Astronomy Education

A report to the National Committee for Astronomy for the Australian Astronomy Decadal Plan 2006-2015
By Working Group 1.2

September 2005

1. Introduction

Astronomy education is one of the largest topics to be tackled by the decadal review as it encompasses all aspects of astronomical education from school students and the public, all the way to the training of professional astronomers. In addition, astronomy education and outreach is conducted by a wide variety of seemingly disparate groups ranging from amateur societies and high schools to universities and national facilities.

In order to be able to cover all topics adequately WG1.2 split the topic into three main subtopics, Professional Training, School and Community Education and Public Facilities.

2. Graduate Skills & Training

In his recent Nature paper, Sir David King the UK's chief scientific advisor states that "*One measure of a nations knowledge base is its output of PhD students*." [1] Australia currently produces around 17 PhDs in astronomy and astrophysics annually and exposes some 2000 students to undergraduate astronomy courses. However, despite the nation's great breadth and depth of astronomical expertise, students trained in Australian institutions are sometimes considered somewhat lacking in their broad theoretical astrophysical background with respect to their North American or European counterparts. This perception is clearly undesirable for the community as a whole. In the following sections we will provide an overview of the current status of astronomical training in the higher education sector and then provide several options to broaden and improve the astrophysical knowledge of our graduate students.

2.1 National Training Overview

2.1.1 Undergraduate Training

Undergraduate courses in astronomy related disciplines[#] are offered in approximately 20 Australian Universities. Of these around 20% offer their courses either online or through other distributed teaching method such as video conferencing to separate campuses. On a per capita basis this is similar to the number of intuitions in the UK which offer undergraduate programs (~50) but much lower than the number of institutions offering such programs in the US. For example, in the current review period (2000 - 2004) about 270 equivalent full-time student units (EFTSUs) per year are credited to astronomy related courses. Typically such courses represent a one eighth load and so this approximates to 2160 students annually [2]. By comparison the US had 165,000 students enroll in similar courses in the 2000-2001 academic year [3], which is a factor of five above the Australian numbers when the relative size of the populations is accounted for.

Defined as having "Astronomy" or "Astrophysics" in the unit title or at least 50% astrophysics content.

2.1.2 Postgraduate Training

Postgraduate research based training is offered in 18 Australian Universities. In addition to this, national facilities such as the CSIRO-ATNF and the Anglo-Australian observatory both contribute strongly to the training of professional astronomers through their co-supervision programs.

During the last decadal review period (1990 -1994) 108 Astronomy PhDs were granted [2] giving an average of 21.6 per annum. In the current period (2000 - 2004) this number has fallen to 83 [2] being an average of 16.6 per annum. By comparison, the American Institute of Physics reports that a total of 245 PhDs were awarded in astronomy and astrophysics in 2000 [4]. This number is likely to increase in future as astronomy and astrophysics have now overtaken condensed matter physics as the most popular choice of physics sub-disciplines for commencing domestic students entering graduate programs in the US in 2002 and 2003 [5], with some 251 per year enrolling. Given the relative sizes of the two countries it can be said that per capita Australia produces a comparable number of PhDs in astronomy and astrophysics to the US, as shown in Figure 1.

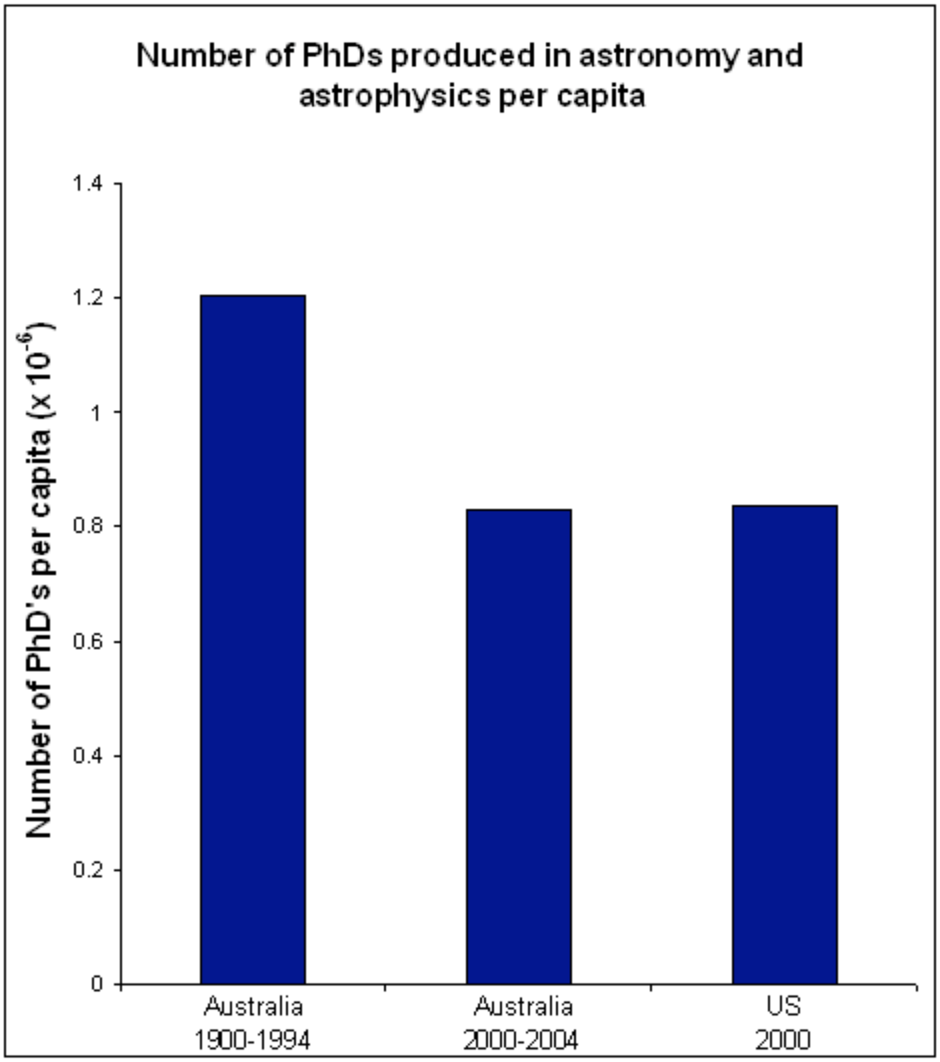

Figure 1. The number of PhDs produced in astronomy and astrophysics per capita. Australia is currently producing an identical number of astronomy graduates as the United States on a per capita basis. Populations statistics used here at 17.93 million for Australia in 1994 [10], 20.0 million for 2004 [11] and 293.6 million for the US in 2000 [12].

Gender ratios of graduate level students in Australia have increased over the current decadal period and this reflects a worldwide trend of increasing numbers of women in astronomy and astrophysics programs. In the last decadal review period the male to female postgraduate student ratio was 85:15, this has changed dramatically in the current period to 63:37 [2] and is similar to the male to female ratios seen in the US in 2002/2003 (67:33) [5], in Italy in 2002/2003 (66:34) and to those reported during the last decadal review in the UK (78:22) (see Figure 2).

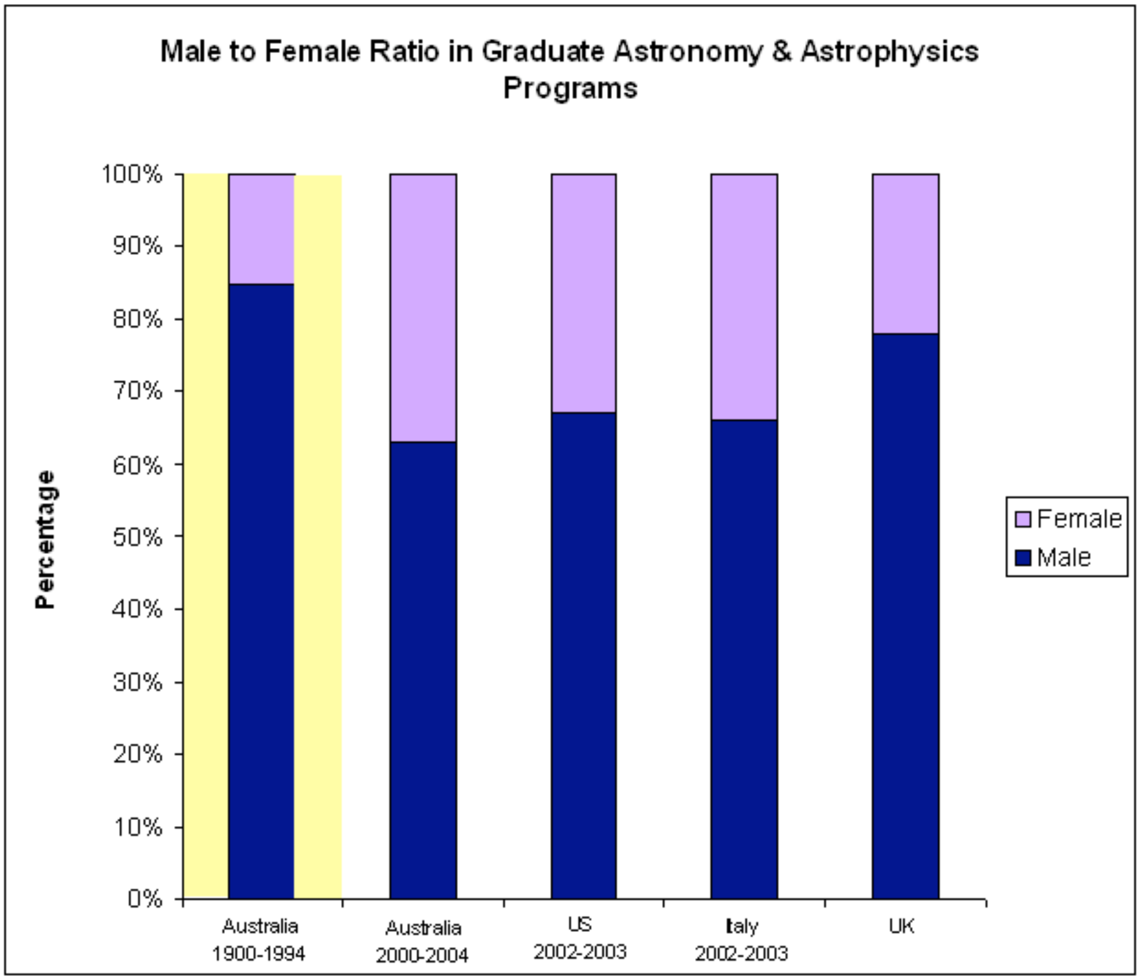

Figure 2. Ratio of male to female students in graduate programs in Australia in the previous decadal review (in yellow) as compared to Australia, the US, Italy and the UK at present.

2.2 Improving Graduate Training

2.2.1 Graduate Training Workshops

The traditional way for graduate research students to learn more is through attendance at conferences, training sessions and workshops. However, the level of attendance and participation in such events is in no way mandated or monitored. Often students are unable to find the funding to attend such events or institutions do not consider student participation as a funding priority.

It is not uncommon however, for institutions to require graduate students to complete some sort of additional course or attend a workshop within the first year of commencing their higher degree program. Rather than have students attend courses or meetings in an ad hoc way, it would be preferable to direct student participation towards meetings and workshops which provide a certain basic level of student training and to ensure that in any given year there are meetings with adequate opportunities for student training.

To this end we wish to see the inclusion of training opportunities in some of the workshops and meetings held in Australia and that an independent pool of money be made available for students to participate in these meetings. We propose the creation of an umbrella label (such as the ASA graduate training program) that could be flagged for meetings with opportunities for graduate training. We further suggest that a management committee be established, perhaps under the auspices of the Australian Astronomical Society, which would be responsible for ensuring a minimum standard of training activities, advertising appropriate workshops and meetings directly to students and coordinating the funding for student attendance. While we do not propose to restrict individual institutions in running workshops and training sessions in their own way, we feel that some minimal coordination would benefit the students wishing to participate. The long-term benefits of such a scheme would hopefully be a significant improvement in the breadth of knowledge of Australian astronomy graduates.

Since the average candidature for a PhD in Australia is four years such a program would have to run for at least one full student cycle (probably seven years) before an assessment of its effectiveness could be made.

Recommendation
We recommend the creation and funding of a program to coordinate student attendance at workshops and meetings with significant training opportunities. This program should be funded on a pilot basis for at least the next seven years.

2.2.2 Distributed Honours and Postgraduate Courses

Knowledge sharing between institutions is an obvious way to address the issue of limited training in fundamental astrophysics, and is inline with the Government's current stance on University education.

Emerging technology, such as the access grid, will make it possible for high level courses to be taught to students across Australia simultaneously. In this way students undertaking honours in astrophysics at different universities could take a course taught by the expert in that particular field even though they were at another institution. This has distinct advantages in that all Australian honours students will gain the very best access to the wealth of astronomical expertise available in Australia. This will be particularly advantageous for students from smaller highly focused research groups who would traditionally not have access to a large selection of honours units. In this scenario, all participating institutions would need to provide a course for distributed training, though we recommend that at most only four course per year should be offered in this way.

Staff workloads in participating institutions would need to be carefully monitored and it should be stressed that this is not an argument to justify the reduction in number of staff at any given institution as these are all very high level specialist courses. As a natural consequence benmarking between honours course at different institutions would also become easier.

Recommendation
The community for takes steps to address the perception that Australian graduates lack theoretical astrophysical knowledge when compared to their peers. One of the ways to do this would be to consider distributed honours and postgraduate courses taught over the access grid. In order to assess the usefulness of such a scheme we recommend it be trialed for a seven year period.

2.3 Regional Interactions

The interest in astronomical research in South East Asia has been steadily increasing over the past decade, and with countries such as South Korea [7], Japan, Taiwan, India and China investing more capital into astronomical projects this trend is likely to increase into the next decadal period. The demand for PhDs in astrophysics in these countries will likewise continue to increase. This coupled with the excellent secondary education [8] means that South East Asian students should be highly sought after by Australian institutions engaged in training future astronomers.

At present of the 157 students enrolled in PhD programs in astronomy and astrophysics in Australia 29% are international students [2]. This compares well with the percentage of international graduate students in astronomy in the US over the same period with is 30-33% [6,5].

However, unlike countries such as the United States, the United Kingdom and the Netherlands, Australian institutions may only offer a tiny number of international student places in PhD programs. This is principally done through the Government's Endeavour International Postgraduate Research Scholarship scheme (IPRS). However, the total number of IPRS places available across all disciplines is miniscule, in 2005 there are only 330 for all institutions [9]. In 2006 there will be a further 17-19 for students from specific Asian nations, but again this will be for all disciplines and across all universities. As a result, international students wishing to undertake PhDs in Australia must attain a ridiculously high standard of scholarship to even be considered. In some cases competition is so high that student must have had 3-4 refereed papers published to be competitive, a feat which would be considered excellent for a domestic student at the completion of their PhD. The consequence of this is that the vast majority of students from the region are undertaking their doctoral research in the US, the UK or other parts of Europe.

Training the best PhD students from our regional neighbors provides, not only high quality research output for Australia during the time of the students candidature but also gives direct and continuing research links between Australian institutions and those in the region after the students return to their home countries. With the increasing emergence of astronomical research in South East Asia it is important that Australia forges strong international ties within the region and the training of students who then take knowledge back to their home country is the best way to achieve this.

Recommendation

We recommend that the total number of IPRS or Endeavour Grants available be increased to allow an increased uptake of the best international students. If necessary this increase could be targeted to key areas of emerging research interest in the region, such as Astrophysics.

1. King, D., "*The Scientific Impact of Nations*", Nature, 430, 311, 2004

2. WG1.1 Report, Gibson et al, this volume.

3. American Institute of Physics "*Enrollments and Degrees Report*", Mulvey, P. & Nicholson, S., August 2003. www.aip.org/statistics

4. American Institute of Physics "*Physics Trends, Fall 2002*" , Mulvey, P., http://www.aip.org/statistics/trends/reports/fall2002c.pdf

5. American Institute of Physics "*Graduate Student Report: First-Year Physics and Astronomy Students in 2002 and 2003*", McFarling, M., Neuschatz, M., Mulvey, P., October 2004. www.aip.org/statistics

6. American Institute of Physics "*Physics students From Abroad in the Post-9/11 Era*", Neuschatz, M., Mulvey, P., June 2003. www.aip.org/statistics

7. "*South Korean Science Ascendant: Output, Impact Trending Upward*" in Science Watch, May/June 2001, Vol. 12, No. 3 http://www.sciencewatch.com/may-june2001/sw_may-june2001_page1.htm, accessed May 2nd 2005

8. Japanese and South Korean high school students top the world in mathematical and scientific literature and numeracy: OECD PISA report "*Learning for Tomorrows World*" http://www.pisa.oecd.org/dataoecd/1/60/34002216.pdf

9. DEST report "*2005 Allocation of IPRS Awards and Funding*" http://www.dest.gov.au/NR/rdonlyres/8012CE8A-8036-4BC7-A70B-B0C65966619E/1322/apa_iprs_funding.pdf, accessed May 2nd 2005

10. Australian Bureau of Statistics report "*Australian Social Trends 1996*" http://www.abs.gov.au/Ausstats/abs@.nsf/0/68180154bf128d91ca2569d000164365?OpenDocument accessed September 5th 2005

11. Australian Bureau of Statistics report "*Population Projections, Australia*" http://www.abs.gov.au/ausstats/abs@.nsf/lookupMF/0CD69EF8568DEC8ECA2568A900139392 accessed September 5th 2005

12. US census Bureau report "Population Estimates" http://www.census.gov/popest/estimates.php accessed September 5th 2005

3 School And Community Education

Education is a vital component of a responsible, healthy and prosperous society. We no longer view education as something that just occurs through the formal schooling of children but rather see it as a life-long process. There are now many avenues for people to continue their learning via formal and informal processes and some of these are addressed elsewhere in this report. Formal schooling, however, still provides an essential component in the education of most in our society.

3.1 Place of Astronomy in Curriculum

Astronomy is part of the school curriculum across Australia although as the syllabus is a state responsibility there is some variation across states. Since the last Decadal Plan many states have introduced new science syllabi that in general have seen an increased place for astronomy and astrophysics within them. This provides both an opportunity and a responsibility for more effective teaching of the related concepts.

Most students receive most of their formal exposure to astronomy concepts in the last year or two of primary school and in their three of four years of junior secondary education.

In primary schools astronomy-related material is normally found within the Science & Technology key learning area or it equivalent. Content tends to focus on concepts such as day and night, shadows, basic awareness of stars and planets. Overall time devoted to astronomy-related concepts is not high and is dependent on overall amount of time devoted to science within typically crowded curriculum demands.

At junior secondary level astronomical concepts are taught within compulsory integrated science courses. As an example of depth, recent syllabus changes in NSW have specified content in more detail than before so all students now have to study the content of the Universe, current scientific models (Big Bang), life of stars, the solar system, scale and distances and how the electromagnetic spectrum is used and problems faced by astronomers in obtaining information. This material is taught over three or four years, depending on the state and is typically broken down into smaller units such as *Earth & Beyond*. In practice junior secondary science syllabi are generally very crowded so the time allocated to teaching astronomy-related sections varies widely. The level to which the syllabus is taught also varies widely from school to school.

Educators and scientists are increasingly seeing astronomy as a valuable context within which students can be taught a range of scientific content. This can include elements of physics, chemistry, earth science and even biology. It also provides an engaging context in which students can develop skills in problem solving, critical thinking, mathematics and ICT. An exciting example of this is “The Eye Observatory Remote Telescope Project” that is detailed in the information box at the end of the report.

There is a wealth of information and effective teaching and learning resources available over the Internet for teachers and students. Whilst much of it is from overseas sources (primarily US and UK), there is useful locally-developed material. The internet is likely to be an increasingly important method of dissemination of resources but attention needs to be paid to quality and the reliability of information.

Astronomy at the matriculation or stage 6 level is generally studied, if at all, within a Physics course. Some states have a small amount of related concepts covered in “Earth and Environmental Science” or generalist “Senior Science” courses as well.

Two states have astronomy/astrophysics explicitly detailed within their senior Physics courses. In NSW it forms part of the compulsory Preliminary Course in module 8.5 “The Cosmic Engine” and is thus studied by all students undertaking physics. In the HSC year 12 course there is an “Astrophysics” option that comprises 25% of a student’s total examinable course. Students must study one of the five options. As an indication of the number of students studying physics at matriculation level, the average from 1997 - 2003 in NSW was about 9,200 or 14.3% of the total HSC candidature. Of these 25% or about 2,300 studied the astrophysics option annually.

Recent changes to the Victorian VCE Physics syllabus have seen two units, “Detailed Study 3.1 Astronomy” in Area of Study 2 and “Detailed Study 3.1 Astrophysics” in Area of Study 3 included. These optional units are studied in Year 11 which typically has about 10,000 students with maybe a third of them studying either or both of these units.

Other states do not have explicit mention of astronomy or astrophysics within their syllabi but may cover associated concepts such as gravitation. The move to teacher or school-developed contexts in some states such as Queensland means that some teachers can develop their own physics programs using an astronomical context to teach the relevant physical concepts.

New South Wales also provides the “Cosmology Distinction Course” as a Board delivered, distance education based subject. This course has run since 1994 for gifted and talented students across the sate. It typically has about 30 students, all of whom have already accelerated in one or more of their HSC subjects at least one year ahead of their age cohort.

Recommendation:

That the professional astronomical community be willing and proactive in contributing to future syllabus reviews and reforms within Australia.

3.2 Teachers

One of the problems faced in the effective teaching of astronomy is that most teachers have no formal training or education in astronomy beyond school. This is even the case with qualified teachers of Physics, most of whom have little or no astrophysics within their degree.

At the primary level, science is usually taught by the class teacher. The majority of primary teachers have little or no formal training in science beyond the units covered within their Bachelor of Teaching. As this has to cover such a broad range of topics the time allocated for science, let alone focusing on astronomical concepts within science, is relatively small. This is often compounded by the fact that many entrants into primary teaching are less likely to have completed courses in the physical sciences or high-level mathematics units in their own post-compulsory secondary education. Perhaps the majority of recent primary teaching graduates has studied biology or general science but may have no science beyond Year 10 level.

Science at the junior high school level is taught as an integrated subject rather than separate subjects such as chemistry, biology and physics. This means that a teacher has to be able to teach all of the content in the junior syllabus so that, for example, a teacher with a degree in biology or chemistry has to be able to teach physics and astronomy-related topics and concepts.

The majority of secondary science teachers have a Bachelor of Science with a Graduate Diploma of Education. Most of the rest have a four-year Bachelor of Educational though eight percent in the recent *Who's Teaching Science* paper released by the Australian Council of Deans of Science (2005)[1] reported that eight per cent of science teachers had not studied any Biology, Chemistry, Physics or Geology at university. None of these options is likely to equip classroom teachers with specific knowledge of astronomy and astrophysics or provide them with many current examples of ways to effectively teach astronomy concepts. This in turn means that most students will be taught all or most of their astronomy by teachers with no formal training themselves in this branch of science. Anecdotal evidence suggests that even though astronomy as a topic is intrinsically of interest to many students, its teaching at the junior high school level often fails to utilize the latest developments in teaching pedagogy or specific scientific content for the subject.

At the senior high school level, astronomy and astrophysics fall under the realm of physics although some earth and environmental science course also include elements of astronomy. A particular problem faced in physics is the scarcity of properly qualified teachers. As *Who's Teaching Science* identified:

> *"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."*

The national outlook on the shortage of suitably qualified physics teachers is even worse if one considers that only about eighteen per cent of science teachers aged under 30 have at least a minor (two years study) in physics compared with over thirty per cent for older teachers.

Given the looming scarcity of physics teachers and the lack of experience in astronomy of other science teachers it is imperative that they be provided with quality professional development opportunities and on-going support. The professional astronomical community can play a role through involvement in teacher workshops and professional development programs, school visits and talks and ongoing partnerships with teachers or groups of schools.

Recommendation:

That the professional astronomical community identify the need for, support and help develop effective ongoing teacher professional development in astronomy.

Example of an Innovative Program

1. *The Eye Observatory Remote Telescope Project*

An outstanding and innovative astronomy education program is “The Eye Observatory Remote Telescope Project” run by Associate Professor David McKinnon of Charles Sturt University in Bathurst. This DEST-funded pilot scheme is operating in 37 schools across four states and all school sectors. Over 2,000 students and 127 teachers are being monitored during the pilot stage. It involves student and their teachers studying astronomy from an activities and enquiry-based approach. Students develop the skills to use the Charles Sturt Remote Telescope over the internet to locate objects in the night sky, take images of them using CCD cameras then download and analyse them. Students develop skills in problem solving, critical thinking, mathematics and ICT whilst gaining greater understanding of a range of astronomical concepts.

Of particular value in this project is the wealth of detailed quantitative and qualitative educational research data that it is being generated and evaluated. It will provide a useful baseline for further studies and programs. An intrinsic component of it too is the need for teacher training prior to classroom implementation of the course materials.

1 "Who's Teaching Science?" Discussion paper of the Australian Council of Deans, April 2005 available at http://www.acds.edu.au/

4. Public Facilities

In early 2005, Working Group 1.2 conducted a survey of Public Astronomy facilities in Australia. This section summarises the data obtained from the survey to provide a snapshot of the ways and means that astronomy education is available to the wider public.

The survey was distributed via email to the following groups:

- the list server of the Australasian Planetarium Society

- listing of astronomical societies maintained by the ASA
- listing of Victorian amateur societies as maintained by the Melbourne Planetarium http://www.museum.vic.gov.au/planetarium/societies.html
- listing of astronomical societies as found on the Australian Astronomy website: http://www.astronomy.org.au/ngn/engine.php?SID=1000022&AID=100136
- listing of public observatories as found on the Australian Astronomy website: http://www.astronomy.org.au/ngn/engine.php?SID=1000014

In addition, telephone surveys were conducted with major public planetaria and observatories who did not respond via email.

The survey requested each organisation to provide information about their operations, including its core activities, annual attendance figures, publications, school programmes, and media activity.

The facilities that were surveyed fell into three main categories:

1. Planetaria, with or without an associated observatory, where the planetarium is the main activity.

2. Observatories and their Visitors' Centres. Some of these centres may have access to a portable planetarium but their core business is the observatory.

3. Astronomical Societies and Clubs.

4.1 Planetaria

Data were obtained for all eight fixed planetaria operating in Australia. Six of these planetaria are operated by State or Local governments, one is operated by a university (Adelaide Planetarium) and one is associated with a Trade Union Workers club (Canberra Planetarium). Data were also obtained for two privately run portable planetaria organisations.

Table 1 shows the attendance figures for planetarium facilities in Australia, with 2004-2005 being estimates in advance. The fixed planetaria were consistent in quoting that about 40% of the annual attendances were from school groups; the actual figures varied only between 30% and 50%. Portable planetaria understandably have a far higher proportion of school groups, as these lend themselves primarily to this type of activity; for the two portable planetaria organisations their school proportion is close to 100%. All planetaria generate activities that are appropriate for the school curriculum in their State.

The core business of planetaria is planetarium shows - either pre-recorded or live presentations. However, the organisations are also involved in a wide range of outreach activities including astronomy courses, guest lectures by professional astronomers, public astronomy nights, teacher orientations, sleepovers, star parties and dinners. Most also have close links with local amateur astronomical societies.

Public enquiry facilities, allowing people to call or email with astronomical questions, are offered at all but two of the planetaria and most planetaria receive enquiries at the rate of 1 per day. The planetaria also make an effort to be a resource for the media: writing articles for newspapers and astronomy magazines; conducting radio and television interviews; and alerting the media to upcoming astronomical events.

While most planetaria produce publications, the type of these varies. Teachers' packs, information sheets on astronomical topics, and night sky notes are the most common types of publications available.

In recent years the Australian planetarium community has been quite prosperous. In 2004, a new facility opened in Perth, and the Brisbane planetarium underwent a major equipment upgrade – the first in 26 years. A third planetarium, Melbourne, is currently in the process of upgrading its equipment. These new facilities and upgrades were made possible through State or Local Government funding. The fitting of these three planetaria with similar projection equipment will provide improved collaboration opportunities that have not existed previously. Furthermore, in 2006 Melbourne Planetarium will host the 18th meeting of the International Planetarium Society. It will be the first time in the 36-year history of the Society that members will meet together in the Southern Hemisphere.

Table 1. Attendances at Planetaria

Facility	Attendance 2002-2003	Attendance 2003-2004	Attendance 2004-2005
Launceston Planetarium	4,392	4,836	5,000
Adelaide Planetarium	7,500	6,500	6,500
Skyworks Planetarium (portable)	12,000	13,000	13,000
Canberra Planetarium	n/a	n/a	25,514*[1]
Wollongong Planetarium	55,000*	47,000*	47,000*
Bendigo Planetarium	n/a	50,000	50,000
Sir Thomas Brisbane Planetarium	34,000*	40,000*	57,000*
Horizon Planetarium (Perth)	n/a[2]	17,000	60,000
Journeyman (portable)	55,000	55,000	65,000
Melbourne Planetarium	135,000	150,000	110,000

Notes
* Attendance figures include visitation to associated observatory facilities.
[1] The Horizon Planetarium (Perth) was not open in 2002-2003.
[2] The attendance figure (the only one quoted) is for the calendar year 2004. The Canberra Planetarium is expected to close during 2005.
(This is not a complete list for all planetaria, only those that responded.)

4.2 Observatories and their Visitors' Centres

Strictly, these facilities fall into two classes. Some (Mount Stromlo, Tidbinbilla, Siding Spring, Parkes and Narrabri) are specifically visitors' centres associated with major astronomical facilities. Others are based primarily on the ability to involve the public in observing through telescopes.

Like the planetarium community, observatories have also taken advantage of new and more affordable technologies. For instance, many have installed 3-D space theatres and/or are currently in the process of upgrading their facilities. The Parkes Observatory Visitors' Centre has seen an influx of visitors due to the release of the movie "The Dish" in 2001, which has also had a flow-on effect to other facilities.

Table 2 shows the attendance figures for category 2 (again, 2004-2005 is estimated in advance) for observatories and visitors' centres in Australia. The visitors' centres attached to professional observatories predominantly attract tourists from families to seniors. They provide displays, exhibitions and audio-visual theatres but their main attraction is to allow people to get up-close to professional telescopes. Public observatories are typically run by individuals and their strength is allowing visitors to view astronomical objects for themselves. The exceptions are Sydney and Perth observatories that are State Government funded and also incorporate the heritage of the original astronomical observing sites in these States.

A majority of the facilities produce publications. The Sydney and Perth observatories, for example, produce annual sky guides, and many produce fact sheets. Most facilities have dedicated school programmes, and provide worksheets and information on the facility itself.

Table 2. Attendances at Observatories and Visitors' Centres			
Facility	Attendance 2002-2003	Attendance 2003-2004	Attendance 2004-2005
Gilgandra Observatory	1,987	1,674	1,500
University of S. Qld.	2,100	2,100	2,100
Macquarie Uni Observatory[1]	1,630	2,258	2,213
Great Barrier Reef Observatory (Hamilton Island)	3,500	2,000	4,000
Perth Observatory	9,772	9,750	9,000
Mount Stromlo Exploratory?			
Narrabri (ATNF)	10,500	10,500	11,000
Skywatch Observatory	12,000	13,000	15,000
Siding Spring Exploratory[2]	21,000	20,000	19,000
Tidbinbilla DSCC Centre	47,372	69,071	70,000
Parkes (ATNF)	132,000	133,000	120,000
Sydney Observatory	125,050	149,538	135,000

Notes:
[1] Macquarie University figures are for calendar years.
[2] Siding Spring Exploratory figures are all estimates.
(This is not a complete list for all Observatories, only those that responded.)

4.3 Astronomical Societies

There are some 50 known astronomical societies or clubs in Australia, dating back, in at least one case, to the late nineteenth century. Each is a local group where enthusiastic numbers of the public can come together to share their passion and learn about the subject of astronomy. Events organised specifically for society members include astronomy courses, lectures by professional astronomers, access to dark sky sites (owned by the societies) and telescope workshops.

Many such societies also run successful and valuable public programmes and events. These are often organised to take advantage of specific astronomical phenomena such as the Transit of Venus or Opposition of Mars. However, they also include regular visits to schools to provide students with easy access to telescope observations.

The Working Group received survey responses from fewer than 50% of these organisations and in some cases the membership total was not included. The figures, where given, ranged from about 20 to about 1000. Based on the responses received, a reasonable figure for the total membership of such organisations in Australia would be in the vicinity of 4000.

Many of these organisations are well known for their public outreach. Only in some cases, however, was the attendance at public outreach activities quoted. The Ballarat Astronomical Society quotes a 2003/2004 attendance figure at its Municipal Observatory as 8000, and the Astronomical Society of South Australia has about 3000 visitors per year at its observatory facilities north of Adelaide. More typically, however, survey responses showed public outreach attendance figures of a few hundred per year. Based on the surveys received, an estimate for all such public outreach attendances would be in the region of 20,000.

Club newsletters dominate publications produced by astronomical societies, although in some cases other publications are made more widely available. One example is the Astronomical Society of Victoria's Yearbook, containing details of astronomical phenomena.

Many societies have websites, and it is often through these that enquiries relating to astronomical phenomena are directed. The societies are also very good at working with media and in particular have formed strong relationships with local newspapers and/or radio programs.

4.4 Interactions with the Professional Community

At present the majority of interactions between the professional community and either public facilities or amateur groups is through ad hoc colloquia and other one off presentations and events. However, in addition to this public observatories and planetaria often provide work for aspiring young astronomers, which enhances their professional development. An excellent example of this is the employment of PhD students as guides at the Sydney Observatory (see case study below).

A case study: Sydney Observatory

> Sydney Observatory is a museum of astronomy and a public observatory. Over the last decade it has substantially increased its visitor numbers through a series of engaging public programs focusing on astronomy and its history. Annual attendances have grown from 65,379 visitors in 1994/95 to 149,538 visitors in 2003/04.
>
> Facilities at the Observatory include an exhibition of modern and historic astronomy, a 3-D Space Theatre developed by Swinburne University of Technology, a very small planetarium and two main telescopes: a historic 29-cm refracting telescope dating from 1874 and a modern computer-controlled 40-cm Schmidt Cassegrain telescope.
>
> Daytime visitors can look at the exhibition and, for a small charge, see a show in the 3-D Space Theatre and tour the telescope domes. During school term the Observatory hosts school groups who take part in one-and-a-half hour educational visits tailored to the age groups of the students and the requirements of their teachers. Children’s workshops and activities are arranged during school holidays. In the evenings people can visit the Observatory for telescope viewing of the night sky with two sessions in winter and one session during summer.

Special open nights are held in association with any major sky event such as eclipses of the Sun and moon, oppositions of Mars, bright comets and, in 2004, the transit of Venus. For example, on the night of Mars's closest approach in 2003 almost 2000 people looked at the planet through the Observatory's telescopes. There are also occasional lectures by professional astronomers, regular introductory astronomy courses and an amateur astronomy group meets at the observatory each month.

The Observatory has a small but dedicated full-time staff and, as part of the Powerhouse Museum, it has access to technicians for maintenance and designers and related staff for exhibition development. There is also a pool of paid casual astronomy educators to conduct the evening sessions. These casual astronomy educators include science teachers, postgraduate students and amateur astronomers. All of these bring unique talents to their interaction with the public, but for postgraduate students at least the experience that they gain at Sydney Observatory in dealing with the public could be highly beneficial to their future careers. Past postgraduate students who worked at the Observatory have gone on to have highly successful careers. Notable examples include Dr Bryan Gaensler (former Young Australian of the Year) who is now an assistant professor at Harvard University, Dr Vikki Meadows who is in charge of NASA's The Virtual Planetary Laboratory and Dr Tanya Hill who is the astronomer at the Melbourne Planetarium.

Bryan Gaensler says of his time at Sydney Observatory,
"My time as a guide at Sydney Observatory taught me how to speak clearly to the public about science, and to explain why this work is important. Without question, this ability to communicate is one of the most important skills any scientist can have, and is certainly the foundation of much of what I have accomplished.".

4.5 Conclusion & Recommendations

People working in the area of public astronomy outreach are aware of the fascination the general public has for this field. It is one area of science that seems readily accessible to all people, and at its core answers the big questions about ourselves and the Universe we live in.

The enjoyment that the general public receives from astronomy can be obtained by a variety of means. It can be as simple as having a good story-teller, a clear night sky and the chance to look through a telescope, to utilising the latest digital technology to become immersed in stunning views of the Universe that are real-to-life and obtained from professional telescopes and space observatories.

Australian planetaria, observatories and astronomical societies all play significant roles in educating the public. In particular, they are a highly used resource for schools with many programs being tailored specifically for school curricula and providing access to unique experiences such as telescope viewing.

Recommendation
At a present large amount of school level education is being assisted by public facilities and amateur groups. It would be desirable if the professional community could work more closely with such groups to further enhance this work.

Public facilities act as a conduit between the interested public and professional astronomers by organising lectures and/or astronomy courses. These facilities also generate strong media coverage — particularly in their local areas and often have excellent media contacts and networks.

Recommendation
Amateur groups often have well established media contacts and liaisons with which they are often better able than professional institutions to promote astronomical science. Professional institutions could significantly improve their promotion of astrophysics to a wider audience by tapping into these networks.

5 Contributors

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