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The Research Training Experiences of Doctoral Students Related to Australian Cooperative Research Centres

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Abstract. This paper reports on the research training experiences of Australian doctoral students working in or funded by Cooperative Research Centres (CRCs), notes how their levels of satisfaction compare with those of their counterparts in regular university science and technology disciplines and assesses to what extent the CRC program is achieving its hopes with respect to PhD training. Findings are based on data from a survey of all enrolled PhD students in two research-intensive universities in Australia, together with supplementary data from student and supervisor interviews. Findings indicate that in the main, CRC-related PhD students fare well compared with their counterparts in regular university departments and that on a number of indicators CRC-related students recorded higher levels of satisfaction with their course experience. This situation suggests that CRCs are playing a significant and worthwhile role in research training in Australia.

Keywords: research training, doctoral students, university-industry links, Mode 2 organisations, research investment

Introduction

Australia, like other developed nations, views research as a key to success in the global knowledge economy and innovation as a key to prosperity. Seen as particularly important are reaping the benefits of research by transforming knowledge and technology into commercially useable form, turning ideas and inventions into income and jobs for Australians and creating better career opportunities for Australia's best researchers (Kemp 1999, p. iv; AusIndustry 2001, p. ii). Government investment in research training is thus a priority.

The CRC program is playing an important role in this vision with its emphasis on generating new and innovative ideas through long-term strategic research, developing skills in researchers and businesses, utilising research-based knowledge via technology transfer or by turning ideas and skills into commercial

success (AusIndustry 2001, p. ii). In this context, research training, particularly PhD training, is a priority (Kemp 1999, p. 1).

From their inception in 1991 CRCs have been involved in PhD training. In order to establish a CRC, bidders must meet the selection criterion that demands a well developed education and training program that 'will demonstrably enhance the employment, prosperity and value of the graduates…in the industry and user environment' (AusIndustry 2001, p. 6). Because of their training focus each CRC must have a university as a core partner. A particular hope expressed by some leaders associated with the program is that one of the most important contributions of CRCs will be in research training, particularly developing in students more favourable attitudes to university-industry collaboration in R&D and more favourable orientations towards careers in industry.

In 2000 the total number of postgraduates in CRCs was almost 1,850 students (AusIndustry 2000, various pp.). Most doctoral students linked to CRCs are full-time and supported by industry-based scholarships. They are aware of the high priority placed on education and training for meeting the particular needs of industry, especially those in fields such as engineering which have had long associations with industry. In most cases PhD students in CRCs are supervised jointly by researchers in universities, industry or government research laboratories.

Key questions addressed in this paper revolve around the extent to which the CRC program is achieving its hopes with respect to PhD training. Are PhD students in or funded by CRCs more or less satisfied with their courses than other science and technology doctoral students, especially with regard to the quality and effectiveness of supervision, the expertise of their supervisors, their access to specialised equipment and facilities, support for their projects, and access to specialised library materials? Do CRC-related PhD students have more positive attitudes towards industry and R&D partnerships with industry than their regular science and technology PhD counterparts, and are they more favourably disposed to the idea of considering careers in industry?

Data collection and sample

Findings reported here are based on questionnaire responses from a survey of all enrolled PhD students in two research-intensive universities, one in Sydney and the other in Melbourne. Supplementary data were gathered from student and supervisor in-depth interviews at these two universities. The descriptive survey involved distributing 3750 questionnaires in the latter part of the year 2000 via PhD/Graduate Studies offices and with support from senior management in both universities. Interviews were carried out in May and June 2001. An overall response rate from the questionnaire of 41% was achieved which provided a suitably large sample to examine (N=1549). From this cohort of respondents 198 PhD students (18.4%) indicated that they either carried out research in a CRC (6.5%) or that one or more of their supervisors

carried out research in a CRC (11.9%). These are referred to as CRC-related doctoral students. Demographic, enrolment, disciplinary, employment and funding details comparing CRC-related students with their non CRC-related counterparts in the larger cohort of respondents are provided in Table 1.

Table 1
Key characteristics of CRC-related students and other doctoral students (Percentages)

Variable	CRC-related Students (N=198)	Non CRC-related students (N=1351)
Gender		
Male	51.0	46.1
Female	49.0	53.9
Age		
Under 30	46.7	40.2
30-39 years	35.0	33.0
40-49 years	13.2	18.1
50 years and over	5.1	8.7
Language & International Status		
First Language English	72.2	79.0
International Student	14.6	9.9
Enrolment		
Full-time	79.2	68.0
Part-time on-campus	8.1	21.8
Part-time off campus	12.7	10.3
Years of PhD Enrolment		
Less than 1 year	29.3	19.7
1-3 years	41.4	46.3
3-5 years	24.7	26.4
5 years or more	4.5	7.6
Discipline		
Agriculture/Animal Science	4.5	1.9
Architecture/Building	1.0	1.9
Arts, Humanities and Social Sciences	8.1	24.9
Business, Administration, Economics	2.5	5.6
Education	3.0	6.7
Engineering/Surveying	23.7	10.2
Health/Medicine	25.8	21.1
Science	27.3	21.9
Veterinary Science	--	1.0
Other	4.0	4.7
Employment		
Full-time	17.3	23.5
Part-time	46.7	48.7
Percentage of full-time students without scholarship	9.7	13.1

Of the CRC-related cohort there was a marginally higher percentage of males (51%) than females (49%), the largest proportion (46.7%) were under 30 years, 14.6% were from overseas, 79.2% were full-time, 12.7% were part-time off campus, the highest proportion (41.4%) were enrolled between 1-3 years, around 25% on average were in the science and technology (S&T) areas of engineering, health/medicine and science, 46.7% were employed part-time, and only 9.7% of full-time students did not hold a scholarship.

The biggest differences between the two cohorts appeared in the areas of enrolment status and disciplinary affiliation. For the non CRC-related cohort, 32.1% indicated that they were enrolled part-time as opposed to 20.8% of CRC-related students. Discipline affiliation indicated that 37.2% of non CRC-related respondents were non-science based, while CRC-related students indicated only 13.6% were non-science. While the disciplines of health/medicine and other sciences attracted on average around 21.5%, engineering showed up a greater differential between the cohorts—it attracted 23.7% of PhD students related to CRCs but only 10.2% outside CRCs.

One important limitation imposed on findings reported here concerns the nature of the interview data. Most of those interviewed were full-time students which means that discussion pertaining to interviewees throughout concentrates mainly on this group.

The CRC program

The CRC program was established just over a decade ago as a government initiative. It is only one program among a number designed to enhance university-industry collaborative research initiatives. From the outset CRC structures were largely influenced by overseas user-driven models of collaborative industry-R&D research centres, in particular the Network of Centers of Excellence in Canada, the Interdisciplinary Research Centres in the UK and the National Science Foundation Industry-University Cooperative Research Centres in the US. A key aim of the Australian CRC development in linking research organisations, industry and a range of research users in the innovation chain is to build on current initiatives, improve business-research links, encourage spin-off opportunities and develop a stronger commercialisation skills-base. Consequently, there is the need to train researchers in skills required to commercialise research and produce innovative business outcomes (PMSEIC 2001, p. 3; Commonwealth of Australia 2001a, p.18). The program's recent substantial boost in additional funding reflects the Government's strong commitment to these aims.

The Centres are multi-site and are based in about 50 locations around Australia. Over 60 CRCs operate currently in the fields of manufacturing and technology, mining and energy, information and communications technology, agriculture and rural-based manufacturing, the environment and medical technology. Winning a bid to establish a CRC is certainly a coveted prize for any Australian university. Competition is fierce, there is stringent peer review and selection criteria are rigorous.

Government investment in the CRC program is substantial with over $140m of government funds committed per year with an additional 80% increase provided over the next five years by the *Backing Australia's Ability* policy (Commonwealth of Australia 2001b, p.1). Extra funding comes from industry,

state governments and other research partners. In all, industry has committed around 20% of CRC total resources (AusIndustry 2001, p. ii).

The program is not only acknowledged in many quarters for being highly successful in contributing to the Australian R&D innovation system, but has had strong support from both the current Government and its opposition Labor Party. Performance is monitored via annual reports and a process of second and fifth year reviews and since their inception many of the CRCs have received highly favourable reports as part of their required external reviews. Benefits to Australia from the program to date have been estimated close to $1.5 billion (Commonwealth of Australia 2001b, p. 1).

Because CRCs are based in universities and carry out both long-term basic and short-term strategic research, they would fit somewhere between the Gibbons et al (1994) 'Mode 1' (university-based) and 'Mode 2' (outside universities) frameworks for organising knowledge. Organisationally, Mode 2 units help to stretch the 'core' university into the 'distributed' or 'peripheral' university where traditional boundaries are transcended and where knowledge is more user focussed (Scott 1997, pp. 11-14 cited in Clark 1998, p. 139).

From their beginnings and in line with business practice of industry, managerial cultures have dominated CRCs. Thus for many researchers who are located there, managed (or program) research is now the norm and research has changed from being traditionally 'bottom-up' and curiosity-driven to a greater concentration on collaborative, multi-disciplinary and commercially oriented research that will produce knowledge and technology of value and applicability to potential users. Consequently, CRC researchers span the boundaries of academe, industry and the market, each with different sets of reward criteria and different meanings of work (Slaughter 1991; Lee and Gaertner 1994; Turpin and Hill 1995). In this situation they often need to juggle a number of conflicting norms and values that underscore their different worlds of work. How satisfied students are within and transcending these diffuse boundaries during their doctoral candidature is a question well worth examining.

Levels of satisfaction with course experience

In the ministerial policy document, *Knowledge and Innovation* (Kemp, 1999: 2), a number of deficiencies in university research training in Australia are reported. An issue singled out for special attention relates to student and employer dissatisfaction with research training:

> Significantly, there was agreement that perceptions of student and employer dissatisfaction with the quality of research training ought to be specifically addressed, together with a willingness to work with industry to achieve improvements in this area… (Kemp, 1999: 2)

It seems axiomatic that high levels of student satisfaction with their course, including the quality of supervision and level of support they receive, will likely engender more positive attitudes towards a research

career particularly in university research, research in industry or R&D in other research-specific agencies. Conversely, poor experiences could well lead to negative attitudes to research and graduates not opting for a research career which in turn could lead to a substantial wastage of talent and ultimately to a poor return on national investment in research training. As the Australian government is to invest substantially more in research training it wants to be assured of the quality of the research training experience indicated by higher levels of satisfaction from both student and employer groups.

While the data reported here did not deal with employers' perceptions, from the student responses both positive and worrying trends regarding satisfaction levels with their course experience emerged as indicated in Table 2.

Table 2
Ratings of particular course aspects as very satisfactory or satisfactory by source of research funding (percentages)

	CRC-related (N=198)	**Non CRC-related (N=1351)**
Overall experience as a PhD student	59.0	56.2
Access to specialised equipment, computers etc	63.6	51.3
Working space available	55.8	48.7
Availability of library holdings and library services	76.3	67.9
Quality and effectiveness of supervision	60.6	61.5
Suitability of research topic to produce a good thesis	67.2	76.7
Competence of supervisor(s) in your area	74.2	71.0
Intellectual environment of your dept/research centre	61.1	57.9
Interpersonal skills of your supervisor	68.2	65.6
Help provided in designing your project	55.6	52.3
Financial support for your project	58.6	47.0

A particular worry is that overall experience as a PhD student did not rate highly with either cohort. Only 59% of CRC-related students and 56.2% of non CRC-related students indicated that they were satisfied or very satisfied with their course experience.

Another concern is that quality and effectiveness of supervision was not rated more highly. Only 67.2% of CRC-related and 61.5% of non CRC-related students expressed satisfaction. Both of these concerns are consistent with what was reported in the 1999 ministerial policy document. Satisfaction with levels of financial support are rated more highly by CRC-related students with nearly 60% expressing satisfaction (note levels of financial support in Table 7). However, only 47% of non CRC-related students expressed satisfaction which leaves the majority of this cohort dissatisfied with levels of financial support. The higher levels of satisfaction indicated by CRC-related students are consistent with CRCs being well resourced.

Access to and ability to purchase specialist equipment and services for their research rarely, if ever, pose problems. As one PhD student in a CRC expressed, 'There is huge support and advantages working in a CRC. There are no real budgeting issues and equipment is no problem…'.

The level of support that CRCs typically offer doctoral students was illustrated by a recently graduated CRC PhD student who explained that, compared with the time-consuming process of trying to secure funding from funding councils, the Australian Research Council (ARC) in particular, the situation in CRCs is much more simple and straightforward:

> It's very easy here. There is no problem with securing equipment or getting funding to follow through with research ideas. Proposals are put to the CRC and the whole process only takes just a month… Getting funding out of the ARC is very complex—it takes about three months to write a proposal and then you have to wait for over a year to get the funding ***if*** you get the funding!

Also many PhD students in CRCs, as well as receiving industry funded scholarships, receive a 'top-up' scholarship from their CRC's healthy budget. As one senior university research manager explained, comparatively, 'CRC students are living in the lap of luxury. They often get top-ups and funding for doing various courses, and lots of money to do things like going to conferences…'.

Out of a choice of eleven items where respondents indicated that they were satisfied or very satisfied with aspects of their course experience, the top five ratings given by CRC-related students, in order of preference, were:

- availability of library holdings and library resources (76.3%)
- competence of supervisor (74.2%)
- interpersonal skills of supervisor (68.2%)
- suitability of research topic (67.2%)
- access to specialised equipment (63.6%)

By comparison non CRC-related students ranked the following five, beginning with their first preference, the most satisfactory:

- suitability of research topic ((76.7%)
- competence of supervisor (71%)
- availability of library holdings and library resources (67.9%)
- interpersonal skills of supervisor (65.6%)
- intellectual environment at work (57.9%)

When, however, the full-time student cohort in the major S&T areas of agriculture, engineering, health/medicine and science are isolated, the CRC-related students' level of satisfaction is higher with every item except suitability of research topic as noted in Table 3.

Table 3
Percentages who rated particular course aspects as very satisfactory or satisfactory: full-time students in agriculture, engineering, health/medicine and science

	CRC-related (N=154)	Non CRC-related (N=915)
Overall experience as a PhD student	65.4	63.8
Access to specialised equipment, computers etc	68.6	66.8
Working space available for research students	63.0	62.3
Availability of library holdings and library services	80.5	71.2
Quality and effectiveness of supervision	65.3	64.1
Suitability of research topic to produce a good thesis	66.7	72.5
Competence of supervisor(s) in your area	74.6	73.1
Intellectual environment of your department/research centre	65.3	63.6
Interpersonal skills of your supervisor	71.0	65.2
Help provided in designing your project	59.4	57.3
Financial support for your project	66.7	60.1

These results indicate that full-time PhD students in the S&T areas who were industry funded were more satisfied with certain aspects of their course experience than students who were in areas such as the social sciences, humanities and other non-science disciplines. Given that students in the non-science fields do not reap the benefits that extra industry funding brings, this outcome is not surprising. Also, close to one third of all non CRC-related students surveyed were part-time and part-timers indicated greater dissatisfaction with their course experience overall.

Results of other aspects of the PhD course experience surveyed are summarised in Table 4.

Table 4
Percentage of students who agree or strongly agree with statements relating to aspects of course experience

	CRC-related (N=198)	Non CRC-related (N=1351)
My department/school/centre is very good in its field	83.8	73.4
My supervisor/main supervisor is an impressive researcher	80.3	72.9
I feel fee to approach other academics for help with my thesis	62.1	60.1
I really want to publish work from my thesis	89.3	90.7

I feel trapped by my area of specialisation	16.2	18.7
My PhD is going to enhance my career prospects	68.7	65.7
Supervision changes have adversely affected my work	17.3	17.0
I have been thinking of dropping out of PhD study	20.7	16.8

Research status of department/centre, expertise of supervisor, freedom to seek help, wanting to publish, and optimism about and seeing the PhD as enhancing career prospects generally scored high levels of satisfaction with both cohorts. CRC-related students scored higher levels of satisfaction on six out of the eight items listed. Only 16.2% of CRC-related students indicated that they felt trapped in their area of specialisation and 17.3% that changes in supervision had affected their work adversely. Figures were similar for non CRC-related respondents (18.7% and 17% respectively). A particular concern is that 20.7% of CRC-related and nearly 17% of non CRC-related students indicated that they had contemplated dropping out of study. As many part-timers, particularly mature-age students, have greater challenges in balancing research, work and family commitments and given that nearly 21% of CRC-related students and 32.1% of non CRC-related students indicated that they were part-time, it is reasonable to contend that part-time status is not as conducive as full-time to completing a PhD. Considering too the low financial support for some students—nearly 15% of CRC-related and 13.3% of their non CRC counterparts indicated that their gross income for the past financial year was less than $15,000 (see Table 7)—it would be reasonable to expect that a number of these would need to seek work in order to survive. Also interview data indicated that a number of other reasons such as illness, pregnancy and accepting a job offer impacted on students' ability to keep going with their doctoral research.

Another indicator of satisfaction with course experience surveyed was frequency of contact with supervisors. Frequency of meetings to discuss work is summarised in Table 5 and results here appeared encouraging.

Table 5
Frequency of discussion of work with supervisor(s). Responses of full-time students in agriculture, engineering, health/medicine and science (percentages)

	CRC-related N=156	**Non CRC-related N=915**
At least once per week	37.8	32.0
At least once every two or three weeks	37.2	36.0
Every month or two	17.9	21.8
Infrequently or irregularly	7.1	10.2

Full-time students in the S&T CRC-related fields had more frequent contact with supervisors compared with their non CRC counterparts overall (75% compared with 68% respectively). 37.8% of CRC-related students had contact with their supervisors at least once a week and 37.2% at least once every two or three weeks. However, a number of doctoral students in this cohort interviewed reported repeatedly the difficulties they had obtaining sufficient time to spend with their supervisors who were often pressed for time because of heavy teaching loads or 'they were chasing funding all the time'. Also, if their supervisor was also head of their department/school, this posed extra problems regarding time available for supervision.

The amount of time S&T students spent per week on research was another factor surveyed as summarised in Table 6. Full-time CRC-related students in the S&T disciplinary fields indicated that they spent more time overall on their research. For both the CRC-related and non CRC-related cohorts the highest proportions indicated that they spent between 40-49 hours/week (34% and 30.9% respectively). Around 26% of both cohorts said that they spent between 30-39 hours/week on their research.

Table 6
Hours per week spent on PhD research by full-time students in agriculture, engineering, health/medicine, science and veterinary science

	CRC-related (N=156)	Non CRC-related (N=915)
Less than 10 hours	2.6	2.8
10-19 hours	1.9	5.8
20-29 hours	9.6	13.5
30-39 hours	25.6	26.4
40-49 hours	34.0	30.9
50 hours or more	26.3	20.6

Level of financial support was another important indicator that was seen to influence student attitudes to course experience. Figures in Table 7 indicate gross financial income of the last financial year for full-time students in the S&T disciplinary fields.

Table 7
Estimated gross income for last financial year (including stipend from any scholarship) of full-time students in agriculture, engineering, health/medicine, science and veterinary science

	CRC-related (N=156)	Non CRC-related (N=915)
Less than $15,000pa	14.8	13.3
$15,000-$19,999pa	28.2	30.7

$20,000-$24,999pa	28.1	27.7
$25,000-$39,999pa	18.8	19.9
$40,000 and over	8.1	6.4

CRC-related students reported less income than their regular university-related counterparts. A possible explanation for this is that PhD students in regular academic departments often do part-time tutoring/demonstrating or lecturing for which they receive small remuneration, whereas CRC-related students are not expected to teach. For both CRC-related and non CRC-related respondents the largest amounts of financial support reported was between $15,000-$25,000 while on average about 7% had an annual income of over $40,000, and about 14% of students received less than $15,000. (An Australian Postgraduate Award for Industry is worth around AUD$16,000 and with a 'top-up' from a CRC would be worth around AUD$21,000.) The figure of 14%, however, is likely to be influenced by the percentage of students who indicated that they were in the first year of PhD candidature, most of whom would have been full-time students with little or no income in the preceding year.

Attitudes towards links with industry

The CRC's commitment to improving business-research links and developing a stronger and more innovative commercialisation skills-base offers attractive opportunities for graduate students, especially the chance to work with private industry partners. Sponsored research however, can pose risks and doctoral students need to be protected from any effort that is likely to detract from advancing their education or their own research, a position that is firmly held in a recent report of the United States Business-Higher Education Forum (2001, p. 74). This raises the issue of how researchers that are sponsored by industry view the value of their links with industry. Findings reported in this section of the paper relate to the majority of respondents who received the bulk of industry funding—those in the S&T disciplines.

Table 8 shows comparative data from full-time S&T students on five dimensions—how much they enjoy working with industry, to what extent career prospects are enhanced, to what extent delays in publication are experienced, how much private industry values and practices threaten traditional academic values and how much control over research agendas they have. Around 63% of CRC-related PhD students said they enjoyed working with industry, while only about 54% of non CRC-related students indicated liking working with industry. Both cohorts saw career prospects greatly enhanced by links with industry with 83.1% of CRC-related and 87.6% of non CRC-related responding positively to this item.

Table 8
Full-time students in agriculture, engineering, health/medicine, science and veterinary science who agree or strongly agree on statements re value of industry links (percentages)

	CRC-related (N=156)	Non CRC-related (N=915)
I like the idea of doing research in industry/Govt department	62.8	53.8
Industry funding can enhance the career prospects of students	83.1	87.6
Industry research funding often delays publication of findings	87.8	79.7
Research links with industry threaten traditional academic values	30.1	33.7
Research users should have more say over research priorities	49.4	44.2

Students were a bit more divided when it came to whether or not users of research should have more control over research agendas. When asked who should have more say in setting research priorities, 49.4% of the CRC-related students and 44.2% of non CRC-related students believed that users should have more say. Given the proportion of students in the S&T areas that are used to working with industry (especially in engineering fields), these figures are not surprising. This does not necessarily mean, however, that only a small majority support the position that research should be a 'bottom-up' (researcher-driven) process. Interview data revealed, for example, that many doctoral students in CRCs and their supervisors engage in long-term pure research that is user-driven and they manage to publish substantial theoretical papers. In addition many supervisors of CRC students interviewed explained that their doctoral students were not put on short-term 'quick-fix' strategic projects. Reflecting on the user-driven versus the researcher-driven approach and how much control companies exercise over research agendas, one doctoral student noted how clever scientists who wanted to retain their autonomy played the game with companies:

> Savvy scientists know how to work the companies—they are good operators whose intellectual interests are driving them rather than profit motives.

Consistent with the 'bottom-up' view of research were the responses to industry posing a threat to traditional academic norms and values. Much of the literature on the risks of researcher-industry links points to the dangers of diluting traditional cultural norms associated with scientific universalism, particularly commitment to disinterestedness, peer review by experts in the field and openness in disclosure and dissemination of new knowledge (Peters and Etzkowitz 1990; Tasker and Packham 1993; Lee and Gaertner 1994; Blumenthal et al 1996; Lee 1996; Krimsky et al 1999). Considering these risks, it is interesting that only just over 30% of respondents on average believed that private industry norms and values pose a threat to academic values.

Much of the interview data reinforced this belief. Illustrative of this view, a PhD student in an engineering-related CRC rejected the idea that graduate students are 'programmed' and that research

agendas are being controlled by industry. He claimed that, 'One of the advantages of working in a CRC is that you are not locked in… I do mainly pure research and there is no problem with this.'

Reinforcing that it was not common practice for CRCs to let industry define what graduate students do, another interviewee explained that the reason for this is,

> … that this action can lead to great uncertainties if companies fold or get taken over. Where this has happened past experience has shown that new company structures do not always want to carry on funding a project which they did not start.

One questionnaire item asked to what extent research findings should be open and shared amongst researchers. Respondents were firmly of the opinion that openness and exchanging information is an important aspect of good science. Much of the interview data supported this value position, with one doctoral student emphasising that,

> Universities are being raided by the corporate world… researchers are setting up companies and I don't like the way students are bound by secrecy agreements. Science is about sharing information, open sharing and openness…

While many students hold firmly to the value of openness and are overall very supportive of being funded by industry, they are nevertheless aware of many of the risks involved, especially regarding delays in publication and dissemination of research findings (Krimsky et al 1999, p. 14). A sizeable majority of respondents (87.8% of CRC-related and 79.7% of non CRC-related) agreed that there were often delays in publication of findings as indicated in Table 8.

Career plans

The PhD experience in Australian universities is regarded as high level research training which represents a significant area of national investment in research (Kemp, 1999, p. 17), mostly in the form of scholarships. For the investment to be seen as worthwhile, it would be reasonable to expect that PhD graduates, especially S&T oriented students, would go automatically into a research career or at least have plans to work in industry-based R&D, assuming that labour market demands matched their skills. Working on this assumption, many of the survey items concentrated on attitudes of PhD students to a research career, as well as their preferred career options and plans.

When asked whether they expected to go into a research career of any kind after graduating, only 56.1% of CRC-related students and 54.1% of non CRC-related students agreed that this was the path they planned to take. The percentage of full-time students in the S&T areas of agriculture, engineering, health/medicine, science and veterinary science who indicated their preference for a research career was similar—55.1% CRC-related and 57.1% non CRC-related students. Given that the number of PhD students has increased

substantially over the last ten years, it could be expected that not such a high proportion as in the past go on to a research career. A further breakdown showing student choices for a range of different research careers looked a bit more encouraging however (see Table 10). But this does not mean that the low percentages opting for a research career should be taken lightly. The outcome is a major concern in terms of potential wastage in the system and lack of capacity to drive high quality research in the future. The future for universities and for institutes, industry R&D and other agencies and institutions that are research-based looks bleak indeed if research careers are not chosen by those who are trained specifically for them. How (or if) the research students who indicated they did not want to go into a research career will apply their research training and what incentives might be provided that will encourage a research career are questions that certainly need to be followed up.

Much of the interview data supported the low survey ratings accorded a research career, especially an academic career as will be illustrated later in the paper. One problem noted by some students interviewed in CRCs was that, because R&D is being wound down in many Australian-based companies, there is less opportunity now to go the industrial R&D route on graduating unless they go overseas, particularly to Germany where industrial R&D is strongly supported. Many students, in particular laboratory-based students, reported on their supervisors' extremely heavy workloads which seemed to be growing exponentially and consequently left them little time to spend with their students. Students commented frequently particularly on the all-consuming job that their supervisors have of chasing funding in order to keep their labs and research teams going. As one laboratory-based student put it,

> Research is too much of a roller coaster. It's very frustrating having to write proposals for funding all the time. And research depends on grants…

CRC-related and non CRC-related students' attitudes to career prospects, the attractiveness of working with industry and reactions to the problem of an oversupply of graduates in their area of expertise are summarised in Table 9 below.

Table 9
Percentage of students who agree or strongly agree on items relating to career prospects

	CRC-related (N=198)	**Non CRC-related (N=1351)**
I'm optimistic about my career prospects	67.2	56.3
I like the idea of doing research in industry/Govt department	61.6	51.5
Oversupply of PhD graduates will affect my career prospects	33.3	30.8

Nearly 70% of CRC-related students but only 56.3% of non CRC-related students were optimistic about their career prospects. The higher percentage of CRC-related students is probably not difficult to understand given the level and nature of industry support and industry looking favourably on CRCs as recruiting grounds for future employees. As noted by the US National Research Administrator's Resources Network (c1996), collaborative enterprises like CRCs provide 'a pool of candidates for job recruitment to the industrial partner'. A higher percentage (61.6%) of CRC-related students expressed that they liked the idea of research in private industry or a government research organisation than non CRC-related respondents where only 51.5% expressed their liking for working in industry. Not too much concern was expressed by both groups about the possible difficulty of an oversupply of graduates in their area.

When asked to select the most attractive career from five options provided, just over 64% of CRC-related students opted for working in industry with close to 62% opting for a post-doctoral appointment. The top two choices for non CRC-related students were a post-doctoral appointment (67.3%) followed by an academic position in a university (64.5%). 56.6% of CRC-related students ranked an academic position as option four. Working in the public service, business management or an advisory position was ranked number five by both cohorts. These patterns are discernible in 0.

Table 10
Attractiveness of different types of employment: percentage of students who rated options as attractive or very attractive

	CRC-related (N=198)	**Non CRC-related (N=1351)**
Academic position as University lecturer/researcher	56.6	64.5
Research position in CSIRO or govt research organisation	57.6	52.2
Post-doctoral appointment	61.9	67.3
Research position in industry	64.1	50.8
Public service or business management/advisory position	39.9	44.5

When interviewed about the possibility of choosing an academic career, students often responded quite emotively and negatively. Their reasons for not wanting an academic career included onerous workloads, little time to do the research that really turned them on, low levels of funding, the continual struggle for funding, too much time spent in writing grant applications, too long an incubation period as a 'postdoc' (in the case of science-based students), the pressure to build up a reputable track record before being appointed, and the 'depressing' current climate in universities which leads to great frustration. The following quotes illustrate well what puts students off an academic career:

> Academia could be far too demanding. Look at the people here! Their workloads are enormous, they have little time to do the things they are really good at like research and they are

> continually overstretched. I'm excited about academic-type work, especially research and the prospect of publishing and this keeps me going. But I wouldn't like an academic career…
>
> The funding is so poor and if you want to become an academic you must do a postdoc for two to three years and then face the big jump of getting grants.
>
> Not an academic!… There is no way on God's earth that I would want to work in a university. The climate of universities is miserable, penny pinching and depressing at the moment…

Concentrating on the S&T cohort of the CRC-related students, when they were asked to respond to a set list of career options and to differentiate their *ideal* from their *realistic* choice of career, some interesting findings resulted. These are summarised in Table 11 below.

Table 11
Responses of full-time students in agriculture, engineering, health/medicine, science and veterinary science about kind of position three years after graduation (percentages)

	IDEALLY		REALISTICALLY	
	CRC-related (N=156)	Non CRC-related (N=915)	CRC-related (N=156)	Non CRC-related (N=915)
Self Employed/consultant	9.3	9.0	9.5	7.7
Academic appointment	19.3	31.0	15.6	18.9
Public Service/industry	10.0	10.7	8.8	9.9
Post-doctoral/research	47.3	36.8	51.7	39.9
Managerial position	8.7	7.3	2.7	4.1
Don't know	5.3	5.2	11.6	19.4

Ideally, both cohorts put as first and second choices post-doctoral/research and academic appointment respectively. CRC-related students indicated 47.3% support and for a post-doctoral/research position and 19.3% and 31% respectively for an academic position. Looking at the options *realistically*, while both student cohort rankings were the same for post-doctoral/research and academic appointments, the strength of support varied only slightly. Whereas 47.3% of CRC-related students opted *ideally* for post-doctoral/research as a career, 51.7% saw this as a *realistic* option. 36.8% of non CRC-related respondents opted *ideally* for post-doctoral/research and 39.9% *realistically.* The least support for both cohorts ideally and realistically was for a managerial position. A particular concern, consistent with previous findings, is the low percentages who opt for an academic career. While 31% of non CRC-related students opted ideally for an academic career, only 18.9% of these saw this as a realistic option. 19.3% of CRC-related students opted *ideally* for academia but only 15.6% *realistically.*

Looking at a number of different indicators of what is seen as very important or important in a career, responses were very consistent between the two cohorts (see Table 12).

Table 12
Relative importance of the following in choosing a career position
(percentage of students who said very important or important)

	CRC-related (N=198)	Non CRC-related (N=1341)
Salary	78.5	74.0
Independence in carrying out the job	89.3	90.5
Interest in the work itself	96.4	96.6
How the job is viewed by others	33.3	30.5
Permanent employment with long term prospects	68.9	68.2
Supportive colleagues	87.3	87.5
Ability to balance work and home/family demands	87.8	87.3
Ability to speak out publicly on professional issues	65.0	72.7

Rankings of the top five options are outlined below.

CRC-related student rankings

1. interest in the work itself (96.4%)
2. independence in carrying out the job (89.3%)
3. ability to balance work and home/family (87.8%)
4. supportive colleagues (87.3%)
5. salary (78.5%)

Non CRC-related student rankings

1. interest in the work itself (96.6%)
2. independence in carrying out the job (90.5%)
3. supportive colleagues (87.5%)
4. ability to balance work and home/family (87.3%)
5. salary (74.0%)

It is interesting that salary is ranked only fifth by both cohorts! 'Sufficient salary' only and 'a good working environment' were seen as necessary to job satisfaction. Interview data backed up the idea that intrinsic interest in the topic was really what drove research students. One doctoral student, reflecting on his future spoke for many when he said,

> What do I want in a job? Enjoyment, stimulation, not money. As long as you like the job money is secondary.

While permanent employment with long term prospects was seen as important for both cohorts (an average of 68.5% support), it ranked lower down the order. The lowest in importance for both cohorts was how the job is viewed by others. This of course is consistent with the superior importance put on intrinsic interest in the job. The ability to speak out publicly on professional issues (part of academic freedom) was ascribed also a lower order in importance by CRC-related students. This is probably not surprising given that PhD students in CRCs usually need to sign over their intellectual property rights to the CRC. However, the non CRC-related respondents still gave nearly 73% rating compared with only 65% of the CRC-related on this item. Given too that non-science students are included in the other cohort, it would be reasonable to

postulate that these students, especially those in the social sciences, are more inclined (or more socialised) to speak out on matters of concern.

For the S&T disciplinary sub-group results for each cohort showing the relative importance of various career indicators are strikingly similar to the larger cohort as indicated inn.

Table 13
Importance of different indicators in choosing a career position
(percentage of students in agriculture, engineering, health/medicine, science and veterinary science who said very important or important)

	CRC-related (N=156)	**Non CRC-related (N=915)**
Salary	78.7	73.0
Independence in carrying out the job	89.1	89.9
Interest in the work itself	96.2	96.5
How the job is viewed by others	34.4	29.7
Permanent employment with long term prospects	72.9	68.0
Supportive colleagues	89.7	87.0
Ability to balance work and home/family demands	88.5	87.2
Ability to speak out publicly on professional issues	60.3	70.2

Interview data on careers proved particularly illuminating in expanding on much of the survey data. For example while many students who were interviewed expressed some anxiety about finding suitable employment at the end of their candidature, many indicated that they were aware of a wide range of career options and were reasonably optimistic that they would be able to find a good job that matched their particular interests. Interview data confirmed that well informed full-time PhD students saw academic careers in universities as difficult to achieve given the competition for good jobs, pressure to secure research funding, rising teaching loads which means less time for research and the relatively meagre salaries for the work involved. A number found the extreme pressure their supervisors are under in trying to keep high level research going very off-putting. Many of the science-based students reported how difficult it would be to secure an academic job even after two or three 'postdoc' appointments. Even if they did, they would then need to attract enough funding to run a laboratory and support research students. Consequently, many doctoral students were engaged in building up a wider range of skills in order to make themselves more marketable to employers by doing short courses offered by their respective university's graduate schools or equivalents. They engaged in topics such as time and financial management, winning grants, leadership, running consultancies and public speaking. Many also learnt about publishing papers in top refereed journals and gained experience in teaching part-time before they graduated.

Many CRC students reported that one of the advantages of working in a CRC was the number of different management skills they learned during their candidature. This is mostly because CRCs encourage their doctoral students to do a range of courses like those listed above, during their doctoral studies. The courses they find particularly useful are applying for grants, managing research projects, writing business plans, leadership and financial skills and presenting their research to client groups. Part of the underlying training philosophy of CRCs is ensuring that their graduates know how to deal professionally with company clients and gaining skills that will make them more attractive to industry.

Conclusions

Findings indicate that overall, CRC-related PhD students fare well compared with their counterparts in regular university departments. CRC-related students recorded higher levels of satisfaction especially with their overall course experience, their financial and infrastructure support, availability of and access to library holdings and library services, access to specialised equipment, the research status of their centre and the amount of contact they have with their supervisors. They also reported higher levels of optimism regarding their career prospects. A further breakdown reveals that CRC-related students in the S&T disciplinary fields reported the highest levels of satisfaction according to all indicators of course satisfaction except one. Other findings indicate that CRC-related doctoral students spend more hours per week on their research than their regular university counterparts and get to experience a range of skill development courses that help them on graduating to deal more professionally with company clients which in turn make them more attractive to industry. All this suggests that CRCs are playing a significant and worthwhile role in research training in Australia.

Findings on attitudes to links with industry are particularly positive. Both CRC-related and non CRC-related PhD students who were industry funded showed positive attitudes to links with industry. For a start, all students believed that industry funding enhances considerably their career prospects. A majority of CRC-related students indicated that they would consider research work in industry or a government department. Also, both the statistical and interview data indicated that a large majority of students in the S&T disciplinary fields who were sponsored by industry funding did not see that traditional academic values were necessarily threatened by corporate values and practices, even though a substantial majority said that delays in publication of findings are common. Students were a bit more divided however, when it came to saying whether or not users of research should have more control over research agendas. Despite the fact that nearly 50% of CRC-related students said that industry should have more say in setting research priorities, many of these nevertheless still engaged in setting their research directions ‘bottom-up’ and claimed that it was still intrinsic interest in the topic that drove them. Perhaps this was so, as many of their

supervisors explained in interview, because doctoral students were not put on short-term, 'quick-fix' strategic projects.

From students in both cohorts there was strong consensus on what was seen as important in a career. The two top survey responses on this item were interest in the work itself and having independence in carrying out the job, both of which reflect long-held academic values. Having supportive colleagues and the ability to balance well work, home/family situations also ranked highly. While salary level was seen as important, it was not seen as the most rewarding aspect of a career. The fact that 64.1%, of CRC-related PhD students indicated they would consider a career in industry further indicates that CRCs, to some extent, are achieving their training objective of enhancing the value to Australia of graduate researchers.

The very low percentages who would opt for a research career or a career in academe appears to indicate wastage of government investment in research training. In academe this could of course indicate the need to address the funding crisis currently facing many Australian universities. However, implications for the future of universities with a potential lack of capacity to drive high quality research are significant. It was alarming enough to find that *ideally* only 19.3% of CRC-related and 15.6% of non CRC-related students saw academia as a feasible choice. It was even more alarming to find that only 15.6%% of CRC-related and 18.9% of non CRC-related students saw academia as a *realistic* feasible choice. The damning comments offered by many of the interviewees only helped to consolidate why students would not choose an academic career.

Care needs to be exercised, however, in interpreting the findings as wastage or poor return on investment in research training. What the findings do not reveal are if and how students who indicated they did not want to go into a research career will apply their research training in some other capacity. Also, as noted earlier, companies in Australia have been cutting back or in some cases abandoning their R&D activity which would help explain why a number of students would not opt for an industry research career unless they are prepared to go overseas. And understandably many part-timers who have invested years of their life in their research, especially those who have found balancing their research with jobs and other demands an extreme burden, may not be likely to opt for a research career.

Nevertheless, findings of this study indicate for a start, that there is a clear need to establish the level of wastage that exists in research training in Australia, why this is so and what can be done about it. How PhD students who do not opt for a research career will apply their research training is an important question that certainly needs to be addressed by research policy makers. Finally, if CRCs are clearly offering their doctoral students more, are successful in achieving greater levels of satisfaction with course experience and are providing their students with access to broader training that gives them useful and employable skills,

implications for university-based doctoral training would seem to be very clear if universities are to grow and survive and if research is to reap the hoped-for outcomes for the nation.

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