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AUTHOR Powles, Margaret
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ABSTRACT

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Margaret Powles

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Centre for the Study of Higher Education

The University of Melbourne Parkville 3052 Vic. Australia

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Postgraduates at the interface between higher education and industry

Margaret Powles
Centre for the Study of Higher Education
University of Melbourne

Abstract

This paper presents a selection of results from the first phase of a longitudinal study of the Australian Postgraduate Awards (Industry) Scheme, a recent government initiative under which graduate students receive grants to conduct projects for Masters or PhD degrees, supervised jointly by university and industry partners. The study involves national surveys of each participating group - students, academics and company staff - seeking to compare views on a range of issues, some pertaining to the operation of the Scheme and its outcomes, others in reference to perennial issues in graduate education. This paper explores questions at the intersection of both sets of issues, demonstrating benefits of the Scheme to each participant group, in contrast with perceptions of some of the constraints on higher degree research in the context of university-industry collaborations.

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Introduction

In 1988, following release of the White Paper which heralded widespread reform in Australian higher education, a Committee was established by the then Minister for Employment, Education and Training to review higher education research policy. The Committee's comprehensive report (Smith Report 1989) included deliberations on the state of Australian research and development, noting by comparison with other OECD countries, its relative strengths in the higher education and public sectors and weak contribution by industry (OECD 1987). The Report placed considerable emphasis on the contribution of postgraduates to the national research effort (see also Powles 1984), alerted the government to a continuing 'brain drain' of research-trained graduates, and to impending shortages in the research labour force (see also Sloan et al 1991) and, *inter alia*, delineated factors influencing the supply of research-trained personnel to each sector.

Noting that like most OECD countries, the last decade in Australia had seen a burgeoning of both formal and informal linkages between higher education and industry (see also Beazley 1992; Free 1992) the Smith Committee recommended the introduction of a scheme which would both reinforce linkages and stimulate research training at the interface between the sectors - along the lines of the Cooperative Awards in Science and Engineering (CASE) Scheme operating in the UK. Released around the same time, a review of the long-established Commonwealth (now Australian) Postgraduate Research Awards Scheme also recommended that a scheme should be set up in which graduate scholarships would be earmarked for collaborative projects between universities and industry (ARC 1989)

The Australian Postgraduate Awards (Industry) or APRA(I) Scheme was instigated in 1990 and is the subject of this paper. Under the Scheme, an academic and an industry colleague collaborate to devise a research project congruent with the scope of a Masters or a PhD degree and with the company's research program. The project is submitted to the Australian Research Council and is assessed by a peer review panel on criteria such as: the research standing of the individuals, institutions and companies involved; adequacy of the proposed supervision arrangements; an undertaking by the company to provide specified supplementary support for the project; and relevance of the research to national priorities. An application judged successful by the review panel is allocated an APRA(I) scholarship for a graduate student who is then recruited to undertake the project. The

APRA(I) thus differs from the 'normal' APRA, for which a student applies to a university and is selected on merit to undertake a project under a particular academic supervisor, both usually of the student's own choosing.

After only two rounds, concerned by what it considered to be a low demand for the Awards, the Australian Research Council commissioned a study of the factors which promote or constrain applications under the Scheme. This report (Madden 1991), based mainly on telephone interviews with a sample of participants, laid some of the groundwork for the present study. It was found that factors which enhance applications included: a strong degree of mutual confidence in the capabilities of individuals in each sector; long-term relevance of the topic to the company's objectives; and the belief that a postgraduate could work towards a higher degree on a 'real-world' problem while developing an understanding of the industrial research environment. Proposals would be constrained by: a lack of awareness of the Scheme; difficulties in finding an appropriate student; and concerns by company personnel over academics' lack of appreciation of industry's time and cost constraints as well as its confidentiality and ownership requirements.

Clearly, these observations are representative of recurrent themes in the already large and growing literature on the positive and negative aspects of higher education and industry liaisons. While the literature is too large to review comprehensively here, *Table 1* summarises the main benefits and constraints, derived from some excellent overviews by: Blackman and Segal (1992); Business-Higher Education Round Table (1991 & 1992); Cerych (1985); National Commission on Research (1980); Fairweather (1988); Williams (1992).

While studies of the postgraduate experience at the university-industry interface are absent from the literature, one may reasonably extrapolate the table items into the graduate arena. Some of the benefits of collaborative arrangements mean advantages for graduate students in that they become acquainted with work in industry, their employment options are multiplied, and they gain access to additional funding, resources and facilities for their research. Concerns about industry linkages can equally represent disadvantages for graduate students if they think, for instance, that the nature of the project or the time constraints imposed by industry limit their control over the direction of the research, or that commercial confidentiality which imposes restrictions on release of theses or related publications will affect their careers.

Similarly, there have been no studies addressing graduate education's broader issues in the context of industry partnerships. Scrutiny of graduate education in the interests of efficiency, effectiveness, and 'quality', undesirably lengthy higher degree completion times, combined with an increase in research student enrolments following the demise of the binary divide between established universities and the advanced college sectors in countries such as Australia and the UK, has renewed interest in perennial matters to do with selection of students for research degrees, the correlates of effective supervision, and aspects of the academic environment which enhance or retard progress in higher degrees (Bowen and Rudenstine 1992; Moses 1991; Phillips ; Powles 1989a&b, 1991, 1993).

The present study and its methods

The present study of the APRA(I) Scheme is the first stage of a longitudinal project which will finish in 1995. It provides an opportunity to explore questions at the intersection of both sets of issues just mentioned - those specific to the university-industry interface and those concerning postgraduate education more broadly.

The diagram below schematises the plan for the longitudinal study of the APRA(I) Scheme which commenced in 1990, showing commencing cohorts and the number of years students would have been enrolled at the time of each survey. For the purposes of illustration a four year PhD candidature is assumed. The boxed section represents the present stage of the study: it indicates that the first survey [A] covers the 1990 cohort who were in their third year of study, the 1991 cohort in their second year and the 1992 cohort in their first year. At the end of 1993 or early in 1994, a second survey [B] will deal with the new commencers as well as those in the 1990 to 1992 cohorts who will have advanced one year in their enrolment. Some students, particularly those doing Masters degrees, will have completed. Those who finish will be also surveyed annually, beginning in 1993 (in the diagram, W represents workforce).

Figure 1: Plan of the longitudinal study

Commencing cohort	Number of years enrolled					Survey
1990	1					
1991	1	2				
1992	1	2	3			A
1993	1	2	3	4	W	B
1994	1	2	3	4	W	C
1995	1	2	3	4	W	D

Three questionnaires, for APRA(I) students and for each of the two supervisory partners were designed in four major sections.

Background information included: degree level (Masters or PhD); entry qualifications; demographic details – date of birth, sex, first language spoken; prior experience in industry; where and when qualifications were obtained; and reasons for undertaking higher degrees. A second section contained questions about the postgraduates' dual research environments such as: provision of facilities and resources; size and composition of research groups; ways in which the student's project fitted in with wider research activities of the university department and the immediate industry research group. A third section of the questionnaire sought information on the candidature itself: supervision arrangements; frequency and length of supervision sessions; time spent on campus and industry sites; satisfaction with various aspects of candidature, adapted to reflect the viewpoints of students and supervisors; problems known to impede progress that the student may have experienced in the year preceding the survey. A further section of the questionnaire sought participants' views on benefits and constraints on the Scheme in particular, and more generally, on areas where conflict of interest might arise during the partnership. The present paper

presents a selection of results mainly on the last-mentioned areas. A full report of the findings will appear in monograph form in late 1993.

As mentioned, the Scheme commenced in 1990. Numbers of Awards originally made available in 1990, 1991 and 1992 were 60, 80 and 104 respectively, totalling 244 for the three years. It was intended that all participants would be surveyed. However, it was found that not all Awards had been taken up. In some cases a suitable student could not be recruited; in others the project had been abandoned either through student attrition or through financial difficulty or bankruptcy of the company. All these cases were excluded from the study, the resulting denominators for calculating response rates becoming 226 student, 226 university, and 208 industry cases. The questionnaires were distributed before the start of the 1993 academic year. Non-respondents from the first round were sent another questionnaire with a reminder a month later.

All 30 higher education institutions participating in the Scheme are represented in the samples. The student and academic response rates were pleasing, at 77 per cent (173 cases) and 68 per cent (153 cases) respectively. A lower response – 47 per cent or 97 cases – was obtained from industry partners. No statistically significant differences were detected between the 1990, 1991 and 1992 cohorts on questions addressed in this paper so that all cases within each group are combined for analysis.

Characteristics of the APRA(I) students

APRA(I) students tended to be young, male, and native speakers of English: 72 per cent of respondents were 30 years of age or under; 75 per cent were male and 83 per cent were native speakers. These characteristics are fairly typical of full-time research students in the sciences and engineering in Australia and are also characteristics which, combined with location in those disciplines, favour timely completion of research degrees (Powles 1989a).

According to figures cited in the Smith Report, regular APRA students' previous qualifications were in 1989: first class honours bachelor 88 per cent; second class 1 per cent; Masters 8 per cent. APRA(I) students by contrast, tended to hold second class honours degrees (47 per cent) or Masters (19 per cent) as opposed to firsts (26 per cent) . In 7 per cent of cases students had been admitted on lower level qualifications. As demonstrated shortly, the distribution of qualifications in the sample was related to recruitment

difficulties that many academic supervisors reported. A high proportion -approximately three quarters of the sample - had had some prior contact or work experience with private sector companies. They also tended to be more mobile in pursuit of scholarships than their regular APRA peers: over 50 per cent had accepted their Award from a university other than the one from which they first graduated compared with approximately 40 per cent (ARC 1992). These findings are reflected in the high rating, by 88 per cent of the candidates, of 'scholarship availability' as an important factor in their decisions to undertake research degrees in the first place.

Otherwise, APRA(I) students' reasons for going on were typical of research students. Factors intrinsic to the research process - intellectual challenge and satisfaction - outweighed extrinsic motivational factors such as set career goals and anticipated status and income rewards. Fifty seven per cent of the respondents indicated that an important reason for going on was an aspiration to a research career in industry and 33 per cent said that they aspired to an academic career, points to be explored in more detail below.

Benefits of the Scheme to postgraduates, universities and industry

Although it must be recognised that the APRA(I) Scheme is only one initiative and currently only a small-scale one in the larger picture of university-industry liaisons, participants who offered general comments praised the Scheme highly. Postgraduates said, for example:

> 'I am very appreciative of the opportunity provided by my APRA(I) scholarship. It is my hope that my research findings will be of use not only to [my sponsoring company], but also to the various government agencies involved in education and employment.
>
> 'Overall, the program is an excellent one and a long overdue encouragement to break down the big gap between academia and industry in Australia.
>
> 'I have nothing but praise for the APRA(I) Scheme. Completing an honours degree I was offered two positions in my field. However, after being offered the APRA(I) there was no choice in my opinion. I have aspirations to a high level management career which I believe will be

greatly enhanced by the technical training provided by the scholarship. I strongly believe that academic knowledge will be important to the leaders of our country and private enterprise in the future'.

Another student had seen new developments arising from the link:

'A major benefit of the industry link has been significantly more industry / university interaction at various levels:
- university-run short courses for industry
- undergraduate thesis topics and support
- manufactured components for undergraduate research
- apprentice rotation schemes'.

Academic and industry supervisors were similarly positive:

'The Scheme is excellent and should be promoted more strongly in industry.

'The Scheme is a very effective inducement to industry/university collaboration and further provides an introduction to industry for students.

'The APRA(I) program is an ideal way of putting flesh on the rhetoric about university/industry cooperation ...'

Against the background of these comments, Award participants' reactions to a series of statements about the benefits of the Scheme and possible constraints upon its operation are analysed in Table 2.

All respondents were asked to indicate on a 5 - point scale the extent to which they agreed or disagreed with a series of statements. For present purposes, the first two and the last two scale points have been combined and statements which were intermixed have been re-classified, to be discussed separately in sections to follow.

Table 2 shows the extent of differences and similarities in agreement between partners about benefits of the APRA(I) Scheme. Just as most respondents who commented on the Scheme praised its merits, a large majority from each sub-sample were highly positive and measures of agreement differed significantly on only one item. Thus, students, academic

and industry supervisors mainly agreed that 'the Scheme provides an opportunity for students to obtain a research degree while working on a real-world problem' (78, 84 and 90 per cent respectively); that the link was likely to lead to further cooperation (82, 92 and 91 per cent); and that 'industry gains an enhanced image in the community through links with universities' (70, 84 and 75 per cent respectively). Large majorities of each group (72, 82, and 78 per cent) agreed that their projects would not have been viable without the Award. Eighty six per cent of both student and academic groups agreed that 'the Scheme provides a way for industry to acquire the benefits of research at low cost, whereas a significantly lower proportion (60 per cent) of industry respondents were inclined to agree.

Overall, then, all partners agreed to have gained by the introduction of the Scheme.

Research career prospects

Since the main purpose of the APRA(I) Scheme is to stimulate the supply of research-trained personnel to the labour force, and particularly to the private sector, several propositions on career prospects were put to all the Scheme's participants who were again asked the extent to which they agreed or disagreed. The results are shown in *Table 3*.

Fifty three per cent of candidates agreed that APRA(I) students were keen to make research careers in industry, and only 18 per cent disagreed, while 29 per cent gave a neutral response; 70 candidates, or 40 per cent of respondents in total said they did not know. Academic supervisors agreed to a slightly greater extent (57 per cent) regarding students' enthusiasm to take up industry careers while industry partners were far surer, and although the difference was not statistically significant, 70 per cent agreed with the proposition.

All three groups were fairly consistent in their agreement or disagreement that 'prospects are poor for research careers in industry' and responses were more evenly spread - respectively 44, 45, and 38 per cent of candidates, university and industry partners agreeing and 35, 34 and 42 per cent disagreeing. Again, industry supervisors appeared slightly more optimistic although the differences were not significant. However, significantly more students than their supervisors agreed with the proposition that 'most of the best research degree graduates in my field seek

employment overseas' (47 per cent compared with 30 and 22 per cent); the pattern was reversed among those who disagreed.

More respondents took the 'don't know' option than they did on questions about the benefits of the Scheme. The percentage distribution within each group of respondents who expressed an opinion are more even, perhaps as a result of the general nature of the questions, but equally may reflect a greater degree of uncertainty about career prospects.

Although these results are not conclusive, the apparent degree of uncertainty about research careers in Australia amongst the Scheme participants is an important policy issue to be taken up in the concluding section of this paper.

Recruitment and selection

One peculiarity of the APRA(I) scheme should be reiterated at this point: recruitment and selection are more distinct processes than is the case for other research degree scholarships where graduates apply to a university, are selected exclusively in order of academic merit and are highly unlikely to be successful without a first class degree. But APRA(I) projects are pre-defined by the academic and industry partners in a proposal which is judged successful or not according its quality. An Award is therefore granted for a project, whereupon a postgraduate needs to be found to undertake it. In some instances only one student will be found who is suitable for or suited to the project and is therefore recruited rather than selected. In other cases selection takes place amongst a number of qualified scholarship applicants.

Academic and industry partners were asked about these processes in an open-ended question and candidates were asked how the first heard about the Scheme. Their responses are collated in *Table 4*.

Marked differences between academic and industry partners' descriptions of the recruitment process are immediately noticeable. Industry partners said that head-hunting was far more common than advertising. They also often indicated that they were not involved in recruitment and had left that – as well as the selection process – up to the university. The discrepancies between the figures may thus reflect ignorance on the part of some company respondents as to what was actually going on.

According to the academic partners, advertising the project and the Award, either in national or state newspapers or within the institution was

the most common form of inviting applications: 58 per cent had found students, and 56 per cent of students said they had first heard about the Scheme by this means.

Academic respondents often wrote that selection amongst more than one applicant was conducted by interview (either with or without the industry partner) with perceived research potential and highest qualifications being the major criteria for selection. Industry experience was also taken into account in many instances. It seemed from such descriptions that the best person for the job was selected, not necessarily the most highly qualified. As one academic partner commented:

> 'It is a good opportunity to involve a more 'practical', less exam-orientated student, in research. Other APRAs are too selective at present to be awarded to such students who are in general useful employees for industrial research. I hope there will be positions in industry for the people so trained.'

The table also indicates that APRA(I)s were not always advertised. Twenty five per cent of academic partners actively sought applicants from previous years' honours or Masters graduates (several were already enrolled in Masters degrees); 27 per cent of students had first heard about the scheme from academic staff.

Eight out of the 25 academics who provided comments on issues raised in the questionnaire alluded to this difficulty, reporting that recruitment had been a protracted and difficult process, and that some students who had been head-hunted in this way would not have been their choice had they the opportunity to select. In fact, a number of projects had been abandoned, or the Award had been postponed until the next year for lack of suitable recruits.

Supervisors' comments about recruitment ran along the following lines:

> 'In implementing this APRA(I), our most serious concern has proved to be finding a suitable student. Out own graduates are far more interested in industry employment than in honours or research study, and still see research to be divorced from the industry. There is a perspective that graduate qualifications will help their employability, but that research will not.

'It has proved difficult to fill a second APRA(I) scholarship recently granted by the hand-picking procedure which was so successful with the first award and general advertisements will be needed. However any one of 10 ideally qualified persons from overseas who have enquired re positions would be available immediately but for the Australian citizen/two year permanent resident constraint'.

This last point will be taken up a little later.

Nevertheless, despite recruitment problems, Table 4 does indicate that other supervisory partners were more fortunate to have a company staff member able to take up the Award. In four cases it was reported that students had actually initiated the project themselves, and had organised academic and industry partners to apply for the Award.

Other comments on difficulties of attracting suitable applicants, however, were to do with timing of applications. This has remained a problem since the Scheme's inception.

'I think the timing of the award announcements is critical in the ability to attract top-class candidates. If the results could be announced earlier each year, there would be adequate time for

(i) Industry to determine if they have any internal candidates,

(ii) If not, university to advertise widely [earlier] to attract best possible research students. At the moment, many APRA(I) adverts appear after the top students have been 'signed up' for APRAs.

'... we are concerned about the difficulties in attracting good first class students as APRA(I) awards are announced too late. It should be possible to adjust the time schedule to coincide with the June to August round of postgraduate enquiries'.

Table 5 shows the extent to which the Scheme's participants agreed or disagreed with some general statements on recruitment. Those who opted for a 'don't know' response are shown in the table but are excluded from the calculations. A fairly consistent proportion of respondents - fluctuating around 25 per cent - neither agreed nor disagreed with most of the items.

In view of the comments on recruitment difficulties cited above and the fact that the universities played the major role in selection, it was not

surprising to find a significant proportion (59 per cent) agreeing that 'appropriate APRA(I) students are hard to find' and only 25 per cent disagreeing. Candidates and industry supervisors were slightly less concerned: respectively, 38 and 43 per cent agreed and 37 and 36 per cent disagreed. Some possible explanations are sought in the remainder of Table 4.

Analysis of the next two items indicates that promotion of the Scheme could be improved. Only 27 per cent of students compared with 56 and 53 per cent of academic and industry supervisors respectively agreed that the Scheme was promoted effectively in universities. More industry partners were unaware whether the Scheme was well promoted in universities. Similarly, many higher education participants did not know about the effectiveness of its promotion in the private sector, but a majority of each sub-sample thought this not to be the case (65 per cent of candidates, 66 per cent of academics and 58 per cent of industry partners).

Academic staff were significantly more likely than students or company supervisors to agree that the labour market attracted the best first degree graduates (41 per cent compared with only 19 and 28 per cent respectively). Slightly more of each sub-sample (around 40 per cent) were inclined to agree than disagree that income from employment was more attractive than the Award stipend. Whereas these factors might be considered to be impediments to attracting students, the 'prestige' of the APRA(I) was generally not: just under 50 per cent of each group agreed that the APRA(I) carried more prestige than the normal APRA, around 30 per cent neither agreed nor disagreed and only approximately 20 per cent disagreed. Differences between the three sub-samples were not significant.

It was suggested earlier that a possible solution to attracting larger numbers of suitable applicants is to waive the Australian citizenship/two year residency requirement. This proposition was put to the Scheme's participants. Only 13 per cent of candidates agreed with the statement compared with 49 per cent of academics and 36 per cent of company staff; a highly significant 75 per cent of the students disagreed compared with 39 per cent of university, and 50 per cent of industry, supervisors. Their replies indicate that this is a contentious issue, one upon which more definite and divergent opinions were expressed than on other items in the table. This issue is an extension of the current debate on excess demand on higher education places by qualified Australian citizens while marketing of courses overseas proceeds apace.

Together the above findings indicate that recruitment is considered to be a common problem and that a range of issues will need to be addressed before the problem is alleviated - including promotion of the Scheme, stipend value, citizenship regulations, and finding ways to persuade more high-achieving honours graduates to undertake research degrees.

Conflict of interests

Table 6 shows a selection of statements on previously identified areas where conflicts may arise between the Scheme's participants. Again, the extent of their agreement or disagreement is recorded.

As already mentioned, academic and industry partnerships can be marred by 'cultural' differences in approaches to research, the nature and scope of projects and time frames for producing results. Postgraduates may need to negotiate differences between supervisory partners for if they are left unresolved, the research can only suffer. The first three items in Table 6 refer to the nature and scope of projects undertaken jointly by universities and industry.

Only small variations in opinion were apparent between groups on the statement, 'curiosity-driven research programs are being curtailed by universities' need to bring in external funds for pre-defined projects.' Over 70 per cent agreed and only around 10 per cent disagreed. This represents a significant change in the research climate of universities, and clearly recognised by industry. While industry funding might be welcome at a time of declining public funding, should this state of affairs be regarded as a threat to the integrity of scientific enquiry or has the nature of scientific enquiry itself changed as a result of economic compromise? In this context it is noteworthy that significantly higher proportions of student and academic respondents (50 and 44 per cent respectively) than industry partners(18 per cent) agreed that 'the short-term pragmatism of industry reduces the chances of making discoveries of long-term benefit'. The percentages of each group disagreeing were 26, 39 and 65 per cent respectively. There was little difference in the distribution of responses to the proposition that 'industry tends to encourage universities to undertake projects that are narrow in scope': around 45 per cent of each group agreed and approximately 30 per cent disagreed. These results also raise the question about the nature of the research degree. As one academic noted:

'There is some conflict between what industry requires as a result of the cooperation and the work required for a PhD which is supposed to make a significant contribution to knowledge. Industry must realise that such a project is for long-term benefit, not short-term profit. Australian industry on the whole sees research more in terms of problem-solving or trouble shooting'.

An industry partner also commented:

'Our few years' experience with the APRA(I) seems to indicate that the requirements for achieving a PhD can be at odds with the objectives of the project'.

Mismatches in perceptions

The last three items in *Table 6* show several significant areas of disagreement between the candidates and their supervisors which had to do with travel and the joint supervisory arrangement. The item on travel was included as it was clear from the survey address lists that some students would have needed to travel long distances, sometimes interstate, between their universities and sponsoring companies. In some cases, multiple sites were involved.

Students were significantly more inclined to agree that travel between sites was onerous (31 per cent) than were their supervisors (only 16 per cent in each group agreeing). If we assume that these students were speaking from their own experience, then travel is a problem for around one third of the sample, a problem to some extent unrecognised by supervisors. Sixty five per cent of industry partners disagreed that travel between sites was onerous for students compared with 44 per cent of the candidates themselves. Similar patterns of differences in agreement emerged on the questions of joint supervision and conflict arising when projects have overlapped. While these were clearly unproblematic in the opinion of the majority of each group, significantly more students than their supervisors agreed that joint supervision poses problems (30 per cent compared with only 16 and 4 per cent of supervisors respectively) and again significantly more students agreed that territorial disputes had arisen (22, 6 and 12 per cent respectively).

These findings are chosen to illustrate common mismatches in

perceptions between candidates and their supervisors. If students become dissatisfied while supervisors thing things are running smoothly, protracted candidature and dropout can result. The longitudinal study will explore in detail aspects of supervision and the more complicated conditions under which APRA(I) students work.

Intellectual property

When applying for an award under the Scheme, the academic and industry partners must stipulate what agreement has been reached in regard to intellectual property (IP). An examination of the original application forms revealed a variety of agreements ranging from the highly formal and detailed to the vague. Rarely was the status of the postgraduate mentioned. Items were included in the questionnaires in order to compare participants' views on aspects of IP and to clarify the postgraduate position.

Table 7 shows that significantly more supervisors (69 per cent of the academics and 64 per cent of the industry supervisors) agreed that the IP agreement posed few problems than did their students (49 per cent). It is noteworthy that 29 per cent of the students, 16 per cent of the academics and 24 of industry respondents disagreed withe the statement. A large number of students did not know whether problems existed or not and a similarly large group did not know whether their institution had clear IP policies. A majority of each group agreed that IP policies were in place (60, 70 and 73 per cent of students, academics and industry staff respectively) while smaller, but also noteworthy proportions disagreed (22, 15 and 9 per cent respectively). An approximately equal majority of each group of respondents (65, 65 and 69 per cent) agreed that it was necessary to withhold information at conferences in the interests of the proprietary position, while significantly more students (70 per cent) agreed that industry's confidentiality requirements were in conflict with academics' desire to communicate research results compared with 51 per cent of the university and 51 per cent of the industry respondents. In *Table 8*, a large majority of each group thought that postgraduates should be treated in the same manner as academic staff in regard to IP and the postgraduates were significantly more likely to agree (89 per cent cf 72 and 76 per cent). They were also more than twice as likely as their supervisors to agree that IP restrictions hamper the acknowledgment that students should receive for their work (53 per cent cf 26 and 24 per cent); 42 per cent of

students compared with 30 and 23 per cent of academic and industry respondents respectively disagreed that restrictions on public release of theses would not affect career advancement.

Several clear messages can be derived from these findings. First, IP requirements governing APRA(I) projects are often more problematic for students than the academic and industry partners. Secondly, there remains a fair degree of ignorance amongst the students about IP and its implications for them. Thirdly, it is apparent that IP need not necessarily be a contentious issue, many of the comments that respondents provided indicated that appropriate compromises had been made particularly when university and company policies were flexible enough to allow projects to be considered on a case-by case basis. Other respondents were experiencing difficulties:

> 'We are having major problems with IP. The company is claiming all rights, the university is claiming all rights, the [State] Department is claiming all rights. It seems to me that the research workers are the ones without any rights.
>
> 'IP is undoubtedly the most difficult area in the collaborative program'.

Conclusions

Under the Australian Postgraduate Awards (Industry) Scheme, in operation since 1990, postgraduates provide a strengthening link between universities and industry. Results from the study of the Scheme reported here indicate that it is highly valued by its participants. Students, academic and industry partners concur that the Scheme provides opportunities for students to undertake research of industrial relevance while working towards a higher degree, research that the partners mainly agree would not have been viable otherwise. The partners were also highly optimistic that further cooperative ventures would result from the liaison.

It therefore augers well that the Scheme seems to be fulfilling one of its purposes which is to enhance collaboration between universities and industry. Its desired outcome of increasing the supply of research workers to Australian industry, however, may be confounded by uncertainties about the availability of research career paths in a country whose record in private sector research has been poor by international comparison, and the

consequent likelihood that a proportion of APRA(I) graduates will join the annual overseas exodus of research degree holders. Academic careers may be available as an alternative, particularly in fields which are currently experiencing recruitment difficulties (Sloan et al 1991), but the erosion of academic salaries and less stable but more demanding conditions of work may make that alternative seem unattractive (McInnis 1992). These possibilities must be kept high on the Australian research policy agenda as students will often make career decisions based on immediate perceptions of the research labour market. There is therefore no cause for complacency - despite deregulation of academic salaries and the recent upturn in private sector research activity which has occurred mainly as a result of the 150 per cent tax deduction for R&D, and other recent government schemes to encourage collaboration (Beazley 1992).

The benefits of the Scheme which this study has identified should motivate the Government and the participants to address problem areas.

The results presented in this paper suggest that the Scheme might be better promoted by Government, particularly in the private sector, if it intends to advance the idea of collaboration beyond the people already involved. Better promotion may also go some way to alleviating the perceived problem of increasing the pool of suitable students. But here, the university departments and individual academics also have a part to play, perhaps by identifying and actively encouraging students with research potential earlier in their undergraduate years to consider the range of postgraduate degree options and the benefits of research careers.

On the other hand, selection of students to undertake research degrees, particularly PhDs, is a perennial question in graduate education and one which is equally pertinent in the context of the APRA(I) Scheme. At present, Award students with first class honours bachelor degrees are a minority and often prior industry experience is taken into account in selection. Despite already cited references to the probability that high grades do not necessarily guarantee successful candidature, and that first class candidates do not necessarily make the best research workers, the impression gained from many of the academic partners was that they would prefer to recruit the highest undergraduate achievers. An important issue requiring future attention is therefore whether selection criteria will change if the Scheme becomes more competitive: currently, the Scheme has the capacity for selecting the best person for the job, not just the most highly credentialled.

Seferis and Williams (1984) have identified possible difficulties arising

from 'the imposition of a highly specific industry-sponsored research program on a university structure characterised by a more expansive and less specialised approach to graduate training and research.' Noteworthy proportions of respondents in the present study have confirmed the shift away from basic research as industry funding is increasingly sought at a time of declining public support. They concede the often narrow scope and short timelines for producing results in collaborative projects. Some have raised the question of tension between what industry requires as a result of the cooperation and the nature of the PhD in which 'students need to make mistakes, move down and out of unproductive pathways and take time to master different facets of the subject (by which) process they acquire both the technical skills and the judgement required for a career in research.' (Clarke 1986)

The issues identified here will be explored as the study of the Scheme enters its next phases. What is clear at this stage is that graduate students working at the interface between academia and industry are in the difficult situation of having to bridge the two cultures and to negotiate two different modes of professional socialisation. Convivial research environments, informed supervisory practice, clear expectations and effective communication between supervisors and students - all critical elements in traditional university-based research education and training - are all the more complex in the three-way relationship. In these matters as well as those peculiar to the collaborative arrangement such as intellectual property, as Bailey (1990) emphasises, the more the partners can get together to ease misunderstandings and to demonstrate sensitivity to the needs of others in the group, the more can be achieved in their own and each other's interest.

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Table 1

Benefits of the Cooperative Research Relationship	Constraints on the Cooperative Research Relationship
Universities	
• Acquaintance with the market place and innovation process	• Inhibition of unfettered choice on research direction
• Research on 'real-world' problems	• Redirection of basic research towards more applied and development programs
• Access to more technical and physical resources	• Suspicion of exploitation of university resources for private benefit
• Additional resources for funding research	• Time constraints on research projects antagonistic to long-term research approaches
• Reinforces autonomy by diversifying funding sources	• Perceived lack of career paths in industry research
• Enhanced graduate employment opportunities	• Funding uncertainty makes long-term planning difficult
• Supplemental income for individuals	• Inadequate appreciation by industry of nature and norms of academic work
• Less paperwork and administrative burdens compared with direct government funding	• Commercial confidentiality conflicts with academic ethos of open publication and widespread dissemination
• Enhanced public credibility for service to society and contribution to economic development	• Research distorted by profit motive
Industry	
• Acquaints research students with industrial research environment	• Loss of some control over a proprietary position
• Access to expert labour force	• Doubts about relevance of university research to industrial problems
• Source of new skills and techniques for research/access to technology	• Lack of appreciation of time scales and norms of industry research
• More efficient exploration of new directions in research	• Suspicion that industry is being exploited to alleviate universities financial burdens
• Increased access to peer review	
• Enhancement of public credibility through association with universities	

Sources: National Commission on Research (1980); Cerych (1985); Blackman and Segal (1992); Fairweather (1992); Business-Higher Education Round Table (1991,92)

Table 2 Benefits of the Scheme: differences and similarities of agreement between postgraduates and academic and industry supervisors

		Student %	Univ %	Industry %	Chi sq. Sig
• The Scheme provides an opportunity for students to obtain a research degree by working on a real-world problem	Agree	78	84	90	
	Neither	13	10	6	ns
	Disagree	10	6	4	
	n	169	131	83	
	Don't know	4	15	3	
• The present project would not have been viable without the APRA(I)	Agree	72	82	78	
	Neither	10	10	9	ns
	Disagree	18	8	13	
	n	160	131	78	
	Don't know	13	15	8	
• The APRA(I) link is likely to lead to future industry-university co-operative research ventures	Agree	82	92	91	
	Neither	14	6	9	ns
	Disagree	4	2	0	
	n	155	127	81	
	Don't know	18	19	5	
• Industry gains an enhanced image in the community through its links with universities	Agree	70	84	75	
	Neither	23	14	21	ns
	Disagree	7	3	4	
	n	159	118	80	
	Don't know	14	28	6	
• The Scheme provides a way for industry to acquire the benefits of university research at low cost	Agree	86*	86*	60	
	Neither	9	8	24	p<.001
	Disagree	5	6	16**	
	n	165	130	83	
	Don't know	8	16	3	

Notes:
(a) *p<.05, **p<.01, ***p<.001 based on chi square and standardised adjusted residuals.

(b) Responses to each item were elicited on a 5-point scale from 1 = strongly agree to 5 = strongly disagree. The first two and the last two points have been combined.

(c) The 'don't' know' option which was provided as an alternative to the scale is shown but has been excluded from calculations. One response to this group of questions was requested from supervisors with more than one student, leaving N for universities and industry at 146 and 86 respectively.

Table 3 Research career prospects: differences of agreement between postgraduates and academic and industry supervisors

		Student %	Univ %	Industry %	Chi sq sig
• Prospects are poor for research careers in industry	Agree	44	45	38	
	Neither	21	21	20	ns
	Disagree	35	34	42	
	n	157	130	82	
	Don't know	16	16	4	
• APRA(I) students are keen to make research careers in industry	Agree	53	57	70	
	Neither	29	33	24	ns
	Disagree	18	10	6	
	n	103	98	50	
	Don't know	70	48	36	
• Most of the best research degree graduates in my field seek employment overseas	Agree	47**	30	22	
	Neither	21	23	31	p<.05
	Disagree	33	47	47	
	n	112	115	62	
	Don't know	61	40	24	

See notes to Table 2

Table 4 **How students found out about Awards and how academic and industry partners said they were recruited, collated responses.**

	Students %	University %	Industry %
From previous honours/Masters cohort		25	74
Honours/masters supervisor	15		
Current supervisor if different from above	12		
Advertisement	36	58	15
Internal university publicity	20		
Student initiated	3	3	1
Company staff member or through company	5	9	7
Word of mouth	6		
Other (head-hunted n/s)	4	5	3
n	162	147	95
Missing n	11	6	2

Table 5 Recruitment issues: differences of agreement between postgraduates and academic and industry supervisors

		Student %	Univ %	Industry %	Chi sq sig
• Appropriate APRA(I) students are hard to find	Agree	38	59**	43	p<.05
	Neither	25	23	22	
	Disagree	37	18	36	
	n	94	128	73	
	Don't know	79	18	13	
• The Scheme is promoted effectively in universities	Agree	27	56***	53	p<.001
	Neither	29	20	24	
	Disagree	45***	25	22	
	n	136	128	45	
	Don't know	37	18	41	
• The Scheme is promoted effectively in the private sector	Agree	14	9	22	ns
	Neither	22	24	20	
	Disagree	65	66	58	
	n	74	87	69	
	Don't know	99	59	17	
• The best students take jobs rather than research degrees	Agree	19	41**	28	p<.01
	Neither	29	20	28	
	Disagree	53*	39	44	
	n	146	125	78	
	Don't know	27	21	8	
• The APRA(I) carries more prestige than the normal APRA	Agree	48	47	47	ns
	Neither	31	25	32	
	Disagree	22	28	21	
	n	121	110	38	
	Don't know	52	36	48	
• The stipend is too low compared with income from a job to be attractive	Agree	43	39	36	ns
	Neither	23	27	30	
	Disagree	34	34	34	
	n	169	131	76	
	Don't know	4	15	10	

• Australian residency requirements should be waived when a non-resident student is the best person for the project	Agree	13	49***	36	
	Neither	12	12	14	p<.001
	Disagree	75***	39	50	
	n	142	126	78	
	Don't know	31	20	8	

See notes to Table 2

Table 6 **Constraints on the Scheme: differences of agreement and disagreement between postgraduates and university and industry supervisors**

		Student %	Univ %	Industry %	Chi sq sig.
• Industry tends to encourage universities to tackle problems that are narrow in scope	Agree	43	47	46	
	Neither	30	24	20	ns
	Disagree	27	29	35	
	n	153	127	77	
	Don't know	20	19	9	
• Curiosity-driven research programs are being curtailed by universities' need to bring in external funds for pre-defined projects	Agree	74	76	79	
	Neither	17	10	14	ns
	Disagree	8	14	7	
	n	147	128	72	
	Don't know	26	18	14	
• The short-term pragmatism of industry reduces the chances of making discoveries of long-term benefit	Agree	50**	44*	18	
	Neither	24	17	18	p<.001
	Disagree	26	39	65***	
	n	159	127	79	
	Don't know	14	19	7	
• Students find travel between sites onerous	Agree	31*	16	16	
	Neither	26	36*	19	p<.01
	Disagree	44	49	65*	
	n	85	86	53	
	Don't know	88	60	23	
• Joint supervision poses problems for APRA(I) students	Agree	30***	16	4	
	Neither	17	22	19	p<.05
	Disagree	53	62	68	
	n	151	130	81	
	Don't know	22	16	5	
• Conflict has arisen when students' projects have overlapped	Agree	22**	6	12	
	Neither	27	17	14	p<.01
	Disagree	51	77*	75	
	n	78	101	51	
	Don't know	95	45	35	

See notes to Table 2

Table 7 **Intellectual property policy issues: differences of agreement and disagreement between postgraduates and university and industry supervisors**

		Student %	Univ %	Industry %	Chi sq sig
• The intellectual property agreement covering the APRA(I) poses few problems for any of the parties	Agree	49	69*	64	
	Neither	22*	15	12	p<.05
	Disagree	29*	16	24	
	n	118	124	78	
	Don't know	65	22	8	
• My institution/company has clear policies on intellectual property in relation to university/industry links	Agree	60	70	73	
	Neither	18	15	19	ns
	Disagree	22	15	9	
	n	116	125	80	
	Don't know	57	21	6	
• Industry's commercial-in confidence requirements are in conflict with academics' desire to communicate research results	Agree	70**	51	51	
	Neither	16	29*	25	p<.01
	Disagree	15	21	24	
	n	154	129	80	
	Don't know	19	17	6	
• At conferences it is necessary to withhold some information in the interests of industry	Agree	65	65	69	
	Neither	17	22	17	ns
	Disagree	18	13	15	
	n	150	127	83	
	Don't know	23	19	3	

See notes to Table 2

Table 8 **Effects of intellectual property restrictions on postgraduates: differences and similarities of agreement between postgraduates and university and industry supervisors**

		Student %	Univ %	Industry %	Chi sq sig
• Intellectual property restrictions hamper the acknowledgment students should receive for their contribution to knowledge	Agree	53***	26	24	
	Neither	28	30	21	p<.001
	Disagree	19	44*	53***	
	n	145	125	76	
	Don't know	42	11	10	
• Restrictions on release of the thesis and related publications does *not* affect APRA(I) holders' career advancement	Agree	41	48	65***	
	Neither	17	22	12	p<.01
	Disagree	42**	30	23	
	n	124	112	74	
	Don't know	49	24	12	
• Postgraduates should be treated the same manner as academic staff in regard to intellectual property	Agree	89***	72	76	
	Neither	9	15	11	p<.01
	Disagree	2	13	13	
	n	150	123	71	
	Don't know	23	23	15	

See notes to Table 2

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