



Research-led education: challenges and experiences

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Introduction

The role of a university education in science is changing. In the new knowledge economy, the fact-centred, narrowly-focussed education often acquired in a traditional science degree is no longer valued for its own sake, partly because such knowledge, and associated technical skills, can rapidly become outdated, but also because people entering the workforce can expect to have to change jobs and duties several times during their lifetimes. Instead, the skills that are most valued in the science graduate are the logical approach, the inquisitiveness and the adaptability that characterise a lifelong learner. This change is reflected in the new emphasis on training students in ‘research skills’ evident in the changing nature of science degrees in many Australian universities, since the skills of the lifelong learner are similar to those of the effective researcher.

To become an effective researcher, an extensive range of skills must be mastered, ranging from the discipline-specific (e.g., data reduction and laboratory-based skills) to the generic (e.g., written communication skills, a (self-)critical approach, or an understanding of uncertainty). There is considerable debate on the best way to teach these skills to undergraduates while not compromising on the mastery of ‘fundamental’ knowledge. The Boyer Report (Boyer, 2000) promoted the view that research universities should capitalise on their expertise and provide all undergraduates with research experience. This represents one extreme of the profile of research-based strategies where an undergraduate contributes to novel research under the supervision of an active researcher. In contrast, other authors have suggested that structured activities targeted at the acquisition of particular generic research skills provide a better approach to research training (Hartberg 2006; Holbrook and Devonshire 2005).

It is often accepted that the experience obtained in research projects is beneficial, resulting in students being better prepared for a future as independent learners both in and out of traditional research contexts. However, while the students generally enjoy these projects, it is not clear that immediate immersion in a research environment, with no attempt to induct the students into a research culture, is the most effective or efficient way to achieve our goals. Indeed, it has been observed that it is difficult to determine objectively the benefits of undergraduate research experiences: students undertaking research projects are often a self-selected group and there is no obvious control (Lopatto 2004) leading to difficulties in evaluating program effectiveness. While students perceive that they have gained both discipline-specific and generic benefits (Seymour, Hunter, Laursen and Deantoni 2004; Lopatto 2004), as far as we are aware there is no definitive research showing that an undergraduate curriculum which is suffused with research experience is of higher educational value than one with only a limited research focus.

The Bachelor of Philosophy (PhB) degree at The Australian National University (ANU) was introduced in 2003 to provide a research-based education for elite students. This program, which is open to students with a UAI of 99 or above, provides students with opportunities to undertake research at a high level from the beginning of their undergraduate degree through the inclusion of six or more research-led projects. A high degree of flexibility in the choice and sequence of courses means that the degree is also somewhat self-directed. The research projects ensure that the PhB students obtain a greater experience of research than most undergraduates, but this raises several



questions relating to the benefits of this experience, the effectiveness with which it is delivered, and indeed whether it is the best way in which to teach students how to think/act like researchers. The small amount of research evaluating the effectiveness of programs of this type suggest limited gains in higher order research skills and understandings such as the nature and development of scientific knowledge (Seymour et al. 2004). The present paper reports on initial research into the PhB program at the ANU. Student and staff surveys were used to examine perceptions of the program aims and implementation of the main program elements, the Advanced Studies Courses (ASCs), staff-student relationships, and perceived benefits to both staff and students. In the following we concentrate on program aims and staff practices in relation to the ASCs.

Approach

Details about the structure of the PhB program can be found in the report by Newitt in these proceedings (Newitt 2007). The following points are important for our discussion. The first three years of the degree include at least six Advanced Studies Courses (ASCs), ostensibly research-focussed experiences which replace standard lecture courses and which are chosen by the student with advice from a mentor. The broad aim is that the ASCs should provide substantial research training and experience, and hence the intention is that many of them should take the form of ‘genuine’ research projects conducted under the supervision of an active/expert researcher. ASCs may take place in either ‘stand-alone’ mode (replacing a full semester lecture course) or ‘add-on’ mode (extending a standard course and typically accounting for 20-30% of the associated assessment).

The design of the student surveys was informed by data from an initial survey of incoming students, promotional material and anecdotal information. The surveys, which were administered online, focussed on the students’ research experiences, including their relationships with ASC instructors, their perceptions of the program aims, and whether or not they were achieving those aims. Students could take as long as they liked to respond. Forty-seven students (45% of the cohort) completed the survey.

Staff surveys aimed to determine how staff perceive the purpose of the program, how familiar they are with the PhB literature and what educational and developmental outcomes they expect for students from ASCs. Staff were also asked what benefits they got from the program, and if they had any concerns. One of our aims was to look at the alignment of intentions and actions: In general, do the design and implementation of ASCs align with the program goals? Do the content and assessment tasks of individual ASCs align with the stated goals of the instructor? Staff surveys were administered in hard copy via internal mail. Each survey was personally addressed and included a short note thanking the participant and assuring them that their responses would be kept anonymous, and a chocolate frog. Of the 87 surveys that were sent out, 38 were returned completed, a response rate of 44%.

We have taken a frequency-based approach to identify emergent themes. If a respondent offered several different answers to a single question, all have been included in our identification of themes, since we are interested in the most common perceptions and experiences of participants in the PhB.

Survey results

General expectations of and responses to the program

The responses to the student surveys can be characterized as overwhelmingly positive, with most students expressing a high level of satisfaction with the program. This is consistent with previous studies (Seymour et al. 2004; Lopatto 2004), which found that students referenced gains from their undergraduate research experiences. However, the responses threw up some interesting points both



in relation to the motivations of the students enrolling in the PhB and their general experiences with coursework and research projects. The incoming cohort of PhB students expressed clear expectations that the PhB program would be significantly different from the normal BSc. They expected a stronger research emphasis, greater flexibility, intellectual challenge and more contact with researchers. There were also some misconceptions evident, in particular that they would be in smaller classes and that they would undertake more advanced coursework than those in the normal BSc (that is, some students anticipated streaming, which is *not* part of the program). Students at all levels indicated that, on entry to the program, they had anticipated receiving both a good preparation for research and a good education.

The responses to the staff surveys were extremely mixed, reflecting a large range of engagement with the PhB program. Due to the ANU's division between the Research Schools (where staff are not necessarily engaged in undergraduate teaching) and Faculties, differences in staff awareness of teaching standards and issues are to be expected.

What is the program for?

The surveys suggest that student and staff perceptions of the broader aims of the program align reasonably well with each other as well as with institutional aims. Two ideas dominated the students' perceptions of the aims of the PhB program, which were almost uniformly thought to be

- to train students in research techniques and give them experience in real research projects in order to prepare them better for research careers, and/or

- to allow students to fulfil their potential by providing a personalised degree for high-achievers

A large majority of staff gave one or more of the following three as the main aims of the program:

- to produce graduates who are well-prepared for research careers,

- to attract high-quality students to the ANU, and

- to offer those students a chance to shine by providing them with a more challenging degree.

A small number of staff also mentioned independence -- students can '*do their own thing under reasonable guidance*' – and flexibility – '*possibility to tailor courses to their interests*'. These views reflect the aims described in the program literature reasonably well, despite the admission by the majority of staff that they have not read any of the documentation

What are the Advanced Studies Courses for?

Student responses to questions about the aims and purposes of the ASCs differed only slightly from their descriptions of the overall program aims, with 'research experience' being a common response. Students undertaking add-ons generally expected them to extend (or at least complement) the standard course material, but expectations were still generally vague.

Staff were asked direct questions regarding aims and hoped-for educational outcomes for ASCs as well as about the - broader program aims, in the hope of eliciting more specific information about day-to-day activities and fewer 'motherhood' statements. The responses revealed differences that may be correlated with the engagement of the staff in day-to-day undergraduate teaching. Although the dominant theme in responses to the question, 'What are the aims of the ASCs?' was 'research', staff were divided between 'research preparation' and 'research exposure'. This division reflects a more general uncertainty within the ANU community as to what is meant by 'research-led' or 'research-based' education. One of the more considered responses was '*[the aims of the ASCs are] To introduce students to a research environment and to teach scientific approaches and thinking*'. Another aim of the ASCs cited by staff was 'higher' or 'deeper' learning: '*to provide challenges to PhBs commensurate with their abilities – a sort of de facto streaming*'. This attitude chimes well with the students' own expectations. The most commonly expected outcomes of ASCs can be summarised as generic research skills and obtaining research experience. Staff responses to these questions were



mostly couched in very vague terms, citing expectations such as '*understanding of the process of research*', '*excitement about research*' and '*a taste of research*', but were sometimes more specific, hoping for '*report writing, literature search and working independently*'. (One person was very specific, listing discipline-specific laboratory skills as learning objectives.) Two instructors expected students engaged in stand-alone projects to achieve a level of expertise in their subject.

Staff also mentioned motivational aims such as stimulating student interest and providing one-to-one staff contact (the latter is of course not an educational aim, and indicates a misunderstanding of the question). One person suggested that ASCs can be used to '*fill gaps*' in the students' knowledge or learning. This is in contrast to the view held by others, that requiring students to replace course work with research projects is a primary cause of gaps in students' learning.

One respondent said that he/she used ASCs to '*test a student's suitability for research*'. Anecdotal evidence suggests that this is a common, if often subconscious, tactic. However this attitude contrasts with the program aim of allowing the students to develop so that they will *become* good researchers, and indicates a preconception about students' abilities which may not align with the developmental and nurturing responsibilities of the teacher. Although admission to the PhB is almost a guarantee that we are dealing with natural learners rather than unmotivated strugglers, the students are young and at varying levels of intellectual (and emotional) maturity. It is the job of the instructor to help them become researchers, not to test them.

One feature which emerges from the survey responses is that many staff don't generally have specific educational outcomes in mind when designing, offering or supervising ASCs. They are aware of the PhB programme aims, and generally reiterate those aims or indicate that they expect students to acquire something very ill-defined. It may be that for many ASCs there is *no* design stage: since the primary perceived motivation of the PhB is to give students '*research experience*', some staff members may feel that the experience of working in an area of active research, possibly in a research group of post-docs and graduate students and under the supervision of a leading researcher (themselves), is somehow enough. Both survey responses and the observations of the authors suggest that, more often than not, the majority of the assessment is carried out by the instructor alone, and although it is nominally based on a logbook, report etc., the student's grade depends mostly on how well the instructor thinks the student has done. Worse still, since many research-only staff have little or no contact with other undergraduate students, their expectations regarding background knowledge and skill levels may be inappropriate, and thus they don't have a good yardstick for choosing how the student is to be assessed (or even when assigning marks). Although mechanisms are in place to provide guidance for those with less experience, it is not clear that these are always used appropriately. Several staff members are aware of this potential weakness and raised it as an area of concern.

What are the benefits of undertaking Advanced Studies Courses?

Benefits perceived by students fall into two broad areas: improved relationships with staff and obtaining generic research skills. The majority of the students felt that their relationships with instructors and mentors have been positive, and in some cases excellent, experiences. They described themselves as '*inspired*' by their instructors and '*feel that people care about my education*'. The most positive feelings are summarized in this response:

'The idea of ASCIs and mentors are a tremendous innovation by the ANU ... the close contact with ASCIs and mentors allowed me to have a broader view and greater appreciation of what is means to be an academic. ... it provides a great deal of intellectual stimulation'

Some responses indicate that the ASCs are producing personal development within the students, one of the higher level outcomes cited by Seymour et al. (2004), and higher conceptual learning:



Projects were described as '*a very eye-opening experience*', '*taught me how much I can do when I put my mind to it*', '*opens your eyes to research areas you had no idea existed ... You appreciate that range of directions available ...*'.

There have been a few bad experiences – one student wished that the '*instructor should give a hand finding or even show some hints on things that we are stucked or don't know how to get, and shouldn't just meet and ask how you are going?, great keep good work*'. Another related how he/she '*had a PhD student helping me for my stand alone, who incidentally was worth 10 instructors ... but how cool would it be to have an instructor to help you??*'

The strongest benefit that the students felt they derived from the ASCs is the acquisition of 'generic research skills', although none of the students elaborated on what is meant by this phrase. Many students also felt they benefited through advanced learning, or from exposure to research life through a real research experience. Some of the students referenced laboratory skills, in particular enjoying the opportunity to do a *real experiment*, in which the outcome is not known and they feel they are contributing to ongoing research. In a previous study (Lopatto 2004), 'readiness for more demanding research' was found to be one of the most highly ranked gains after an undergraduate research experience.

A large majority of staff get both enjoyment and stimulation for their own research out of their contact with PhB students – they enjoy the opportunity to '*meet wonderful students*' and find that supervising ASCs acts as a '*stimulus to work on research projects I might not otherwise find time for*'. However, a significant minority explicitly answered 'none' or 'few' to this question: '*at the moment, they add stress!*' and '*zero*' being two of the more depressing responses,

Concerns?

The students overwhelmingly felt that the program is fulfilling its aims, although several admitted that they were not yet in a position to judge. But the enthusiasm was frequently qualified by concerns regarding the degree of stress experienced by PhB students, as is evident in comments describing the program as '*so much work*', and '*more stressful than I could ever have imagined*'. Students also expressed concerns that it is '*hard to get the HD average and maintain a balanced lifestyle*'. Other concerns focus on the variability in experience: students perceived '*problems in ensuring that students are given a sufficiently broad education*', and expressed the opinion that '*more guidance ... could be useful*'. In some cases, they '*didn't expect the program to be so dependent on individuals making the most of it*' – indeed, the flexibility of the degree and the focus on independent study and self-motivation in many of the ASCs may presume too much maturity in some students. Most worryingly, students '*sometimes feel that the structure of the ASCs is not a well thought out compromise between learning and assessment*'. One student commented recently that he rarely knows what an ASC is about until he gets to the end of it, and sometimes not even then. Many students also expressed a desire to place more emphasis on generic research skills.

There was a clear perception that more academics need to be pulled in to the program as ASC instructors, and that students would benefit from a wider choice of projects. Students thought that the PhB '*needs to be able to procure more enthusiastic and proactive academics ... who are willing to take on PhB students and also offer a more stimulating range of ASCs*'. There were also concomitant concerns about the poor performance of some instructors, and hence about the homogeneity of ASC standards. One student articulated this clearly: '*Mentor and instructors are very important. Please inform them their roles so that its easier for them to know how they can advise us ... not all mentors actually know what they have to do or even how the ASC works ...*'. Finally, echoing a concern felt by several staff members, some students worried that their core education may suffer as a result of the number of projects replacing standard course material.



The question about staff concerns received the most varied response in the staff surveys. Seven people mentioned staff time issues, five were concerned about pressure on students leading to stress, five commented on the possibility of missing core curriculum elements and a few more commented on the related fact that there is insufficient coordination which can lead to an unbalanced program. There was a general feeling that the instructors need more guidelines – this ties in with the feelings expressed by the students that some instructors do not really know what they are supposed to be doing. Staff felt that expectations (presumably of both them and the students) are not clear, and that the ASCs themselves can be very ‘uneven’ (again, this ties in with student feelings as described above). This is perhaps indicative of a deeper problem where some staff have not adequately considered the educational goals of an ASC and have therefore not designed assessment for optimal student learning. Some staff were also concerned about the lack of skill development of the students, particularly in areas such as analytical thinking and problem solving: comments such as ‘*the student had some difficulty achieving the analytical rigour needed*’ were not unusual.

Conclusions

It is too early to tell whether students completing the PhB degree are more ‘research-ready’ than their peers on completion of BSc Honours degrees, and we intend to continue our research in a longer term study to try to evaluate this. However, the survey data do indicate that there is very strong support for the PhB program from both students and staff, and it is clearly meeting a need to extend and enrich talented students. Students in the program perceive that there are significant scientific and personal benefits from interacting more closely with researchers and being more involved with current research, and that they have a better understanding of what life as an active researcher in an academic position is like. Similarly, staff appreciate the increased opportunities to interact with enthusiastic and motivated students. However, the surveys also suggest that there are ways in which the program could be made still more valuable/successful. It appears that increased homogeneity in the standards of ASC design and implementation is desirable. This may be achieved in part by encouraging staff to articulate the educational goals of ASCs more clearly, with particular emphasis on (i) the aims and expected outcomes of ASCs for students, (ii) the ways in which the chosen forms of assessment support those aims, and (iii) the ways in which the project relates to or extends the standard curriculum. This might ensure that more staff considered their ASC supervision in an educational, as well as a research, light.

This research has been approved by the ANU Human Research Ethics Committee (Protocol 2006/227).

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