in educational reform.
>
> We need to draw on innovations in this country and overseas that exemplify:
>
> - a rethinking of content, based on a rigorous pursuit of the guiding principle of scientific literacy
> - the promotion, through teacher education and resource development, of more varied and open pedagogies known to elicit middle years students' engagement with learning
> - the development of assessment policy and practice that support a more flexible and open, but challenging curriculum.
>
> What is needed, above all, is the vision and will to establish a fresh and coherent vision to guide this process and bring all stakeholders on board. The time has passed where it is enough to tinker round the edges with a science education that belongs to the past. (pp. 67-8)

Comment

This report is well worth reading for its efforts to re-engage students. It makes a number of recommendations, including in the areas of: pedagogy, assessment and teacher learning.

Jenkins, E. W., &, & Pell, R. G. (2006). ***The Relevance of Science Education Project (ROSE) in England: A summary of findings Leeds, UK*****. Centre for Studies in Science and Mathematics Education, University of Leeds.**

http://roseproject.no/network/countries/uk-england/rose-report-eng.pdf

Background

The report is based on the responses of over 1,200 students aged 15-16 years.

Summary

In considering this summary, it is important to remember that students express a variety of views and that drawing attention to gender differences runs the risk of ignoring important differences among boys and among girls themselves.

1. Most students agree that science and technology are important for society and are optimistic about the contribution that these disciplines can make to curing diseases such as HIV/AIDS and cancer. Science and technology are also seen as creating greater opportunities for future generations and as making everyday life healthier, easier and more comfortable. optimistic about the contribution that these disciplines can make to curing diseases such as HIV/AIDS and cancer. Science and technology are also seen as creating greater opportunities for future generations and as making everyday life healthier, easier and more comfortable.

2. There is a lower level of agreement that the benefits of science are greater than its possible harmful effects, although a majority of both boys and girls hold this view. Only a minority of boys and girls agree that science and technology will help to eradicate poverty and famine in the world.

3. Students' positive views about science, technology and society are not reflected in their opinions about their school science education. While this is regarded as 'relevant' and 'important' by most students, most boys (and rather more girls) don't like it as much as other subjects.

4. There is a group of students who like science better than other school subjects but do not find school science interesting.

5. There is a minority of students who are strongly supportive of science, like their school science, want as much science as possible at school and envisage themselves working in the future as a scientist or technologist. For these students, the commitment to science is, at best, only weakly associated with notions such as utility and relevance.

6. Most students do not agree that school science (GCSE) is a difficult subject.

7. Most boys and girls disagree that school science has made them more critical and sceptical, opened their eyes to new and exciting jobs or increased their appreciation of nature.

8. When asked what they wished to learn about, there are marked differences in the responses of boys and girls. For girls, the priorities lie with topics related to the self and, more particularly, to health, mind and well-being. The responses of the boys reflect strong interests in destructive technologies and events. Topics such as 'Famous scientists and their lives' and 'How crude oil is converted into other materials' are among the least popular with both boys and girls.

9. There are major differences in the out-of-school experiences of boys and girls. Those of girls are associated with activities involving the natural world, such as planting seeds or crafts such as knitting or weaving. In the case of boys, activities that might be described as mechanical are to the fore, although the engagement of girls with the use of simple tools should not be overlooked.

10. When asked about a future job, both boys and girls attach importance to having time for a family and to using their talents and abilities. However, helping other people is more important for girls than boys and they attach less importance than boys to becoming famous.

11. Both boys and girls disagree strongly that threats to the environment are not their business. However, such disagreement is not reflected in a corresponding general

willingness to sacrifice many goods to solve or alleviate environmental problems. There is also, at best, only a moderate level of interest in learning about a range of environmental issues, save for the possible radiation dangers associated with mobile telephones and the protection of endangered species of animals.

12. Students are optimistic that solutions can still be found to environmental problems but girls are less confident than boys in the ability of science and technology to do so.

13. Some students see environmental problems as exaggerated, the cause of too much anxiety and as best left to experts to resolve. Others attach more importance to the role of individuals in addressing environmental problems and are willing to make personal sacrifices to this end.

14. When asked to choose a field of research they would pursue as a scientist, most students chose the treatment and cure of disease or aspects of space science. The former was much more popular with girls than boys but the difference was much narrower in the case of the latter. The two most common reasons for the choice of field of research involved references to curiosity/interest/excitement and to helping people or animals.

15. The responses of the students from schools in England fall within the broad pattern of responses from the industrialised countries within the ROSE project, although there are some important differences in means and gender differences. Given the differences in the cultural norms, education systems, school curricula, assessment regimes and pedagogy among these countries, it seems likely that students' views about science and technology are strongly coloured, if not determined, by elements that characterise the industrialised world but which are absent, or much less in evidence, in countries within the developing world.

16. The data raise a number of important research questions that need to be answered if attempts to encourage more students to choose the physical science as subjects of advanced study are to be successful. For example, at what age and in response to what influences do students choose, or rule out, careers for which scientific qualifications are important? How important is the role played by parents, careers' advisers, students' peer groups, teachers and others? To what extent, if at all, can the reluctance of students to

study the physical sciences beyond compulsory schooling be attributed to school-based factors? Any attempt to answer questions of this kind will require sophisticated, complex and longitudinal studies that will allow the relevant issues to be identified and explored over time.

Comment

Although these are not Australian students, many of the findings will provide guidance to STEM providers.

Fensham, P. J. (2008). ***Science Education Policy-making: Eleven emerging issues.*** **Paris: UNESCO.**

http://unesdoc.unesco.org/Ulis/cgi-in/ulis.pl?catno=156700&set=48EB22B3_2_3&gp=0&lin=1

Background

This report was commissioned by the by the UNESCO Section for Science, Technical and Vocational Education. It began with the statement: 'The quality of school education in science and technology has never before been of such critical importance to governments.' (p. 4) This importance is governed by three 'imperatives': first, the preparation of future scientists; second, the need for 'scientifically and technologically informed citizens' to support sustainable development; and, third, the pervasive influence of digital technologies.

Recommendations

A. SCIENCE IN SCHOOL AND ITS EDUCATIONAL PURPOSES

A.1 As a first priority, policy makers should consider what are the educational purposes that science and technology education can best provide for students as they move through the stages of schooling

B. ACCESS AND EQUITY IN SCIENCE EDUCATION

B.1 Policy makers should consider, within whatever funding is available, how to maximise the number of students whose science and technology education is in the hands of able science teachers.

B.2 Policy makers should review the participation of boys and girls in S&T education and seek to implement actions that will reduce the explicit and implicit factors that still disadvantage girls in their access to the fields of S&T as interests and careers.

B.3 Policy makers should consider means of overcoming cultural disadvantages that some groups of students experience specifically in science and technology education.

C. INTEREST IN AND ABOUT SCIENCE

C.1 Policy makers should make the issue of personal and societal interest about science the reference point from which curriculum decisions about learning in science and technology education are made about content, pedagogy, and assessment

D. HOW TECHNOLOGY RELATES TO SCIENCE IN EDUCATION

D.1 Policy makers should consider mandating that science education should move progressively (as has been done in several countries) towards a real world, "Context-based" approach to the teaching and learning of school science at all levels of the school curriculum

E. THE NATURE OF SCIENCE AND INQUIRY

E.1 Policy makers should consider what will encourage a better balance between teaching science as established information and those features of science that are referred to as the Nature of Science

F. SCIENTIFIC LITERACY

F.1 Policy makers should consider replacing the generic use of "scientific literacy", as a goal of school science education, with more precisely defined scientific knowledge and scientific abilities, that have meaning beyond school for the students at each of the stages of schooling, for example, lower primary, upper primary, lower secondary, the last years of compulsory schooling and the final secondary years

G. QUALITY OF LEARNING IN SCIENCE

G.1 Policy makers should consider changing the assessment procedures, as critical curriculum factors, in ways that will encourage higher levels of learning as the intended outcomes of school science and technology.

H. THE USE OF ICT IN SCIENCE AND TECHNOLOGY EDUCATION

H.1 Policy makers should consider the cost, provision and maintenance of ICT across the school system in terms of the educational benefit and equity it will bring to schooling in general and to science and technology education in particular.

I. DEVELOPMENT OF RELEVANT AND EFFECTIVE ASSESSMENT IN SCIENCE EDUCATION

I.1 Policy makers should consider how the intentions of the science curriculum for students' learning can be more authentically assessed, both within schools and externally, by the use of a wider variety of assessment tools.

J. SCIENCE EDUCATION IN THE PRIMARY OR ELEMENTARY YEARS

J.1 Policy makers should consider a quite different curriculum for science and technology in the primary years, that engages the considerable pedagogical skills of these teachers, provides their young learners with a series of positive and creative encounters with natural and human-made phenomena, and builds their interest in these two areas of learning.

K. PROFESSIONAL DEVELOPMENT OF SCIENCE TEACHERS

K.1 Policy makers should consider the policy implications (financially and structurally) and the benefits in establishing the provision of ongoing, focused professional development in science and technology and their teaching, as an essential aspect in the careers of all science teachers.

Comment

The report is aimed explicitly at policy makers. It is written by one of the leading international science educators, and it makes recommendations which are supported by an elaboration of 'operational aspects' for improving STEM education. It would be difficult to find a more thoughtful or compelling case for improving STEM education.

Osborne, J., &, & Dillon, J. (2008). ***Science Education in Europe: Critical Reflections.*** **London: Nuffield Foundation.**

http://www.pollen-europa.net/pollen_dev/Images_Editor/Nuffield%20report.pdf

Background

This report provides a European perspective on STEM education.

Summary

Recommendation 1

The primary goal of science education across the EU should be to educate students both about the major explanations of the material world that science offers and about the way science works. Science courses whose basic aim is to provide a foundational education for future scientists and engineers should be optional.

Recommendation 2

More attempts at innovative curricula and ways of organising the teaching of science that address the issue of low student motivation are required. These innovations need to be evaluated. In particular, a physical science curriculum that specifically focuses on developing an understanding of science in contexts that are known to interest girls should be developed and trialled within the EU.

Recommendation 3

EU countries need to invest in improving the human and physical resources available to schools for informing students, both about careers in science – where the emphasis should be on why working in science is an important cultural and humanitarian activity – and careers from science where the emphasis should be on the extensive range of potential careers that the study of science affords.

Recommendation 4

Countries should ensure that:

- teachers of science of the highest quality are provided for students in elementary and lower secondary school;

- the emphasis in science education before 14 should be on engagement.

Evidence would suggest that this is best achieved through opportunities for extended investigative work, and 'hands-on' experimentation and not through a stress on the acquisition of canonical concepts.

Comment

Although European in perspective, the recommendations are, in the main, relevant to Western Australia.

Lyons, T., &, & Quinn, F. (2010). *Choosing Science, Understanding the declines in senior high school science enrolments.* National Centre of Science, ICT and Mathematics Education for Rural and Regional Australia (SiMERR Australia), University of New England.

http://www.asta.edu.au/media/reports/choosing_science_report

Background

This is a report on declining enrolments in science. It is an attempt to understand what leads Year 10 students to make subjects choices for Year 11 study. In the first phase, 589 secondary science teachers were asked about their perceptions of this issue. In the second phase, 3759 Year 10 students were surveyed about their Year 11 study intentions.

Recommendations

Recommendation 1:

That education authorities, science organisations and other stakeholders seeking to formulate policy to address declines in science enrolments take into consideration the findings of this study concerning the relative contributions of various factors to these declines.

Recommendation 2:

That the Australian Curriculum, Assessment and Reporting Authority (ACARA), federal, state and territory education authorities and others relevant stakeholders ensure the new National Science Curriculum reflects teachers' and students' recommendations for increasing enrolments by making school science learning experiences more interesting, practical and personally relevant.

Recommendation 3:

That federal, state and territory education authorities, professional teacher associations and science organisations work together to develop adequately funded, sustainable and coordinated strategies to improve links between school science and scientists in university and industry settings. The strategies should have a particular focus on authentic, research-based science experiences both inside and outside the classroom and creating greater awareness among Year 10 students of the variety and scope of science-related careers.

Recommendation 4:

That education authorities and universities ensure that the value of academically challenging subjects such as physics and chemistry (and indeed difficult non-science subjects) is adequately recognised in calculations of university entry scores/rankings and entry requirements across Australia.

Recommendation 5:

That science teachers should encourage girls to have greater confidence in their science learning and ability to achieve. Education authorities, professional associations and science organisations should continue working towards removing the barriers to participation by girls in some areas of science, and encourage initiatives to educate students about the range of opportunities available to women in science careers.

Recommendation 6:

That federal, state and territory education authorities and other stakeholders should carefully consider which stage of schooling represents the most cost-effective target for strategies aimed at improving and sustaining senior high school science enrolments.

Recommendation 7:

That professional science teacher associations take steps to ensure their members are made more aware of the strong influence teachers have on students' decisions about choosing science.

Recommendation 8:

Education authorities and other stakeholders should initiate further research to investigate why students in rural schools have less positive attitudes to school science than their city peers.

Recommendation 9:

Education authorities and other stakeholders should initiate further research to investigate how school type (single sex or coeducational) affects Year 10 students' perceptions of their abilities in science.

Recommendation 10:

Education authorities and other stakeholders should initiate further research to determine the influence of students' attitudes to science on their enrolment intentions, and in particular to clarify at what point students' attitudes are most salient to their decisions.

Comment

Declining STEM enrolments is major issue for many Western nations. One theme which emerged from this report was 'the failure of school science to engage a wider range of students' (p. i). This conclusion is based on the evidence gathered during the study, and is a theme echoed in many other reports included in this supplementary volume.

Readers might find this recent review of the international literature on student choice relevant here:

Vetleseter, M. B., Henriksen, E. K., Lyons, T., Schreiner , C., (2011) Participation in science and technology: young people's achievement-related choices in late-modern societies. *Studies in Science Education,* 47(1), 37-72.

National Research Council, (2011). ***Successful K-12 STEM Education, Identifying Effective Approaches in Science, Technology, Engineering and Mathematics.*** **Washington, D.C.: National Research Council of the National Academies.**

http://www.nap.edu/openbook.php?record_id=13158&page=R1

Background

This report summarises what are believed to be criteria which lead to effective STEM education in schools. The work was conducted under the auspices of the National Academies in the USA. Its beginning assumption was:

> Science, mathematics, engineering, and technology are cultural achievements that reflect people's humanity, power the economy, and constitute fundamental aspects of our lives as citizens, workers, consumers, and parents. What can schools do to meet this goal for their students? (p. 3)

Summary

Summary of criteria to identify successful K-12 STEM schools

Effective STEM instruction capitalizes on students' early interest and experiences, identifies and builds on what they know, engages them in STEM practices, and provides them with experiences to sustain their interest. Key elements that contribute to effective STEM instruction include a coherent set of standards and curriculum, teachers with high capacity, a supportive system of assessment and accountability, adequate instructional time, and equal access to quality STEM learning opportunities. The research also suggests that effective elementary schools share common elements, namely, strong leadership, professional capacity among teachers, strong ties to parents and the community, a student-centered learning climate, and instructional guidance for teachers. These elements have been shown to support learning gains even in schools in areas of extreme poverty and hardship. (p. 32)

What Schools and Districts can do to support effective K-12 STEM education

First, districts seeking to improve STEM outcomes beyond comprehensive schools should consider all three models of STEM-focused schools described in this report to meet the various goals they may hold for STEM education. Districts should be aware that each type comes with its own set of strengths and limitations. The research base does not support recommending one school type over another or treating a particular type of school as an indicator of STEM excellence by itself.

Second, districts should devote adequate instructional time and resources to science in grades K-5. A quality science program in the elementary grades is an important foundation that can stimulate students' interest in taking more science courses in middle school and high school and, possibly, in pursuing STEM disciplines and careers.

Third, districts should ensure that their STEM curricula are focused on the most important topics in each discipline, are rigorous, and are articulated as a sequence of topics and performances. Ideally, STEM curricula should be aligned across disciplines from grades K-12.

Fourth, to improve teaching and learning in the STEM disciplines, districts need to enhance the capacity of K-12 teachers. STEM teachers should have a deep knowledge of their subject matter and "an understanding of how students' learning develops in that field, the kinds of misconceptions students may develop, and strategies for addressing students' evolving needs."

Fifth, districts should provide instructional leaders with professional development that helps them to create the school conditions that appear to support student achievement …. School leaders should be held accountable for creating school contexts that are conducive to learning in STEM.

What State and National Policy makers can do to support effective K-12 STEM education

To make progress in improving STEM education for all students, policy makers at the national, state, and local levels should elevate science to the same level of importance as reading and mathematics. Science should be assessed with the same frequency as mathematics and literacy, using a system of assessment that supports learning and

> understanding. Such a system is not currently available. Therefore, states and national organizations should develop effective systems of assessment that are aligned with the next generation of science standards and that emphasize science practices rather than mere factual recall. National and state policy makers should invest in a coherent, focused, and sustained set of supports for STEM teachers to help them teach in effective ways. Teachers in STEM should have options to pursue professional learning that addresses their professional needs through a variety of mechanisms, including peer-to-peer collaboration, professional learning communities, and outreach with universities and other organizations. Furthermore, federal agencies should support research that disentangles the effects of school practice from student selection, recognizes the importance of contextual variables, and allows for longitudinal assessments of student outcomes, including the three strategic goals of STEM education and intermediate outcomes. Federal funding for STEM-focused schools should be tied to a robust, strategic research agenda. Only knowledge of this sort will allow a full response to the questions that were put to this committee. (p.35)

Comment

Although this report is written for US audiences, there is much useful advice for Australian audiences to consider. This is especially true for schools which have declared themselves to be specialist 'science' or 'technology' schools.

Beatty R. A., (ed.) (2011). *Successful STEM Education: A Workshop Summary.* Division of Behavioral and Social Sciences and Education., Washington, D.C.: National Research Council.

www.nap.edu/catalog/13230.html

Background

This is the report of a workshop on 'Successful STEM education' by the Committee on Highly Successful Schools or Programs for K-12 STEM Education, under the auspices of the National Academies in the USA. It focused on what helped schools achieve successful STEM outcomes.

The concluding section of the report is headed 'Closing thoughts'; it is reproduced below.

Summary

> With regard to the broad question of what makes STEM education effective, … definitive answers are simply not on the horizon in the short term. There is promising research in progress that can provide some help to policy makers and school leaders, and other studies will eventually yield findings about the efficacy of different school models and the different approaches taken under each of the different models. Yet neither the research findings that are available now nor even the findings that will be available when the research now under way is complete will support general conclusions about the efficacy of different school models. There will still be gaps in the knowledge base.… Teachers matter greatly to schools' outcomes … particularly their content knowledge. … Much of the discussion of school types focused on high schools, for example, although grades K-8 are also very important. There was more attention to mathematics and science than to engineering and technology education. These are imbalances that reflect the literature, and they may also reflect the emphasis of current accountability policies. The T in STEM has always been easy to overlook, one participant observed, because it is difficult to define. Is it educational technology? Is it technology as a result of engineering?

Comment

The workshop report provides useful reading for those teachers and other education leaders in specialist ‘science’ or ‘technology’ schools. It is important to remember that engineering is treated differently in the US educational systems.

B: Directory of STEM education reports:

STEM Teachers

STAWA (2000). ***Review of the Quality and Supply of Science Teachers: a report by STAWA.*** **Perth, Western Australia: Science Teachers' Association of Western Australia.**

http://www.dest.gov.au/NR/rdonlyres/56DC1CEE-6509-42EA-8038-C7DBA3BB3C7/1733/RTTE133.pdf

Background

This report provides an early view on science teachers in WA.

Summary

1.That the State Government establishes a scholarship scheme for university undergraduates who elect and complete the study of Physics and/or Chemistry units.

2. That the State Government establishes a scholarship or bursary scheme for new university graduates of Physics and Chemistry to study education units with a view to entering teaching.

3. That for undergraduates studying Physics and Chemistry units the State Government subsidises the study of one science communication unit that involves some aspect of teaching or mentoring high school science students.

4. That the HECS repayment for teachers of all subjects are the same and that inequities between repayments are met by the Federal Government.

5. That the Education Department of Western Australia offers suitably qualified science teachers of Physics and/or Chemistry receive salaries that are more commensurate with their peers who enter other non-teaching scientific professions.

6. That the State Government provides scholarships for the study of education qualifications to physical science graduates employed in other professions.

7. That teacher-employing bodies offer ten scholarships for teachers to retrain as Physics and/or Chemistry teachers together with incentives such as increased remuneration, preferential teaching locations and accelerated career pathways.

8. That the State Government provides financial incentives for experienced, qualified teachers of Physics and/or Chemistry to teach in country schools.

9. That teacher-employing bodies provide career incentives for experienced, qualified teachers of Physics and/or Chemistry to teach in the country, particularly in isolated areas.

10. Those teacher-employing bodies provide five days of science professional development each year for teachers of science in remote and regional areas.

11. That the Education Department provides new teachers of science in District High Schools with the opportunity to participate in a mentoring programme in which they spend two, one week periods during the year working with a science teacher at a Senior High School. The mentoring teacher reciprocates by spending two, two-day periods in the District High School.

12. That the Science Teachers. Association of WA continues to develop their on-line science-mentoring programme for new teachers.

13. That the Science Teachers. Association of WA continues to develop on-line resources for teachers such as the Teacher Survival Kit.

14. That the Science Teachers. Association of WA continues to manage the operation of their listserver, Catalist.

15. That teacher-employing bodies provide support for new teachers of science by reducing their teaching load to 80% of the normal teaching load for their first year of teaching.

Comment

It is interesting to reflect on which of these recommendations have been acted on.

Lawrance, G., A., &, & Palmer, D., H. (2006). ***Clever Teachers, Clever Sciences.*** **Retrieved from:**

http://www.dest.gov.au/NR/rdonlyres/C571311D-04D5-4DB3-BA26-65051BD21FBE/812/03_06.pdf

Background

This study was commissioned by the Department of Education, Training and Youth Affairs (DETYA) to examine practices in initial teacher education in science, mathematics and technology. The main data source was telephone interviews with 119 university science, mathematics and technology education specialists.

Summary

We offer some suggestions for the directions that future innovation and research may take in the development of science, mathematics and technology initial teacher education:

1. At present, secondary science education students typically have content studies in only two sciences (a major and a minor). A step forward would be to develop patterns of discipline studies that will maintain a high professional standard, but include significant preparation in the full range of junior sciences.

2. Students in graduate programs are often strong in one science area, but deficient in others, so future programs should develop ways of including targeted science/mathematics content in graduate programs.

3. The huge breadth of the school curriculum in design and technology has created problems for technology teacher education programs, and some streamlining should be seriously considered.

4. At present, the ratio between content studies and education studies in secondary programs is normally 50:50, but whether this is the best ratio for a future teacher still needs to be established by future research.

5. According to interviewees, many teachers in schools are still using traditional 'chalk and talk' or textbook approaches, which are at odds with the strategies advocated at university. Innovative ways to ensure that the practicum reinforces what the students learn at university are still needed in all specialisations.

6. Double degree programs offer students the opportunity to complete two degrees in four years, but low enrolments show that they have not been a successful innovation for attracting students into mathematics and science teaching. Any future developments of this type of program, for mathematics and science at least, should take this factor into consideration.

7. Several institutions have non-Education based programs which give 'mainstream' mathematics and science students experiences in schools. The potential of these programs to be linked to existing education programs should be further explored.

Comment

This report updates an earlier report into an earlier inquiry into science and mathematics teacher education by Speedy et al (1989): see below. The suggestions made in the report are likely to be overtaken by any future demands of a national standards initiative: see the Australian Institute for Teaching and School Leadership (AITSL) website at http://www.aitsl.edu.au/ .

Speedy, G., Annice, C. and Fensham, P. (1989). *Discipline review of teacher education in mathematics and science* (Vol. 1). Canberra: Australian Government Publishing Service.

Committee for the Review of Teaching and Teacher Education. (2003). ***Review of teaching and teacher education, Interim Report: Attracting and Retaining Teachers of Science, Technology and Mathematics.*** **Canberra: Committee for the Review of Teaching and Teacher Education.**

http://www.dest.gov.au/archive/schools/teachingreview/InterimReport.pdf

Background

Retaining teachers is as important as attracting students to teaching. This report makes suggestions about how this might be done.

Summary

> Too many teachers leave teaching in the first three to five years of their teaching careers, representing an excessive loss of talent. It needs to be borne in mind, however, that as with other occupations, there is an increasing trend towards movement 'in and out' of a variety of occupations. Episodic career change will be increasingly common in all parts of the labour market.
>
> Greatly improved programs of support, induction and mentoring for beginning teachers need to become commonplace if successful transition to a continuing career in teaching is to occur. Here again there is need for continuing partnerships between universities and schools in guiding new teachers through the early, demanding period of their career. Positive work environments, in which teachers feel valued and are able to fully engage students, are crucial to student learning. The physical conditions within schools, curriculum materials, teaching loads, appropriate class sizes, access to and use of technology, access to appropriate in-service training and the opportunity for study leave and professional development increase teacher satisfaction and therefore retention.
>
> The provision of high quality and pertinent professional learning and development opportunities will serve to rejuvenate, motivate and retain good teachers. Where possible, giving teachers the opportunity to gain experience in the broader education profession and other industries relevant to their teaching can reinvigorate and add new dimensions to teaching skills. (p. xi)

Comment

This ‘interim report’ appears not to have been followed up by a final report.

Harris, K.-L., Jensz, F., &, & Baldwin, G. (2005). ***Who's Teaching Science? Meeting the demand for qualified science teachers in Australian secondary schools: Report prepared for Australian Council of Deans of Science.*** **Melbourne, Victoria: Centre for the Study of Higher Education, The University of Melbourne.**

http://www.cshe.unimelb.edu.au/people/harris_docs/Who'sTeachingScience.pdf

Background

This is a significant report on the discipline background of science teachers; it complements those reports on the discipline background of mathematics teachers.

Summary

Key Findings:

- Nearly 43 per cent of senior school physics teachers lacked a physics major, and one in four had not studied the subject beyond first-year. This, coupled together with the reported difficulties in attracting physics teachers (40 per cent of schools surveyed), paints an alarming picture. No matter how good their pedagogical skills, teachers who lack knowledge in their discipline are manifestly unprepared.
- Among senior school chemistry teachers, one in four lacked a chemistry major, whereas 14 per cent of senior school biology teachers lacked a biology major.
- There is a clear preference among heads of secondary school science departments for staff with a university degree in science supplemented by an education qualification, rather than a university degree in teaching with some study in science.
- There is agreement among heads of secondary school science departments that, in future, teachers of senior science should have at least a major in the appropriate discipline area – a view supported by the ACDS.
- There is a relatively high percentage of Year 7/8 teachers with no university exposure to any of the four surveyed disciplines: even at the senior years of schooling, up to 6 per cent of teachers have not studied these subjects beyond first year at university, if at all.
- There is concern of the heads of secondary school science departments at the difficulty in recruiting suitably qualified staff, especially in light of the age profile of existing staff: more than one third of male science teachers are at least 50 years of age.
- There is a need for early career teachers to have effective mentoring.

Recommendations:

The Australian Council of Deans of Science calls on State and Federal governments, as well as secondary and tertiary education authorities to:

1. take note of this report;

2. implement rigorous workplace planning to ensure that sufficient numbers of suitably qualified teachers of science disciplines are available to nurture future generations of school students;

3. cooperate across sectorial, State and Territory boundaries to develop a national science teacher workforce plan;

4. work with the university sector to develop international best practice in science teacher education programmes;

5. adopt minimum standards, focused on science as well as pedagogy, of qualifications for science teachers at the various levels of secondary school education;

6. in the medium term, introduce a meaningful accreditation mechanism for science teachers, involving minimum qualification levels in science as well as pedagogy.

Comment

Some of the recommendations may be adopted if AITSL policy is implemented.

Harris, K.-L., &, & Jensz, F. (2006). *The Preparation of Mathematics Teachers in Australia, Meeting the demand for suitably qualified mathematics teachers in secondary schools*. Melbourne: Centre for the Study of Higher Education, The University of Melbourne.

http://www.cshe.unimelb.edu.au/people/harris_docs/Prep_Math_Teach_Aust.pdf

Background

This report complements the *Who's teaching science?* report.

Summary

The Australian Council of Deans of Science calls on State and Federal governments, as well as secondary and tertiary education authorities, to:

1. Take note of this report;

2. Implement rigorous workplace planning to ensure that sufficient numbers of suitably qualified teachers of mathematics and science are available to nurture future generations of school students;

3. Cooperate across sectoral, State and Territory boundaries to develop a national science and mathematics teacher workforce plan;

4. Work with the university sector (particularly Deans of Education) and state government education departments to develop international best practice in science and mathematics teacher education programmes;

5. Adopt minimum standards, focused on science as well as pedagogy, of qualifications for science and mathematics teachers at the various levels of secondary school education;

6. In the medium term, introduce a meaningful accreditation mechanism for science and mathematics teachers, involving minimum qualification levels in science as well as pedagogy;

7. Implement bonded teaching scholarships to encourage students to enrol in combined science, mathematics and education programs

Comment

The shortage of well-qualified mathematics teachers is a continuing problem in many Western nations, for which there is no ‘quick fix’.

Brown, G. (2009). *Review of Education in Mathematics, Data Science and Quantitative Disciplines,* Report to the Group of Eight Universities: Group of Eight.

http://www.go8.edu.au/__documents/go8-policy-analysis/2010/go8mathsreview.pdf

Background

The report reviews education in quantitative areas of STEM.

Summary

Recommendations

1. The Go8 should encourage dialogue between Faculties of Education and Mathematics Departments with a view to introducing a component in the primary training program giving mathematical confidence and resources to future teachers. This would be taught by the Mathematics Department or School

2. The Go8 should support the raising of mathematics and science awareness in the community, covering all years of high school. This includes extra-curricular resource provision

3. Each Go8 vice-chancellor should review service teaching arrangements especially the internal funding model which drives them. Insight should be shared.

4. The Go8, sharing expertise already gained, should develop a systematic structure of enabling programs to counter the drop in students entering with low mathematics experience.

5. The Go8 should encourage research networking within Australia, not confined to its own universities. One specific proposal is that AMSI should be invited to organise research programs of six months or a year on specific topics with international visitors. The Go8 by contributing $10K each annually could, in sequence, second a program leader on sabbatical. Other costs could be sourced from research agencies and philanthropic organisations.

6. The Go8 should pay particular attention to Statistics, the ongoing consulting needs within the universities, the training of the next generation and the recovery of a strong research culture.

Comment

This report needs to be read in conjunction with other reviews of science and mathematics teacher education.

B: Directory of STEM education reports:

Supporting STEM Education

Rudd, K., & Smith, S. (2007). *New Directions for Maths and Science, Encouraging Young Australians to study and teach Maths and Science.* Canberra

http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;query=Id%3A%22library%2Fpartypol%2F4X2M6%22

Background

This is a report from the Australian Labor Party.

Summary

For Australia to succeed in a highly competitive global economy our children need to have a strong grasp of basic maths and science and encouragement to pursue careers in these areas. We are currently being left behind by other nations.

In our schools:

- Australia has a declining proportion of students who complete Year 12 studies in physics, biology and advanced mathematics. We need more qualified teachers:
- nearly half of all senior physics teachers do not have a major in physics and around 25 per cent of senior chemistry teachers do not have a major in chemistry;
- 25 per cent of science teachers don't have a science qualification;
- around 25 per cent of maths teachers do not have a major in maths and nearly 10 per cent have not studied any maths at university; and
- around a third of all science teachers are aged over 50 years;

And at our universities,

- 0.4 per cent of Australian university students graduate with maths and statistics qualifications compared with an OECD average of around 1 per cent.

Labor will encourage the study of maths and science and offer incentives for graduates to take these skills into related occupations including the teaching profession by:

- reducing the HECS contribution for new maths and science students from the current annual student contribution rate of $7,118 to $3,998 from 1 January 2009 ($80.2 million over 4 years)
- paying 50 per cent of the HECS repayments of maths and science students as at 1 January 2009 who, upon graduation from university, engage in relevant maths and science occupations, particularly the teaching of maths and science.
- This HECS remission will be available for a period of up to five years from graduation and while the graduate continues working in a relevant maths or science occupation. ($30.8 million over four years)
- Labor will ensure that universities are not financially worse off as a result of this reduction in student contribution to the costs of a maths or science degree. This assistance to universities will be included in Labor's higher education funding commitments to be announced in advance of the election.

Comment

It is useful to examine these promises to see which were fulfilled.

Hackling, M. R. (2009). *The Status of School Science Laboratory Technicians in Australian Secondary Schools:* Research report prepared for the Department of Education, Employment and Workplace Relations (DEEWR) and ECU, in collaboration with ASTA and SETA

http://www.deewr.gov.au/Schooling/Programs/Documents/Status%20of%20School%20Science%20Technicians%20report.pdf

Background

This is a valuable report, as it is the only one to concentrate on a sometimes overlooked, but important group: laboratory technicians.

Summary

Recommendation 1:
That the vocational education and training sector develop and offer courses for the initial training of technicians, aligned with the requirements of school science technicians and the school science curriculum.

Recommendation 2:
That minimum standards be established for the training required for employment of science technicians in secondary schools and for their induction into the role.

Recommendation 3:
That nationally consistent job specifications be established for various levels of science technicians to which appropriate salary scales are linked.

Recommendation 4:
That mechanisms be established to enhance the availability of ongoing training for school science technicians and increase technicians' participation in ongoing training

Recommendation 5:
That a minimum standard be established for technician servicing of secondary science programs.

Recommendation 6:

That a national internet-based advisory service be established to provide consistent and authoritative advice and support to secondary school technicians and teachers.

Recommendation 7:

That resources be provided to facilitate ASTA and SETA's involvement with and leadership of the development of national standards for the employment, roles and provision of training and ongoing support of technicians.

Recommendation 8:

That further research and development activity be funded to investigate ways of more effectively deploying paraprofessionals in Australian schools.

Comment

The role of the lab technician in supporting STEM initiatives should be incorporated into any future proposals.

Bell, P., Lewenstein, B., Shouse, A. W., &, & Feder, M. A. E. (2009). ***Learning Science In Informal Environments: People, Places And Pursuits.*** **Washington D.C.: National Academies Press.**

http://jcom.sissa.it/archive/08/03/Jcom0803%282009%29R02/

Background

This report was produced by the Committee on Learning Science in Informal Environments of the National Academies in the USA. Its underlying premise is: 'Science is shaping people's lives in fundamental ways.' (p. 1). The report makes specific recommendations on 'how to organize, design, and support science learning' (p. 6). These recommendations are given below.

Recommendations

Exhibit and Program Designers

Recommendation 1:
Exhibit and program designers should create informal environments for science learning according to the following principles. Informal environments should

- be designed with specific learning goals in mind (e.g., the strands of science learning)
- be interactive
- provide multiple ways for learners to engage with concepts, practices, and phenomena within a particular setting
- facilitate science learning across multiple settings
- prompt and support participants to interpret their learning experiences in light of relevant prior knowledge, experiences, and interests
- support and encourage learners to extend their learning over time.

Recommendation 2:
From their inception, informal environments for science learning should be developed through community-educator partnerships and whenever possible should be rooted in scientific problems and ideas that are consequential for community members.

Recommendation 3:
Educational tools and materials should be developed through iterative processes involving learners, educators, designers, and experts in science, including the sciences of human learning and development.

Front-Line Educators

Recommendation 4:
Front-line staff should actively integrate questions, everyday language, ideas, concerns, worldviews, and histories, both their own and those of diverse learners. To do so they will need support opportunities to develop cultural competence, and to learn with and about the groups they want to serve.

Researchers and Evaluators

Recommendation 5:
Researchers, evaluators, and other leaders in informal education should broaden opportunities for publication of peer-reviewed research and evaluation, and provide incentives for investigators in nonacademic positions to publish their work in these outlets.

Recommendation 6:
Researchers and evaluators should integrate bodies of research on learning science in informal environments by developing theory that spans venues and links cognitive, affective, and sociocultural accounts of learning.

Recommendation 7:
Researchers and evaluators should use assessment methods that do not violate participants' expectations about learning in informal settings. Methods should address the science strands, provide valid evidence across topics and venues, and be designed in ways that allow educators and learners alike to reflect on the learning taking place in these environments.

Comment

This is a substantial report (349 pages), with a wealth of valuable ideas. Readers will find the 17 ‘conclusions’, which precede the recommendations quite instructive. Conclusion 1 reads: ‘Across the life span, from infancy to late adulthood, individuals learn about the natural world and develop important skills for science learning’; this, and the remaining 16 conclusions form a productive starting point for all STEM providers.

McCallie, E., Bell, L., Lohwater, T., Falk, J. H., Lehr, J. L., Lewenstein, B. V., & Wiehe, B. (2009). ***Many Experts, Many Audiences: Public Engagement with Science and Informal Science Education. A CAISE Inquiry Group Report.*** **Washington, D.C.: Centre for Advancement of Informal Science Education (CAISE).**

www.caise.insci.org/uploads/docs/public_engagement_with_science.pdf

Background

This was a report by the Center for the Advancement of Informal Science Education (CAISE) in the USA. Their website notes: 'Informal science education supports people of all ages and walks of life in exploring science, technology, engineering, and mathematics (http://caise.insci.org/). The Centre set up a 'Public Engagement with Science Inquiry Group'; its report began with the statement:

> Science and technology are embedded in every aspect of modern life. This report describes how Public Engagement with Science (PES), in the context of informal science education (ISE), can provide opportunities for public awareness of and participation in science and technology. (p. 11)

The report provided neither a set of findings nor a set of recommendations. Nevertheless, its concluding statement, reproduced below, gives a sense of its work.

Summary

> Public Engagement with Science in informal science education has many potential benefits—bringing meaning and richness to the lives of publics, contributing to the fulfillment of some of ISE's pressing goals, keeping scientists energized and involved in their work, and even inspiring the direction of scientific research and science policy making. By bringing together a variety of expertise and skill sets, PES in ISE facilitates opportunities to address complex issues that scientific knowledge alone cannot resolve.
>
> The CAISE Public Engagement with Science Inquiry Group developed working definitions for key terms including PES, ISE, PES in ISE, and publics that may be

useful in continuing discussions. We also distinguished between PES mechanisms and PES perspectives, and between PES and PUS. Our group identified ways that PES can benefit informal science education, considerations and factors to take into account when designing and evaluating PES activities, a spectrum and dimensions by which to examine PUS and PES, and opportunities for various stakeholders (funding agencies, ISE professionals, scientists, and publics) to become more involved in PES endeavors.

Many of us in the ISE field have been tinkering with and talking about concepts and practices related to PES in ISE for many years. There are many "right answers," and this report is intended to serve as a prompt for further discussion, not as an authoritative sourcebook. We seek to push the boundaries of what PES in ISE could mean as well as its effectiveness and impact. We do so by offering up the consensus of a small group of people interested in and committed to broadening dialogue and mutual learning between publics and science. We anticipate that the ISE community will build from this document over time to enhance the usefulness and relevancy of PES in ISE as we collectively seek to serve individuals, communities, and our society. (p. 53)

Comment

This report was written for audiences in the USA. Nevertheless, it makes interesting reading for those involved in ISE projects. For example, Appendix D lists 'Potential impacts of PES-based ISE projects': behaviour, skills, attitude and interest/ engagement. These potential impacts are described for these audiences: publics, scientists and 'others' (such as policy makers).

Department of Innovation, Industry, Science and Research. (2009). ***Inspiring Australia: A national strategy for engagement with the sciences. A report to the Minister for Innovation, Industry, Science and Research.*** **Canberra, ACT.: Commonwealth of Australia.**

http://www.innovation.gov.au/science/inspiringaustralia/Pages/default.aspx

Background

This is the first national science communication report, which was adopted by the Commonwealth government as a national science communication strategy.

Summary

Recommendation 1

That DIISR's terminating Science Connections Program (SCOPE) be replaced with a broader national initiative designed to increase the level of public engagement in the sciences. Such an initiative would provide ongoing support for existing, successful activities while developing innovative approaches to effectively engage a wider audience.

Recommendation 2

That the Australian Government strongly articulate the goal of a scientifically engaged Australia and support development of strategic national priorities for communicating science and its benefits.

Recommendation 3

That leadership for this national initiative be provided by Questacon within DIISR, with input from a broadly constituted national advisory group to guide implementation, monitoring and evaluation, and reporting.

Recommendation 4

That a science communication summit be convened to secure buy-in from the diverse range of organisations and individuals in the science communication sector and to identify strategic priorities and the optimal roles for different agencies and institutions.

Recommendation 5

That the national initiative include continued funding for the highly regarded Prime Minister's Prizes for Science, with an enhanced promotional strategy targeting the wider Australian community and international audiences.

Recommendation 6

That the national initiative support promotional and awareness-raising activities, including travelling exhibitions showcasing Australia's capability in the sciences and promotional materials for scientists, science policy makers, overseas counsellors and other potential Australian science 'ambassadors' to use abroad.

Recommendation 7

That a national Science and Society forum be held annually to focus on the priorities for community engagement in science and key issues where science can serve the needs of society.

Recommendation 8

That the national initiative provide continued funding to extend the successful community-based activities of National Science Week, stimulating and leveraging further contributions by organisations across Australia and targeting new and under-served audiences.

Recommendation 9

That the national initiative include collaborative projects

That stimulate science organisations and networks across Australia to work together to promote information sharing, including holding 'Hot Science' briefings for elected members and policy officers of Federal, state and local governments, and leaders in the legal and business sectors.

Recommendation 10

That the national initiative support science communication and media training for scientists and

That a short-term working group be established to review mechanisms for further developing Australian science media content.

Recommendation 11

That a key focus of the national initiative should be raising awareness among young people of opportunities in science and research. The Australian Government's investment in schools, higher education and research should be harnessed to achieve this.

Recommendation 12

That the national initiative support science communication exhibitions and programs That target under-served groups, such as those living in outer metropolitan, regional and remote areas; Indigenous communities; people for whom English is a second language; and people who are disabled or have limited mobility.

Recommendation 13

That a 'national framework—local action' approach be adopted, led by a national hub collaborating with federal and state jurisdictions, business and the community. Such an approach should aim to increase cooperation amongst organisations involved in science communication down to the regional level, and drive partnerships and complementary activities.

Recommendation 14

That the national initiative include development of a national Web presence to increase the visibility of Australian science to national and international audiences, and to promote links to other relevant science-related sites.

Recommendation 15

That the national initiative support a program of research in science engagement—such as baseline and longitudinal attitudinal and behavioural studies, activity audits, program evaluations and impact assessments.

Comment

Some issues are treated well in this report. However, it pays insufficient attention to the importance of evaluation of science communication initiatives.

Scitech, (2011). ***The case for a Western Australian science and innovation education and engagement strategy.*** **Perth: Scitech.**

Background

The briefing paper, prepared by Scitech, April 2011, recommends a series of actions to government.

Summary

1. Key actions to improve formal and informal science education:

• The Minister for Science and Innovation and the Minister for Education establish an independent committee with Scitech as the secretariat

• Scitech develop a stronger network of informal science education providers in WA to promote opportunities for increased partnerships with schools to support the formal education sector

2. Key actions to increase effective science communication:

• The WA Government continue its proactive engagement strategy with the Federal Government's Inspiring Australia and National Science Week to ensure maximum returns of national programs

• That TIAC adopt a proactive communication plan that aims to inform and engage the science and innovation community in its policy directions and operational targets

• That Scitech's roles and responsibilities and contractual obligations be reviewed to enable it to take a clear leadership role in increasing the effectiveness of science communication across Western Australia through its Regional Strategy

3. Key actions to improve effective science awareness and promotion:

• TIAC to conduct base line data surveys and then to conduct ongoing monitoring surveys through Scitech

• Scitech expand its activities in coordinating activities for National Science Week, the International Years of Science (e.g. biodiversity 2010, chemistry 2011) with support from Lotterywest to create public science awareness and engagement opportunities

• ScienceNetwork WA be powered up to embrace Regional activities in WA reaching more of the local communities

4. Key actions for increasing science engagement opportunities across the community:

• That Scitech is asked to extend ScienceNetwork WA as a key facilitator of science events and programs that will increase interest in science and provide opportunities for community engagement

• Scitech to continually explore opportunities that will take science to the community in stimulating and exciting formats, such as Astrofest, which attracted 4,300 people

• The Chief Scientist be asked to develop a stronger media profile for the Minister of Science through a series of critical science events that increase engagement for key decision making audiences through events such as the following: - CCI State Science Workshops - Business Leaders Science Breakfasts - Women in Science Events - Science in the Media Events

Comment

Scitech is a key STEM provider in WA.

B: Directory of STEM education reports:

Evaluation Reports

Rennie, L. (2003). ***The ASTA Science Awareness Raising Model, An Evaluation Report.*** **Perth: Australian Science Teachers Association.**

www.dest.gov.au/NR/rdonlyres/...3188.../ASTASARMWEB2.pdf

Background

This report is a follow up to the Goodrum, Rennie & Rennie (2001) report on the status of science education in Australian schools.

Summary

Recommendation 1

It is recommended that the Commonwealth continue to promote and support schools, teachers, communities and industry to increase scientific literacy and science awareness through the adoption and adaptation of the Australian Science Teachers Association (ASTA) Science Awareness Raising Model and Package.

Recommendation 2

It is recommended that the package and model be put up on the World Wide Web to facilitate ease of access and uptake of the model and package to raise science awareness.

Recommendation 3

It is recommended that the package and the model also be prepared in hard copy so that those schools, teachers and communities with limited access to the World Wide Web can access and take up the model and the package to raise science awareness.

Recommendation 4

It is recommended that the Commonwealth continue to document current community/ industry projects and initiatives to create synergies and interaction between those projects and the ASTA Science Awareness Raising Model and Package.

Recommendation 5

It is recommended that the Commonwealth government look to furthering the ASTA Science Awareness Raising Model by the delivery of professional development workshops to partnerships of schools, industry, local government and community groups.

Comment

One of the case studies was a project based at Easter Goldfields Senior High School.

Tytler, R., Symington, D., Smith, C., &, & Rodrigues, S. (2008). ***An Innovation Framework based on best practice examples from the Australian School Innovation in Science, Technology and Mathematics (ASISTM) Project.*** **Melbourne: Educational Futures and Innovation: Science, Technology, Environmental and Mathematics Education (STEME) Research Group, Deakin University.**

http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/innovative_framework_asistm.htm

Background

The Australian School Innovation in Science, Technology and Mathematics (ASISTM) project was a significant, national STEM initiative. The report summarises research into 16 ASISTM projects, including two from WA.

Summary

Recommendation 1:

That programs such as ASISTM should encourage a separation of management and educational leadership duties and ensure that project proposals factor the costs of each into their budgets.

Recommendation 2:

That programs such as ASISTM encourage proposal writers to explore the antecedents of the proposed project, and indicate whether and how it builds from existing ideas and/or relationships.

Recommendation 3:

That programs such as ASISTM should not be unduly influenced by prior notions of which topics will be of interest to students, but should recognise that students' interest in many topics in science and technology can be captivated when explored in a context where they can see their relevance and where those responsible for the instruction show passion for the topic.

Recommendation 4:

That programs such as ASISTM give consideration to the extent to which proposals will provide opportunity for students and teachers to be exposed to contemporary practice in the field of study. This includes giving attention to both the selection of appropriate Teacher Associates and how their contribution to the project can be maximised.

Recommendation 5:

That programs such as ASISTM require project proposals to give clear indication about how positive features of the program will continue beyond the life of the program.

Recommendation 6:

That programs such as ASISTM create timelines and the possibilities for change in response to evolving circumstances which allow for the type of complexity which arises from projects involving multiple partners.

Recommendation 7:

That programs such as ASISTM build a requirement that project proposals include a plan for communicating the experiences of the project through personal experience and/or testimony and that the costs of this be built into the budget for the project.

Recommendation 8:

That DEEWR investigate ways in which experiences of, and understandings developed from, innovative approaches can be shared effectively across education systems. (p. 13)

Comment

The ASISTM project featured a number of innovations, such as the use of 'critical friends' to projects. Perhaps the most powerful conclusion was:

The case studies illustrate the power of local curriculum innovation based on local expertise, local issues and resources, and individual teachers' passions and expertise. (p. 13)

Henstridge, J., Roberts, P., Maclean, M., &, Caccianiga, R., (2009). ***Evaluation of the Primary Science Project.*** **Perth: Department of Education and Training.**

Background

This reports the evaluation of a significant STEM initiative, the WA DET Primary Science Project (PSP) in 50 schools.

Summary

There are a number of features of the PSP that appear to be instrumental in its success. These include:

- A high level of support provided by the PSP team at DET;
- Professional learning that addresses common concerns teachers have about teaching science;
- A program that is based on sound learning principles, such as modeling whereby the SST demonstrates science lessons with the target teacher's class so the target teacher can watch an example in action;
- Flexibility in the model that allow teachers to use it and adapt it to fit their varied circumstances and teaching styles;
- Materials for teaching science appropriate to primary school students. These include Primary Connections and Spellbound Science resources as well as the kits and materials assembled by host schools for their own use; and
- The involvement of schools in the PSP for at least several years is very important. It takes a number of years for teachers to develop knowledge and skills through a combination of experience using the PSP model, and support, professional learning and resources provided by the PSP team.

Comment

The authors stressed the importance of the final point. It underlines the limited use of a 'one off' professional learning experience in the case of primary science.

Dawson, V. (2009). ***Science is Primary, A review of Primary Connections Stage 3, 2006-2008.*** **Perth: Department of Education, Employment and Workplace Relations (DEEWR)**

http://www.science.org.au/primaryconnections/research-and-evaluation/images/science-is-primary.pdf

Background

This science and literacy program is aimed at primary teachers.

Summary

1. That whole school implementation of Primary Connections be facilitated by providing additional curriculum support to schools.

2. That the Primary Connections team works with jurisdictions to train local, state based master facilitators.

3. That the Primary Connections team continues to monitor and evaluate the progress of Primary Connections during Stage 4.

4. That the reference group consider strengthening the relationship between Primary Connections and early childhood education.

5. That the reference group consider strengthening the relationship between Primary Connections and indigenous education.

6. That Primary Connections endeavours to align itself with the national science curriculum.

7. That Primary Connections supports state and territory stakeholders to accept responsibility for Primary Connections activities in state and territory jurisdictions.

Comment

Funding for this initiative has been withdrawn by the Commonwealth government.

Rennie, L., J. (2010). ***Evaluation of the Science by Doing Stage One Professional Learning Approach 2010: Report prepared for the Australian Academy of Science.***

www.science.org.au/sciencebydoing/.../SbD-report-020211.pdf

Background

The Science by Doing (SbD) project is a national initiative for the improvement of secondary science education. It has four components: professional learning workshops, professional learning resources, curriculum resources and visits to schools by SbD team members.

Summary

The following recommendations are made on the basis of how SbD was implemented during 2010 and should be interpreted in that context.

Recommendation 1

Professional learning workshops assist teachers to become familiar with the concept of a professional learning community and the SbD resources, and enables them to begin planning the introduction of Science by Doing in their school. The introductory workshop must be continued with consideration giving to involving more than one person from each school. Consideration should also be given to an additional workshop, perhaps locally based, after one or two terms to consolidate progress.

Recommendation 2

Introductory material for the initial professional learning workshop should be reviewed to ensure that principals and teachers become cognisant of the professional learning focus of SbD and the overall structure of the program.

Recommendation 3

The teachers' professional learning resources are the backbone of the SbD professional learning approach. There should be some revision of content to maximise flexibility and appeal to teachers with variable levels of experience. The following should be considered:

- Additional modules that focus on specific issues, such as dealing with students with cultural differences.

- The production of a module for laboratory technicians.
- The production of a module relating to the development and characteristics of a PLC.
- The placement of an overview flowchart or guide to the suite of resources in the end papers of each module.

Recommendation 4

Some revisions to the student resources are required and these should be made in the context of feedback from the teachers who used them. The focus on inquiry-based learning should be maintained. Ensure that revised, and any new, resources link clearly to the Australian Curriculum: Science.

Comment

Because the project is new, the report notes (p. iv)

> No empirical data are available to attest to improved student learning because the resources are new and no comparative study was possible. However, teachers and Coordinators believed that student learning was enhanced, that students were more engaged, more enthusiastic, and asked more and higher level questions when using the SbD resources.

The report also noted the importance of effective leadership within the school.

C: Directory of STEM education support providers

- Analysing STEM education support initiatives
- Analysis of a sample of STEM education providers
- Overview of additional of STEM education providers
- Additional STEM education providers

Analysing STEM education support initiatives

Context

The national curriculum aims to achieve the outcome of scientifically prepared citizens with a curriculum structured as follows:

The Australian Curriculum: Science has three interrelated strands: *Science Understanding, Science as a Human Endeavour* and *Science Inquiry Skills*.

Together, the three strands of the science curriculum provide students with understanding, knowledge and skills through which they can develop a scientific view of the world. Students are challenged to explore science, its concepts, nature and uses through clearly described inquiry processes (http://www.australiancurriculum.edu.au/Science/Content-structure, accessed 11 July 2011).

The strands of the Australian Curriculum: Science are used in the following directory as a guide to users.

Science inquiry Skills:

This box indicates whether or not an organsition/initiative or project does, to varying degrees promote any of the Science Inquiry skills in the Australian Curriculum: science, including:

- questionning and predicting;
- planning and conducting
- processing and analysing data and information; and,
- evaluating;
- communicating

Most science inquiry skills are be embedded in the form of STEM competitions/ projects for students

Science understanding:

In this instance, “other” may include but is not limited to: mathematics, sustainability or conservation

In addition, we note the primary audiences in two ways, as follows:

Level:

ECE, Primary or Secondary**.** "Other" – may include but is not limited to: PD or PL for (Science) Teachers, Community/VET practitioners/lab technicians/tertiary

Location of Target audience:

Regional (i.e. the area has one or more Senior High School)
Remote (i.e. the area has no Senior High School)
Metropolitan (i.e. within Perth and surrounds)

C: Directory of STEM education support initiatives

Analysis of a sample of STEM education providers

Perth Zoo

Overview

Science inquiry skills: ☑ Yes ☐ No
Science understanding: ☑ Biological Sciences ☐ Chemical Sciences ☐ Earth and Space Sciences ☐ Physical Sciences ☑ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☑ Careers
Level: ☑ ECE ☑ Primary ☑ Secondary ☑ Other
Location: ☐ regional ☐ remote ☑ metropolitan

Website information summary

http://www.perthzoo.wa.gov.au/

All programs offered by Perth Zoo are crossed with sustainability and conservation and also links with a wide range of Science Inquiry Skills, Science Understanding and Science as a Human Endeavour. All programs are clearly linked to WACE K-12 and programs are separated into the following Year groups:

- K-3
- 4-7
- 8-10

- 11 and 12

For each year grouping, there is a collection of between 10 and 20 programs that teachers can choose from. Links to the WA curriculum can still be seen even where the new links have been made (e.g.: where the Biology section has been changes to link to the national curriculum (inquiry, understanding and human endeavour). Types of visits are broadly categorised into assisted (where an education officer facilitates) or unassisted (teacher directed with use of support materials provided by the zoo). There are also many special programs aimed at the different year groups as outlined below and details of each of these are available on the website.

- Special Programs:
  - Junior wildlife conference (yrs 4-7)
  - Biology Day (yrs 11 and 12)
  - Teaming With Wildlife (yrs 5-10)
  - GEES day (Geography, Earth, Environmental Sciences)
  - Wildways Conservation Art Project
  - Little Bobo – theatrical interpretation of a children's story of Orangutans (Primary)
- In addition:
  - TiWest Night Stalk (community and school research to survey local native animals in local environment)
  - Zoo camp yrs 4-8.

Perth Zoo has programs to suit all age ranges and school year groups but the focus is most clearly geared towards the *use and influence of science*, in particular biology. Career pathways are covered to varying degrees in some programs but sustainability and conservation are stronger themes underpinning all programs.

Water Corporation

Overview

Science inquiry skills: ☑ Yes ☐ No
Science understanding: ☑ Biological Sciences ☐ Chemical Sciences ☐ Earth and Space Sciences ☑ Physical Sciences ☐ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☐ Careers
Level: ☐ ECE ☑ Primary ☑ Secondary ☑ Other
Location of target audience: ☐ regional ☐ remote ☑ metropolitan

Website information summary

http://www.watercorporation.com.au/Education/education_index.cfm?uid=4576-3851-2201-1717

The Water Corporation provides water education for all students across the state. The aims of the Water Corporation are to support teachers in teaching water education through the different learning areas of the curriculum from Foundation to Year 10.

The Water Corporation Education office provides comprehensive curriculum materials and the website offers information on a wide range of water themed topics including:

- Water and the natural environment
- Drainage and stormways
- Water and health
- Water supply
- Water conservation
- Waste water

It is also possible to book lectures and tours online and access online education resources.

Waterwise Schools Program

In addition, the Water Corporation introduced the Waterwise Schools Program in 1995 as a long term, whole-of-school approach to water education which complements the Curriculum Framework across all major learning areas, especially Society and Environment. Curriculum links can be clearly seen on the website on a chart. There are also lectures on water topics are available in the metropolitan area for all year levels.

Lectures are free of charge to all Waterwise schools in the metropolitan area. Lectures available include:

- Water supply – K-12
- Desalination – 6-12
- Water conservation – K-12
- Waste water – K-12
- Storm water and waterways – K-6
- Water and health K-6

Education tours

Advanced water recycling plant tours

The Water Corporation have a Visitor Centre which has been built at the Advanced Water Recycling Plant in Craigie. The Centre gives students and opportunity to see the recycling facility and they are taken on the water cycle journey through the use of interpretive walkways, a purpose built multimedia centre and viewing stations of the treatment facility.

Curriculum resources

Also available through the website is a range of curriculum and supporting resources covering various water themes and topics. Teacher Resource Files include topic booklets (catering from F-10) which feature water-related activities linked to the new Australian Curriculum.

Scitech

Overview

Science inquiry skills: ☑ Yes ☐ No
Science understanding: ☑ Biological Sciences ☑ Chemical Sciences ☑ Earth and Space Sciences ☑ Physical Sciences ☑ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☐ Careers
Level: ☑ ECE ☑ Primary ☑ Secondary ☑ Other
Location: ☑ regional ☐ remote ☑ metropolitan

Website information summary

http://www.Scitech.org.au/

Scitech offer a wide range of projects, incursions/excursions/ lectures, activities, competitions and teaching resources to both the general public and to schools.

A team of five dedicated people provides Professional Learning workshops and resources to teachers at a regional and metropolitan level.

- Excursions. 50% of school visitors do planetarium and exhibitions and 50% do science shows and exhibitions. Also available is the CSIRO Lab (part of Australia network of nine labs) and the Digital Studio – computer based learning lab

- Aboriginal Education Program
- Lectures/activities and competitions include work done around national science week e.g.:
    - Robocup;
    - Woodside Scitech Science Awards (90%) penetration into Primary schools);
    - Animation Film Competition
- Online resources:
    - Science Network WA – news portal
    - Astronomy WA – news and teaching resources.

Scitech – Outreach

Overview

Science inquiry skills: ☑ Yes ☐ No
Science understanding: ☑ Biological Sciences ☑ Chemical Sciences ☑ Earth and Space Sciences ☑ Physical Sciences ☑ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☑ Careers
Level: ☑ ECE ☑ Primary ☑ Secondary ☑ Other
Location: ☑ regional ☑ remote ☑ metropolitan

Website information summary

http://www.Scitech.org.au/outreach/travelling-programs/index.php

Incursions programs, also known as" outreach" programs are provided by Scitech. These programs consist of Scitech staff taking hands-on shows, portable exhibits & planetariums, and hands-on activities into schools and host regional centres. The shows are predominantly Science, Maths and Careers based.

There are a total of about 10-12 programs but each one includes many sub-themes or subsets, which can be tailored to meet content requirements of the host school or centre, or to meet the requirements of a particular audience.

These “travelling programs” as they are called on the website include:

- *Aboriginal education:* Accessible and culturally relevant science programs for Indigenous students and their teachers.
- *Community events:* Live demonstrations for community events, agricultural shows, shopping centres or fetes etc
- *CSIRO lab-on-legs:* Hands-on laboratory experiences that highlight everyday applications of scientific research.
- *DIY Science:* 12 easy to assemble portable exhibits for use by teachers to bring science to life for their students.
- *Early Childhood:* Scitech's early childhood program focuses on learning through play for children 0-5 years old.
- *Maths:* Engaging and educational maths activities for metropolitan and regional middle school students
- *Science after School:* Fun after school activities to ignite children's interest in science beyond the classroom.
- *Science Careers:* A free program designed to inspire Year 8-10 students to pursue careers in science.
- *Science Shows:* Shows and hands-on activities covering a variety of science topics for different ages.
- *Scientists in Schools:* For teachers who are passionate about promoting science or maths in their classroom.
- *Spacedome:* An inflatable planetarium featuring a special stellar projector.
- *Technology:* Motivate, encourage and inspire students in Years 8-10 to explore new technologies.

CSIRO Lab (located at Scitech)

Overview

Science inquiry skills: ☑ Yes ☐ No
Science understanding: ☑ Biological Sciences ☑ Chemical Sciences ☑ Earth and Space Sciences ☑ Physical Sciences ☐ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☑ Careers
Level: ☐ ECE ☑ Primary ☑ Secondary ☐ Other
Location: ☑ regional ☐ remote ☑ metropolitan

Website information summary

http://www.csiro.au/resources/ps6dc.html

Located at Scitech, the CSIRO Lab is part of CSIRO's nationwide network of nine interactive science and technology education centres.

The CSIRO Lab is designed to excite and inform students and their teachers about the vital role scientific research plays in the community.

It does this through programs which enable students to experience realistic laboratory research in classes that challenge on a number of levels, including investigating, learning about materials, communicating ideas and science in society. A student's experiences in the Lab highlight the everyday applications of scientific research from forensics to food, the environment to electronics.

Through their involvement with the CSIRO Lab, students have the opportunity to become involved in various programs designed to help excited them about science, such as the Double Helix Science Club. They also are given the chance to participate in projects with actual scientists through the Scientists in Schools program.

Programs are supervised by an experienced Education Officer and linked to WA Curriculum Framework and Australian Curriculum. The 2011 programs available in the CSIRO Lab include:

Experiment Skills/Investigating

Chemists at work: Years 6-9

CSI forensic investigators: Years 5-12

Chemistry Skills/Materials

Slime time: Years 4-8

Nanotechnology: Years 6-12

Biology Skills/Life and Living

Plantech: Years 5-8

Entomology:Years 6-9

DNA to the max:Years 8-12

Global change: Years 5-9

Microscopic world: Years 5-9

Earth Science Skills/Earth and Beyond

Rocks to rockets: Years 4-8

Physics Skills/Energy and Change

Freewheeling physics: Years 6-10

Technology

Cyborg electronics: Years 5-7

Robotics: Years 5-12

SPICE WA
(DoE and UWA partnership)

Overview

Science inquiry skills: ☑ Yes ☐ No
Science understanding: ☑ Biological Sciences ☑ Chemical Sciences ☑ Earth and Space Sciences ☑ Physical Sciences ☑ Other
Science as a human endeavour: ☑ Nature and development of science ☑ Use and influence of science ☐ Careers
Level: ☐ ECE ☐ Primary ☑ Secondary ☐ Other
Location: ☑ regional ☑ remote ☑ metropolitan

Website information summary

http://www.spice.wa.edu.au/

The SPICE program, a secondary science teachers' enrichment program, is a partnership between the Department of Education Western Australia and The University of Western Australia. The SPICE program has three interconnected components:

development of teaching and learning resources
professional learning
enrichment and interaction with UWA scientists

SPICE aim to ensure that teachers in WA government schools:

- have an increased enthusiasm for science and for their roles in teaching science to their students
- have increased knowledge and understanding of the latest science in their specialist area and of the associated investigative skills
- can select and utilise a range of modern learning technologies in their classrooms
- have the knowledge and confidence to implement teaching, learning and assessment approaches that will enhance their students' learning

The SPICE program offers all DoE teachers at least two opportunities per year to enhance their skills and their understanding of advancements in science and technology by participating in purpose-designed workshops. The SPICE team travels around the state to provide workshops in schools using SPICE curriculum teaching resources to provide a context for professional development.

To facilitate worthwhile professional learning for this range of participants the PD program has a flexible two-tier design incorporating collaborative and inclusive learning strategies. Teachers are able to learn, apply knowledge and plan within school science departments or collaborate with colleagues from other schools through the networks promoted by the SPICE professional development program. The workshops are also designed as a "hands-on" exploration of the resources that enhance the development of skills in utilising learning technologies.

Development of curriculum resources for teachers to use in the classroom is a major part of the SPICE program. High quality curriculum resources are developed in collaboration with scientists. The content of each resource fits within the WA and Australian science curriculum and is relevant to major science disciplines of physics, chemistry and biological sciences. Focus is also placed upon the application of science across disciplinary boundaries. Although SPICE sequences are targeted at particular year levels, individual resources within them may be appropriate for use with other years, or in different discipline areas.

SPICE also operate the SPIRIT telescope, a remote-access telescope that can be operated through the Internet by students across the state. A range of workshops and curriculum resources that make use of the telescope have been developed.

STAWA
Professional Learning and Conferences

Overview

Science inquiry skills: ☑ Yes ☐ No
Science understanding: ☑ Biological Sciences ☑ Chemical Sciences ☑ Earth and Space Sciences ☑ Physical Sciences ☑ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☐ Careers
Level: ☐ ECE ☑ Primary ☑ Secondary ☑ Other
Location: ☐ regional ☐ remote ☑ metropolitan

Website information summary

http://www.stawa.net/

The Science Teachers' Association of Western Australia, (STAWA) is an independent association of Science Educators dedicated to promoting science and science teaching in Western Australia. STAWA has grown to include Pre-service, Primary, Secondary and Tertiary teachers.

Mission and Goals

- Provide professional development for teachers of science
- Promote equitable access in science education
- Promote the importance of science education
- Strengthen science and education and industry links
- Provide a range of resources to support the teaching of science
- Maintain and strengthen the Association's financial independence
- Strengthen the membership base of the Association
- Promote science teaching as a profession
- Maintain an independent voice in representing teachers of science

For teachers, STAWA offers professional development, publication for purchase, student activity ideas, Conferences, access to Catalist (email list for all WA Science Educators) and access to up-to date and relevant journal articles about science education.

STAWA also caters for students, providing “Science Talent search”, lists of tutors for use by students, publications which students will find relevant as well as activities and competitions that students will have fun with.

Earth Science Western Australia

Overview

Science inquiry skills: ☑ Yes ☐ No
Science understanding: ☐ Biological Sciences ☐ Chemical Sciences ☑ Earth and Space Sciences ☐ Physical Sciences ☐ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☑ Careers
Level: ☑ ECE ☑ Primary ☑ Secondary ☐ Other
Location: ☑ regional ☑ remote ☑ metropolitan

Website information summary

http://www.earthsciencewa.com.au/

The role of ESWA is to support the teaching of earth science in schools by developing teaching and learning resources, providing professional development for teachers and to assist with field and classroom experiences for students. This website places the Western Australian Earth & Beyond syllabus (Years 8 & 9) and the Earth and Environmental Science syllabus (Years 11 & 12**)** in a Western Australian context. It is designed to be especially useful to teachers new to the subject.

In 2007, a new upper secondary course, Earth and Environmental Science (EES) was introduced in Western Australia. The development and implementation of the course was supported by Earth Science Western Australia (ESWA).

In early 2011 ESWA released an EES Textbook that directly reflects the Western Australian EES Curriculum and encompasses the essential components of the National Curriculum for EES (Senior Years) that is currently being reviewed and will be introduced from 2014 across Australia. This EES text is tailored to the Western Australian context and uses examples that are relevant for Western Australian students and teachers.

As they come to hand, high quality support materials will be available through this ESWA site to assist in the teaching and learning of EES. Sharing of teaching resources via ESWA can be coordinated through the ESWA office. Whilst the office is based in the metropolitan area, the website can be accessed and utilized by remote and regional areas and education officers travel to regional and remote areas regularly (and upon request). The Geoscientists in Schools program also coordinates volunteer working Geoscientists to speak to groups of students about their specialties and careers.

Department of Environment and Conservation

Overview

Science inquiry skills: ☑ Yes ☐ No
Science understanding: ☑ Biological Sciences ☑ Chemical Sciences ☐ Earth and Space Sciences ☐ Physical Sciences ☑ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☑ Careers
Level: ☑ ECE ☑ Primary ☑ Secondary ☑ Other
Location: ☑ regional ☑ remote ☑ metropolitan

Website information summary

http://www.dec.wa.gov.au/

The DEC website contains information and resources about the conservation end environmental protection community and how to be part of it. There is information about EcoEducation, the Aboriginal Heritage Unit, AirWatch, Wastewise, Ribbons of Blue and the Bush Rangers programs for school-aged students.

Schools programs

The Department of Environment and Conservation runs a variety of education programs and provides professional learning opportunities for teachers and educators.

Programs cover all aspects of the department's work, from air and water quality monitoring, to waste, wildlife and conservation education.

Resources are developed so as to help fulfil student outcomes under the WA curriculum framework, and programs include opportunities for both in-class and outdoor experiences.

DEC Staff are able to provide exciting, relevant and valuable learning resources and support, whether based in a metropolitan area or more remote area of Western Australia. Examples of programs include:

DEC Bush Rangers: Bush Rangers WA, Helping the Community through a variety of local conservation projects
EcoEducation: Fostering appreciation for the natural environment and its relation to traditional Aboriginal culture
Waste Wise Schools: Provides information for Teachers, Students, and Households.
Ribbons of Blue: WaterWatch WA
AirWatch: Provides information for Teachers, Students, and Households.
Marine Parks WA: A wealth of resources and information about Marine Parks

Ecoeducation Programmes:

Outdoor classrooms and nature-based education which are:

For students from Early Childhood to Late Adolescence
Applicable to all Learning Areas with a focus on
  Society & Environment
  Science
  English
Contribute to Health & Physical Education outcomes
Address the clusters of core values-

Environmental Responsibility

Social and Civic Responsibility

The programs help fulfil student outcomes of the Curriculum Framework .

EcoEducation programs provide many opportunities for students of all ages to take part in nature-based learning on biodiversity conservation, ecosystems and the threats to these. Programs have three elements linked to the outcomes of all curriculum learning areas:

- excursions or camp activities based at a number of venues
- classroom resources
- professional learning for educators.

EcoEducation links to most learning areas and through experiential learning in the natural environment, builds concepts, skills, values and the ability to make environmentally responsible decisions. Programs on the website have been listed and categorized year/age groups.

C: Directory of STEM education support initiatives

Overview of a sample of STEM education providers

Overview

Science inquiry skills: ☐ Yes ☑ No
Science understanding: ☐ Biological Sciences ☐ Chemical Sciences ☑ Earth and Space Sciences ☐ Physical Sciences ☐ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☐ Careers
Level: ☐ ECE ☑ Primary ☑ Secondary ☑ Other
Location: ☑ regional ☐ remote ☐ metropolitan

Gravity Discovery Centre

Overview

Science inquiry skills: ☐ Yes ☑ No
Science understanding: ☐ Biological Sciences ☐ Chemical Sciences ☑ Earth and Space Sciences ☑ Physical Sciences ☑ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☐ Careers
Level: ☐ ECE ☑ Primary ☑ Secondary ☑ Other
Location: ☑ regional ☐ remote ☐ metropolitan

WA government museums:
The maritime museum

Overview

Science inquiry skills: ☐ Yes ☑ No
Science understanding: ☑ Biological Sciences ☐ Chemical Sciences ☐ Earth and Space Sciences ☑ Physical Sciences ☑ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☐ Careers
Level: ☑ ECE ☑ Primary ☑ Secondary ☑ Other
Location: ☐ regional ☐ remote ☑ metropolitan

WA government museums:
The WA museum – shipwreck galleries

Overview

Science inquiry skills: ☐ Yes ☑ No
Science understanding: ☐ Biological Sciences ☐ Chemical Sciences ☑ Earth and Space Sciences ☑ Physical Sciences ☑ Other
Science as a human endeavour: ☑ Nature and development of science ☑ Use and influence of science ☐ Careers
Level: ☑ ECE ☑ Primary ☑ Secondary ☑ Other
Location: ☐ regional ☐ remote ☑ metropolitan

WA government museums:
The WA museum – Albany

Overview

Science inquiry skills: ☑ Yes ☐ No
Science understanding: ☑ Biological Sciences ☐ Chemical Sciences ☑ Earth and Space Sciences ☐ Physical Sciences ☑ Other
Science as a human endeavour: ☑ Nature and development of science ☐ Use and influence of science ☐ Careers
Level: ☑ ECE ☑ Primary ☑ Secondary ☑ Other
Location: ☑ regional ☑ remote (some outreach programmes) ☐ metropolitan

Overview

Science inquiry skills: ☐ Yes ☑ No
Science understanding: ☑ Biological Sciences ☐ Chemical Sciences ☑ Earth and Space Sciences ☑ Physical Sciences ☑ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☐ Careers
Level: ☑ ECE ☑ Primary ☑ Secondary ☑ Other
Location: ☑ regional ☐ remote ☐ metropolitan

WA government museums:
The WA museum – Kalgoorlie-Boulder

Overview

Science inquiry skills: ☑ Yes ☐ No
Science understanding: ☐ Biological Sciences ☐ Chemical Sciences ☐ Earth and Space Sciences ☐ Physical Sciences ☑ Other
Science as a human endeavour: ☐ Nature and development of science ☑ Use and influence of science ☐ Careers
Level: ☑ ECE ☑ Primary ☑ Secondary ☑ Other
Location: ☑ regional ☐ remote ☐ metropolitan

C: Directory of STEM education support initiatives

Additional STEM education providers

Organisation/initiative	**Recommended by interviewee(s)**
AQUA www.aqwa.com.au	
Peer tutoring programs - STAR, STEP-Up and SEEK (funded by DOIR)	
BioGenius (Department of Commerce) http://www.commerce.wa.gov.au/scienceinnovation	
Special events run by diverse organisations – for example, Huntington's Western Australia run a day for students	
Competitions – for example, the Science Talent Search (STAWA) http://www.stawa.net/pages/science_talent_search	Y
Mining Hall of Fame http://www.mininghall.com/index.php?page_id=1	
Perth Observatory www.perthobservatory.wa.gov.au	
Engineers Australia http://www.engineersaustralia.org.au	Y
Whiteman Park www.whitemanpark.com.au	
Kings Park http://www.bgpa.wa.gov.au/kings-park	
Perth Mint www.perthmint.com.au	
The West Australian Newspapers in Education nie.thewest.com.au	
Fire and Emergency Services Education and Heritage Centre www.fesa.wa.gov.au/educationandheritage/fehc/Pages/default.aspx	
Caveworks www.margaretriver.com/pages/caveworks-eco-centre-research	
City of Wanneroo – Heritage, Museums and Arts www.wanneroo.wa.gov.au	
Raptor Presentations www.raptor.id.au	
Piney Lakes Environmental Education Centre www.melvillecity.com.au/pineylakes	
Western Australian Birds of Prey Centre http://wabirdsofprey.com	
U Can Hatch Us www.ucanhatchus.com.au	
Department of Fisheries – Naturaliste Marine Discovery Centre www.fish.wa.gov.au	
State Library of Western Australia www.slwa.wa.gov.au	
Canning River Eco Education Centre http://www.canning.wa.gov.au	Y

Leeuwin Ocean Adventure Foundation www.fremantlewa.com.au/.../leeuwin-ocean-adventure-foundation	
Rockingham Wild Encounters www.rockinghamwildencounters.com.au	
Rottnest Island Authority www.rottnestisland.com	
Kidz Bodz www.kidzbodz.com.au	
Kelmscott SHS Foothills Farm	
Bushtucker River and Forest Tours : http://www.bushtuckertours.com	Y
The Department of Culture and the Arts – ArtsEdge www.artsedge.dca.wa.gov.au	
Scientists in Schools CSIRO Education www.scientistsinschools.edu.au	Y
STELR Australian Academy of Technological Sciences and Engineering (ATSE) http://stelr.org.au/about-stelr/	
National Youth Science Forum (NYSF) www.nysf.edu.au	
Engineers Australia www.engineersaustralia.org.au	Y
Summer Science Schools run by universities	
Teacher Earth Science Education Programme (TESEP) www.tesep.org.au	
Primary Industry Centre for Science Education (PICSE) www.picse.net	Y
Tall Poppies http://www.aips.net.au/tall-poppies/tall-poppy-campaign	
Perth Observatory www.perthobservatory.wa.gov.au	
Adventure Team Builders www.adventureteambuilders.com.au	
Barking Gecko Theatre Company www.barkinggecko.com.au	
Claremont Museum www.claremont.wa.gov.au/Community/Museum.aspx	
Department of Sport and Recreation www.dsr.wa.gov.au	
Edcursions WA www.edcursions.com.au	
Fremantle Children's Literature Centre www.fclc.com.au	
Fremantle Prison www.fremantleprison.com.au	
Geographe Bay Tourism Association	

www.geographebay.com	
Gingin Observatory and Gravity Discovery Centre www.gravitycentre.com.au/gingin-observatory	
Government of WA, Department of Environment and Conservation www.dec.wa.gov.au	Y
Hawaiian Alive www.hawaiianalive.com.au	
New Norcia Benedictine Community www.newnorcia.wa.edu.au	
National Trust of Australia (WA) www.ntwa.com.au	
Naturaliste Marine Discovery Centre www.nmdc.com.au	
PCYC Camp Kalbarri www.campkalbarri.com.au	
RSPCA www.rspca.org.au	
The Bell Tower www.thebelltower.com.au	
Regional technicians group headed by Ruth Kempton http://www.rtg.wa.edu.au/content/page/contact-us.html	Y
AuSSI www.det.wa.edu.au/curriculumsupport/sustainableschools	Y
National Science Week http://www.scienceweek.gov.au/Pages/EventsMap.aspx?state=wa	Y
Planting the seeds of science in early childhood Education: Christine Howitt & Elaine Blake	Y
Labnetwest http://labnetwest.asn.au/	Y
STAWA – workshops for lab technicians. http://www.stawa.net/	Y
Inspiring Australia http://www.innovation.gov.au/Science/InspiringAustralia/	Y
Association of Perth Attractions http://www.perthattractions.com.au/	Y
UWA Maths enrichment program http://www.maths.uwa.edu.au/community/academy	Y
Free Choice Youth Program	Y
Labtech	Y
Tammin Landcare Centre www.tammin.wa.gov.au/	Y
Mundaring Hills Forest project www.mundaringtourism.com.au/	Y
Primary Connections http://www.science.org.au/primaryconnections/	Y

Science by Doing http://www.science.org.au/sciencebydoing/index.html	Y
BP – Energy Package	Y
CSBP in Kwinana	Y