Stimulating our talented: the Bachelor of Philosophy (Honours) program

Paula Newitt, College of Science, The Australian National University, Australia
Paula.Newitt@anu.edu.au

***Abstract**: Supporting, stimulating and broadening the opportunities for talented science students led The Australian National University to establish the Bachelor of Philosophy (Honours), PhB, degree program in 2003. The degree is designed to provide supported opportunities for elite level undergraduate students to undertake research in science or mathematics from the commencement of their undergraduate studies. This paper reviews the progress of this degree following the graduation of the initial cohort of students.*

Background/Introduction

Many Australian universities now offer advanced science degrees to high achieving students (e.g. The University of Sydney, The University of New South Wales, Monash University, University of Western Australia, Macquarie University, University of New England, University of Wollongong and University of Western Sydney). These degrees are most often of the form Bachelor of Science (Advanced) (Honours) and are usually open to students achieving in the top 5% of the year 12 cohort. The Bachelor of Philosophy (Honours), PhB, degree in Science at The Australian National University was established in 2003 and offers a high degree of flexibility, mentoring and individually tailored programs involving substantial research experience for the 120 students in the four-year degree.

The report from the Boyer Commission (1998) provided benchmark guidance to the development of undergraduate education that is both enriching and inspiring. The first recommendation of this report is that 'Beginning in the freshman year, students should be able to engage in research in as many courses as possible.' This recommendation was under the heading 'Make Research-Based Learning the Standard'. Later recommendations focus on enquiry-based learning, mentoring, communication skills and establishing communities of practice that include undergraduate students. This report is aimed at all undergraduate students and the ripples through the tertiary academic community have led to significant improvements in the learning experience of undergraduates. However, the establishment of advanced science degrees is aimed at providing a higher level of this experience to intellectually gifted students who, we hope, can make the most of this opportunity.

There is an expansive literature describing and evaluating programs for gifted and talented students in the primary and secondary years of schooling. For example, Bleske-Rechek, Lubinski and Benbow (2004) evaluated longitudinal data covering 30 years and relating to 3937 students who undertook academically advanced programs in high school. The authors found that:

> *'Students who took Advanced Placement courses, compared with their intellectual peers who did not, appeared more satisfied with the intellectual caliber of their high school experience and, ultimately, achieved more. Overall, this special population placed a premium on intellectual challenge in high school and found the lack of such challenge distressing.'* (p. 217)

Similarly, Campbell, Wagner and Walberg (1999) investigated academic competitions (such as the Science Olympiad programs) and other out of school programs that seek to develop and inspire talented secondary school students. Campbell et al. found significant positive differences in long term outcomes for students who had experienced Olympiad programs as compared to their peers who did not receive this extension activity. In delving deeper, they were also able to demonstrate that Olympians who were mentored achieved a 'startling' increase in productivity, as measured by number of publications, compared with Olympians who did not receive mentoring.

While the evaluation of secondary school programs for gifted and talented students has been carried out extensively and over a long period, relatively fewer investigations have focused on the tertiary education sector. However, the establishment of summer science research programs in the United States of America has led in particular to studies of the effectiveness of research apprenticeship models to attract, inspire and retain intellectually talented students in science. Authors such as Hunter, Laursen and Seymour (2007), Frantz, DeHaan, Demetrikopoulos and Carruth (2006), and Lopatto (2004) have reviewed the effectiveness of such programs and provided support for the view that the undergraduate research experience is broadly effective in increasing the interest of students in a career in science as well as developing and supporting skills intrinsic to scientific research. Perceptions of the outcomes of these undergraduate research experiences have been investigated and Kardash (2000) has noted that students and faculty mentors express similar, positive responses about the research experiences but that the specific criteria to measure the outcomes are often somewhat vague and subjective. Kardash has developed a survey instrument in an attempt to provide a more objective measure of the learning experience associated with apprenticeship research experiences. Wilson, Howitt and Wilson (2007) respond to this in the context of the ANU PhB degree.

Structure of the PhB degree

Degree characteristics

The PhB degree in Science at ANU is directed at intellectually ambitious students who want to study at the highest level. The content of the degree consists of the equivalent of four years full-time study, although the degree can be accelerated and be completed within 3.5 years. The degree includes an Honours year in a discipline area within the College of Science.

Every PhB student receives intensive individual supervision by academic staff. During the first three years of their degree they have opportunities to extend their learning by doing their own research, and then in the fourth year undertake an Honours project. The PhB degree is intended to provide excellent preparation for research and support higher student learning leading naturally to PhD programs for those students who wish to follow this path.

Entry requirements

Prospective students for the PhB degree are recruited predominantly from high achieving school leavers who are contemplating the possibility of a postgraduate research degree. Specifically, these students need to obtain a graduating high school score (UAI, ENTER, TER or equivalent) of 99, or another major academic achievement, to be accepted into the PhB. An example of the latter entry would be a medallist in an international Science Olympiad competition. Applicants are also required to submit a written application, describing why they want to join the program and provide two academic referee reports. Approximately 30 such students are admitted each year.

Highly qualified mature age students are also considered for entry and at present one student in this category is studying for the degree. Additionally, a small number (3 – 4) of current students are considered for transfer into the degree at the end of their first year of undergraduate study.

Mentoring and advice

All PhB students are allocated an academic member of staff in the discipline area of their choice to act as a mentor for the duration of their degree. Due to the highly personalised and flexible nature of this degree, students are also encouraged to seek advice from the PhB Coordinators representing major discipline areas within the College of Science (biology, chemistry, earth sciences, environmental and sustainability studies, mathematics and physics). The PhB Program Coordinator is also heavily involved in ongoing advice to students and staff with respect to all aspects of the degree.

Research experience

The research experience in this degree is formalised through Advanced Studies Courses (ASCs). These courses are undertaken under the direction of an academic supervisor and are only open to students enrolled in this degree. The kinds of study undertaken within an ASC most commonly include involvement in current research at the University or CSIRO, or special research projects from across all discipline areas of the College of Science. ASCs can be substantial standalone projects (approximately 150 hours) that accrue the same number of credit units (points) as for normally timetabled undergraduate subjects. They are taken as part of the full-time load, not as an additional activity. Alternatively, ASCs can also be an extension or add-on to a subject, in which case the research project is much more constrained and intended to take approximately 30 hours over the normal expected load for the subject.

PhB students must complete six ASCs prior to commencing their Honours year. They are required to undertake at least three 'standalone' ASCs and typically a student would complete three standalone ASCs and three 'add-on' ASCs. Overwhelmingly, students take their first ASC in semester 2 of their first year in the degree, after they have had a chance to adjust to university life. Most commonly, this would be an extension-style (add-on) ASC. This is a modification of the degree requirements, following the experience of the first two years of the degree. Initially, all ASCs were standalone projects, but it was soon realised that this affected the ability of students to undertake foundation studies across a range of disciplines in their first year. The modification of the ASC structure has fully addressed this concern.

As noted by Kardash (2000), assessing the quality of the outcomes from a research experience such as an ASC can be problematic, particularly for staff involved in full-time research and with little experience of the levels of achievement normally encountered with undergraduate students. The process in place for ASCs is that a summary of the ASC is submitted to the PhB Program Coordinator by the end of week 2 of semester. The summary contains a description of the project (including anticipated project outcomes and description of the styles and breakdown of assessment). The summary is agreed to and signed by the student, the ASC supervisor (instructor), the PhB student's mentor, the Head of School or Department (the supervisor of the ASC instructor), and finally by the PhB Program Coordinator. While this process sounds unwieldy, it works well and acts to keep the mentor and student in contact as well as providing a process that seeks to ensure the research projects are approved as appropriate and within the scope of student and staff resources.

The issue of equity and relativity of assessment across a wide range of research experiences is non-trivial. The normal process for assessment of ASCs is that if the instructor is in the Faculty (as distinct from a Research (only) School, then the academic marks everything by him or herself except for the oral presentation. In the case of a talk usually several academic staff give some feedback on this aspect of the assessment. If the instructor is part of a Research School and has little experience with marking (or appropriate expectations), then the PhB Program Coordinator requests that they submit the student's final report to an experienced member of the Faculty for an additional mark. This frequently (although unfortunately not always) occurs. If an academic researcher is completely new to marking an ASC, then it is normal practice to discuss expectations and marking guidelines with the Program Coordinator or one of the discipline-specific PhB Coordinators. Inexperienced instructors also are encouraged to talk with an experienced colleague in the discipline area to gain more specific guidance in the area of the project. Finally, all ASC results are considered (one by one!) at the PhB Committee examinations meeting where, if necessary, the PhB Discipline Coordinators provide specific information on each ASC. Each student's ASC mark is then compared statistically with the marks the student achieved in regular subjects. Any ASC marks that vary significantly from the student's other marks are queried and if necessary, the work is reassessed by the PhB Coordinator in the discipline area, or someone else who is qualified.

Degree requirements
The PhB degree does not have the rules and regulations that are common to most degrees. For example, there are no regulations requiring certain numbers of discipline-subjects at certain levels in order to satisfy the degree requirements. The flexibility that is inherent in the degree means that is possible to support the sometimes eclectic interests or advanced entry standards of this cohort of students. At the same time, it is imperative that these students follow a rigorous and academically sensible degree path. Provision of support and advice through the network of mentor, discipline PhB Coordinators and Program Coordinator ensures the rigour and depth of the degree for each student.

The PhB degree has two formalised degree requirements: that students successfully complete six ASCs prior to commencing the Honours year; and that students achieve a First Class Honours grade in their final year. The working approach to the latter, is that students' results are reviewed by the PhB Committee at the end of each semester. Students are permitted to remain in the degree provided the Committee is assured that the student is performing at a level consistent with achieving First Class Honours at the end of the degree. This is interpreted as an average of 80% (high distinction) for all science subjects. If a student does not meet this level of achievement in a given semester, they are counselled. The focus is on identifying the impediments to their success and helping and supporting them. However, if the student does not achieve the necessary standard in the following semester, they are normally transferred to a Bachelor of Science degree.

Communities of practice
Students are encouraged and supported to become part of a network of PhB students, across all years and all discipline areas. All new students are invited to participate in a casual weekend at the ANU's coastal facility at Kioloa (NSW central coast). This trip is organised for the weekend immediately prior to the start of Semester 1 in order for students to start the degree already knowing some of their peers. The emphasis is on meeting the new students as well as talking with PhB representatives from later years. A small number of carefully chosen research staff are invited to give talks to the students about the excitement of their research. The main focus though is on providing an opportunity to establish friendships and collegiate relationships between students and between students and staff. The establishment of a broad community of practice starts with this casual weekend involving students, staff, science (including field trips), a beach and good food. The community is reinforced and supported though the year by a dedicated PhB online site (currently offered through *WebCT* and with active discussion boards) as well as periodic seminar sessions and other activities organised on a discipline basis. Discipline communities of practice naturally develop as students become more focused in their studies and undertake substantial ASCs. In the last two years the students have organised an annual PhB Conference to formally present the outcomes of a selection of ASCs to their peers and staff. The presentations can be assessed, but in most cases the students simply wish to model academic practice and demonstrate what they have learnt 'just for fun'.

Results

The PhB degree program is now in its fifth year at ANU. The first students who commenced in the degree as first year students have now graduated and it is timely to consider 'what the degree looks like'. Firstly, there are some common threads concerning student characteristics. Incoming students are likely to identify their interests as being in mathematics and/or physics (65%), expect to proceed to a higher research degree (95%), and attended a secondary school outside the ACT (65%). Table 1 shows that the majority of students are male (67%) but that there is an equal retention rate of males and females (82-83%) in the degree. Of the 28 students who have transferred out of the degree, 13 have transferred voluntarily. The reasons include transferring into a professional degree (e.g., medicine, engineering, actuarial studies), transferring to an alternative PhB degree (PhB–Arts), or transferring to another tertiary institution (Princeton). Two students took leave from the degree due to

ill health and then subsequently transferred to a Bachelor of Science degree. A small number of students (15; 9%) have been transferred from the degree due to lack of appropriate levels of achievement. A higher proportion of male students than female students have found it difficult to maintain high grades to the point of being transferred from the degree (M: 11%; F: 6%).

Table 1. Number of students who are (or have been) enrolled in the PhB science degree since 2003
Voluntary transfer = Voluntary transfer out of the PhB; Compulsory transfer = Compulsory transfer out of the PhB

	Total	1st yr	2nd yr	3rd yr	Honours	Graduated	Voluntary transfer	Compulsory transfer
Male	106	20	24	16	18	9	7	12
Female	53	8	13	10	8	5	6	3
Total	159	28	37	26	26	14	13	15

Student directions often change from their initially declared interests. Prior to commencing first year, similar proportions (65%) of the male and female cohort are interested in maths/physics. More male students than female are interested in chemistry and the remainder of the students express an interest in biology (15% - mainly females) or psychology (2%) or environmental studies (1%). Table 2 shows the discipline interests of female and male students from second year on. The figures show the percentage of students in each discipline area, relative to the numbers of female or male students. It is clear that biology gains in interest for both males and females, and this is overwhelmingly in topics of molecular biology. Recent trends suggest that mathematics loses some ground for female students, with physics and biology the prime beneficiaries. The exception is the current cohort in Honours where female students have clustered in mathematics rather than physics. At present, the trends for male students are away from chemistry and towards mathematics and physics. The subject enrolment trends are being explored in more detail in order to establish the factors influencing student choice. Note that Table 2 shows the major area that students are focusing on – they might be (and most likely are) still undertaking subjects from a range of discipline areas up until their Honours year.

Table 2. Major studies within gender groupings
[a] Psychology; [b] Cross-disciplinary environmental sciences

	Female Students (%)					**Male Students (%)**				
	Phys	Math	Biol	Chem	Other[a]	Phys	Math	Biol	Chem	Other[b]
Year 12	65		15	18	2	65		4	30	1
2nd Year	31	8	39	15	8	29	37	17	12	4
3rd Year	44	0	33	11	11	33	47	20	0	0
Honours	12	50	38	0	0	50	33	17	0	0

Students complete an application form when seeking admission to the PhB degree. One open ended question on the application form asks them to explain why they want to undertake this degree. Table 3 shows the responses from 246 students who were offered places in the degree from 2004 onwards.

Table 3 shows that the students attracted to the PhB degree are looking for a science degree that offers challenging advanced learning opportunities, in particular research experiences, in a supportive and mentored environment. The reputation of the university is highly significant. What is not evident from the table, but that is expressed at the Kioloa orientation weekend, is that significant numbers (up to 30%) of new PhB students express a lack of confidence in their academic capabilities, despite their top 1% Year 12 ranking. This observation has been noted at the orientation weekend for the last three years. Campbell et al. has recorded similar findings with Science Olympians and refers to this as ‘delayed recognition’. Our students too seem to take up to a year to ‘realise the extent of their talent’ and the ASCs appear to play an important role in this self-recognition.

Table 3. Responses noted by PhB applicants in answering the question 'Why do you want to enrol in the PhB degree in science?'. The question forms part of the application form for admission to the degree.

Motivation to join the PhB degree	**%**
General	
Interest in science	32
ANU's reputation	14
PhB reputation and prestige	9
ANU facilities	4
Career, employment and further study possibilities	
Desire a career in research	15
Pathway to postgraduate studies	11
Wish to pursue research opportunities to help humanity	10
Enhance employment possibilities	8
Contribution to the world	7
Degree's philosophy	
Supporting advanced learning	19
Explore own interests	5
Pathway for high achieving students	2
Degree attributes	
Opportunity for undertaking research	26
Flexibility of study options	17
Individual mentoring	12
Opportunity to combine science with other subjects	2
Student exchange opportunities	1
The degree experience	
Study with renowned academics	12
Study with academic peers	8
Be involved with cutting edge science	4
Personal growth	
Be challenged to reach academic potential	23
Utilise own capability and develop skills	4

Wilson et al. carried out an anonymous survey (response rate 49%) of PhB students in 2006, focusing on the research experience. Overall they found the students highly valued the ASC projects ('I learnt a lot from my standalone [ASC project] in chem. as well as having heaps of fun', 'The process of going out and arranging an ASC opens your eyes to research areas you had no idea existed', '…also realising that some areas are not for you has been important', 'I feel like I am more involved in research and other things happening in the uni, so again it increases my confidence levels').

Fifteen students have now graduated from the PhB degree in Science. Of these students, two are taking a short break before commencing higher degree study, three are undertaking further coursework degrees (Law, Medicine, Science Communication), five have commenced PhD degrees at ANU, one has commenced a PhD degree at ANU in partnership with another university (Oxford) Cornell), three are completing PhD degrees at other institutions (Cornell, Harvard, Max Planck), and one has commenced work for the Commonwealth Treasury. All are committed to lifelong learning and all intend a career in science.

Discussion

The PhB degree program requires an enormous input from academic staff across the ANU College of Science. The flexibility of the degree and the opportunities to undertake individualised research projects mean the demands on staff time, energy and creativity can be stretched. ANU is fortunate in having a significant number of research-only staff to call upon to contribute to this degree. Nonetheless, it is a common experience that Faculty staff (involved in both research and teaching) share a disproportionate load in managing the research experiences of first year students. This is not unexpected, given that new students are likely to approach their lecturers for their first experience of an ASC. However, these same lecturers are also frequently involved in offering extension activities to direct entry Honours (i.e. advanced) students. As a result, in a given subject a lecturer might be involved in assessment activities directed at the whole cohort, extension activities for the advanced students, and ASC projects for PhB students. Debate exists between ANU staff and students about issues of time, equity and resources devoted to PhB students. Whether this is a manifestation of 'tall poppy syndrome' or a reflection of pressures on staff and students is under investigation.

Despite these stresses, overall responses from PhB students and supervising academic staff remain overwhelmingly positive. Continuing evaluation of the program is aimed at measuring the outcomes of the degree at a more detailed level, including institutional measures (publications, levels and directions of graduate study) as well as more personal measures (recognition of research skills, learning to 'be a scientist', developing scientific attitudes, beliefs and ethics, and becoming integrated into the scientific community of practice).

Acknowledgements

The author wishes to acknowledge and thank Sue Wigley for invaluable ongoing administrative support in running the PhB degree program and for providing the statistics for this article.

References

Bleske-Rechek, A., Lubinski, D. and Benbow, C.P. (2004) Meeting the educational needs of special populations: Advanced placement's role in developing exceptional human capital. *Psychological Science*, **15**(4), 217–223.

Boyer Commission on Education Undergraduates in the Research University (1998) *Reinventing Undergraduate Education: A blueprint for America's research universities*. Available at http://naples.cc.sunysb.edu/Pres/boyer.nsf/ (Accessed June 2007)

Campbell, J.R., Wagner, H. and Walberg, H.J. (1999) Academic competitions and programs designed to challenge the exceptionally talented. Chapter 16, In K.A. Heller, F.J. Monks, R.J. Sternberg and R.F. Subotnik (Eds) *International Handbook of Research and Development and Giftedness and Talented*, Oxford, UK.: Elsevier.

Frantz, K.J., DeHaan, R.L., Demetrikopoulos, M.K. and Carruth, L.L. (2006) Routes to research for novice undergraduate neuroscience. *CBE – Life Sciences Education*, **5**, 175–187.

Hunter, A-B, Laursen, S-L. and Seymour, E. (2007) Becoming a scientist: The role of undergraduate research in students' cognitive, personal and professional development. *Science Education*, **91**(1), 36–74.

Kardash, C-A. (2000) Evaluation of an undergraduate research experience: perceptions of undergraduate interns and their faculty mentors. *Journal of Educational Psychology*, **92**(1), 191–210.

Lopatto, D. (2004) Survey of undergraduate research experiences (SURE): First findings. *Cell Biology Education*, **3**, 270–277.

Wilson, A.N, Howitt, S.M. and Wilson, K.F. (2007) Research-led education: challenges and experiences, UniServe Science, *Symposium Proceedings Science Teaching and Learning Research including Threshold Concepts*, 154–160.

Copyright © 2007 Paula Newitt

The authors assigns to UniServe Science and educational non-profit institutions a non-exclusive licence to use this document for personal use and in courses of instruction provided that the article is used in full and this copyright statement is reproduced. The author also grants a non-exclusive licence to UniServe Science to publish this document on the Web (prime sites and mirrors) and in printed form within the UniServe Science 2007 Conference proceedings. Any other usage is prohibited without the express permission of the author. UniServe Science reserved the right to undertake editorial changes in regard to formatting, length of paper and consistency.