What Did You Do With Your Science Degree?

A national study of employment outcomes for Science degree holders 1990-2000

**Prepared for the
Australian Council of
Deans of Science (ACDS)**

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CONTENTS

List of Tables

List of Figures

EXECUTIVE SUMMARY

The critical role of universities in preparing a workforce capable of meeting the demands of the knowledge economy is now becoming more widely understood. Science faculties must be at the forefront of the national effort to provide research and innovative solutions to lead and support the changing national priorities. Much of this effort will depend on the quality of undergraduate programs in Science and the effective use of graduate skills in the workforce. However, there are major gaps in our knowledge of what graduates do with their Science degrees and how undergraduate Science courses might best address the needs ofgraduates and the demands of emerging national priorities.

The study reported here was commissioned by the Australian Council of Deans of Science (ACDS) as part of an ongoing program to monitor the state of Science education in universities, and specifically in response to recent evidence of a decline in student enrolments in the Sciences, especially the enabling Sciences (Physical Sciences and Mathematics) and the growth of numbers in the broader Life Sciences, psychology and, especially, information technology. The study investigated the initial and subsequent employment of Science degree holders, and their perceptions of the skills an undergraduate Science degree provides for employment and advancement over the first ten years of work.

The analysis is based on an investigation of existing data bases for what they can tell us about employment of Science graduates; a CSHE survey of 1245 Science graduates from six Australian universities; an invitation to potential respondents to access the same survey on line (106 responded); face-to-face and telephone interviews with 32 Science graduates, and with a selection of employers across a range of areas.

The survey respondents were balanced across three groups in terms of time since graduation, with 37 per cent from 1990-93, 35 per cent from 1994-1996, and 28 per cent from 1997-1999. Almost all were educated in Australian secondary schools, most had gone directly from school to university, and around 60 per cent had completed a pass degree. A disproportionately high number of respondents were female and the data were weighted where appropriate.

The following summarises the major findings:

• A Science degree provided an effective entry into employment for most of the graduates surveyed. Eighty per cent are working full-time, 12 per cent part-time; 3 per cent are unemployed, and 6 per cent are not in the workforce;

• The survey respondents are evenly distributed between people who said they work in a Science-based organisation (35 per cent); in an organisation that is broadly Science-based (33 per cent) and in an organisation that is not Science-based (32 per cent). Most graduates were working in jobs related to their initial Science qualification. At least three-quarters thought their undergraduate degree was a key factor in getting their current or most recent job;

• Most of the graduates think of their current employment in terms of a career path, with 41 per cent describing it as a 'desired career position' and 44 per cent who see it as a 'stepping-stone to a desired career position'. Only 15 per cent regarded their jobs as an 'interim' or short-term prospect. However, it is does not seem appropriate to talk about a career path. The research shows quite marked variations in the sequence and direction of people's employment histories;

• Of all the respondents in employment, full-time or part-time, 39 percent are working in a Science job at manager, professional or technical level, and most are at the professional level. Almost as many people overall are in managerial, professional or technical jobs in other areas (33 per cent), and 16 per cent are in IT jobs (most at the professional level). Full-time employed males are much more likely than females to be IT professionals while females are more likely to be Medical/Health professionals;

• Around 46 per cent of graduates went straight into a professional or managerial job in the first year after completing their undergraduate degree (most into professional rather than managerial positions); 20 per cent found work at the technical level; 10 per cent had other jobs. Following the first year, movements between professional and technical positions were varied, and not all one way;

• The highest employment rates were recorded for those whose major area of study were Computer Sciences (99 per cent), Mathematical Sciences (93 per cent) and Computing and Maths (94 per cent). The lowest rates were recorded for those whose major areas of study were Life and Medical/Health (86 per cent), Maths and Physical (88 per cent), and Life and Physical Sciences (88 per cent);

• Graduates whose undergraduate study was in Computer Sciences, Computers and Maths, and Maths and Physical Sciences are most likely to be in the top third of respondents in terms of income. While most progress from a lower to a higher income across the ten years, around 20 per cent of those who completed their undergraduate Science degree in the early 1990s were in the bottom third income group;

• The great majority of respondents (around 80 per cent) said that their undergraduate Science degree was 'directly' or 'somewhat' related to their current or most recent job. A significant minority of the Science graduates in the survey have found employment in areas other than their initial area of study, and for many this is likely to follow further study after the undergraduate degree. Graduates from a Computer Sciences or Medical/Health Sciences area of study are most likely to say their degree is directly related to their job. Fewer graduates than expected —around 16 per cent —said their undergraduate studies were not at all related to their job, irrespective of their qualification;

• Almost 60 per cent of respondents agreed that their job gives them the chance to use the skills and abilities acquired in their undergraduate Science training with responses ranging from highs of 70-90 per cent for Computing and Mathematics, Computer Sciences and Medical/Health Sciences area, to a low of 36 per cent for other than the main recognised

categories of Science combinations.   Those most likely to say their job does *not* give them an opportunity to use their Science skills are from the Mathematics and Physical Sciences;

• Science graduates clearly agree that their undergraduate degrees provided them with analytical skills, problem solving skills, subject specific knowledge and understanding, an ability to use research to inform analysis and decision-making, and an awareness that knowledge is always being revised and expanded;

• However, there are large gaps in perceptions of attributes gained in an undergraduate course and the importance of those attributes in the current jobs of the respondents. Major differences on some items include management skills, quite large discrepancies in relation to written communication, the ability to work with others, flexibility and adaptability (considered very important by employers) and the ability to use information technology effectively. The need for a high level of oral communication skills stands out as an attribute needed by almost nine out of ten respondents in their current employment, while only four out of ten felt they gained such skills in their undergraduate course.

The research reported here confirms that most people do undergraduate Science degrees because they are interested in the area and 'love Science'. Across all occupational groups, the Science graduates surveyed are generally positive on a range of indicators of work satisfaction, and the extent to which they find their work worthwhile. Science technicians and other technicians are perhaps the exception, although they rate relatively highly on the scale of job interest and use of skills. It is noteworthy that only 45 per cent of respondents from a Medical/Health Sciences background and 61 per cent from a Computer Sciences background say that doing the degree has been worthwhile irrespective of the employment outcome, in contrast to the three-quarters or more respondents from Life Sciences, Life and Physical Sciences, and Maths and Physical Sciences—courses which tended to lead to more diverse employment outcomes.

ACKNOWLEDGMENTS

1: INTRODUCTION

This report is part of continuing efforts by the Australian Council of Deans of Science (ACDS) to gather up-to-date information about Science education in Australia and to explore ongoing issues of concern in relation to Science education in universities. In 1998, the ACDS commissioned a report with the aim of resolving some contradictory information, especially in regard to student enrolments in Science. That report (Dobson and Calderon 1999) identified a relative decline in enrolments in the enabling Sciences (the Physical Sciences and Mathematics) and high growth in the broader Life Sciences, psychology and information technology. The enabling Sciences underpin and support the development of new sciences. They also contribute to Science literacy and awareness amongst the general population, a necessary factor if innovation and high technology enterprises are to be supported and used in socially responsible and effective ways.

In relation to general employment opportunities, Dobson and Calderon concluded that there is 'major growth occurring and likely to continue in the professional and managerial fields, particularly those linked to finance and business services and to public administration. Computing is expected to be a crucial component of this growth' (p. 83). They also noted that, while it was difficult to be specific, their analysis of 1996 Census data indicated that Science graduates were already moving into these fields, and that if this trend continued, it was likely that it would be on the basis of their generic analytical skills. When figures from the 2001 Census become available, it will be interesting to see the extent to which the trend noted by Dobson and Calderon for Science graduates to move into areas other than Science has continued.

The present study was commissioned with the express goals of investigating the initial and subsequent employment of Science degree holders, and the skills a Science degree provides for seeking employment and later advancement through the first decade of their careers. They are the key foci of this report. The research project had four main aims:

1. To identify the extent to which the employment of natural and Physical Sciences graduates in their profession, in management and other areas, increases to levels comparable with technology professionals by about ten years after graduation.

2. To investigate a range of issues related to the employment opportunities, graduate destinations and career structures of Science graduates, and perceptions of the nature, relevance and value of their initial Science degree.

3. To identify employer perceptions of the skills of Science graduates, and the extent to which those skills are valued.

4. To establish baselines for monitoring future trends in the employment of Science graduates.

Organisation of the report

This introductory chapter briefly describes the background to the project and summarises key trends and issues regarding employment of Science graduates, including research on employer requirements. In Chapter 2, the various elements of the project are briefly described and a profile of the survey respondents provided. Chapters 3-10 discuss findings from the research; they are designed to explore the specific questions which guided the study. The final chapter reviews conclusions from the project and discusses their implications for Science education.

Science graduates and the future: trends and challenges

Questions about Science education and the employment of those who complete a Science degree sit within the broad context of very significant transitions occurring in many post-industrial countries, the most profound of which are the shift from previous so-called 'old' economies to new knowledge-based economies, and major changes in the nature and organisation of work. These changes are having an impact across all fields of endeavour and will affect the future of all Australian citizens; some of the trends and the issues noted are not unique to Science degree holders. However, Science has a special place in the transformation to a knowledge economy, and investment in scientific research and innovation has major implications for the economic, social and ecological future of Australia.

Knowledge-based economies and Science graduates

Research and innovation is the foundation of a range of new Science-based industries that are part of new knowledge-based economies, but they are also of key importance to the profitability of older industries that have been the foundation of the Australian economy (Lowe 1997). Several recent reports have reiterated the critical nature of Science for current developments. The ARC/CSIRO report on Australian patenting and basic Science (ARC and CSIRO 2000) confirmed the essential nature of the relationship between publicly-funded research and the development of new technologies. A discussion paper by Australia's Chief Scientist noted that, despite differences between the old and new economic paradigms, Australia's traditional economic base depends heavily on the knowledge base that supports it, so science capability is crucial to both the development of the 'new economy' and the competitiveness of existing industries (Batterham 2000, p. 7).

An oversupply of Science graduates?

The project brief raised the question of whether there was an oversupply of Science graduates in Australia. This reflects similar concerns expressed in a number of countries. Contributing factors to a perceived over-supply are seen to be world economic trends and associated government policies, the expansion of tertiary education, contracting opportunities for tenured academic positions, and widespread contract-based employment.

The oversupply issue has certainly been raised in Australia, although perhaps not to the extent that it has been for example in the United States. It has also been disputed both overseas and in Australia. The Australian Chief Scientist's Discussion Paper argues a directly contrary position — that Australia has insufficient graduates with SET (science, technology and engineering) skills to support developing knowledge-based industries (Batterham 2000 p. 20) and that more resources ought to be directed to both school and university Science education. There is also the general argument for the importance of an informed and educated populace — how can we seriously say we have too many people who understand science?

Changing career structures for Science graduates

Debates about oversupply raise questions about the purposes of an undergraduate Science degree and the vocational aspirations and expectations of Science graduates. It is clear that a 'basic' three year degree is now a beginning only in the employment market and the possibilities of gaining a Science-related job following graduation are much less than with an Honours degree. In this regard, Science degrees are now more akin to Arts degrees, in that they provide general skills rather than a qualification for a specific vocation. Pass degree graduates are increasingly competing for jobs with both non-graduates and with graduates from fields other than their own (Andrews and Wu 1998). At the other end of the scale, career opportunities and pathways for those who go on to further study and pursue a research career, in or out of academia, have also altered quite dramatically over the past ten years or so.

The Dobson and Calderon report (1999) indicates that career patterns for Science graduates are changing and becoming more diverse. Again, to some extent this reflects a pattern for graduates in other fields of study and is likewise a response to general demands for multi-skilling and adaptability in the work place, and to the emergence of new jobs. An increasing number of students are opting to do combined first degrees, and to undertake a wide variety of postgraduate courses — postgraduate diplomas and coursework and research higher degrees — in order to increase their employment options. Jobs in Science as in other fields are being re-shaped and new jobs, many of which require people with a mix of skills, are being created by technological developments.

Notions of a career and a working life are becoming increasingly diverse and much more individually based and entrepreneurial. In an era where generic skills, portability of qualifications and transferable skills are key concepts underlying the vocational training system; where rapid change is occurring in the skills required in many areas of employment; and where there is greater fluidity of employment options for people with a range of skills, the notion of a set career structure based solely on the nature and type of initial training is no longer appropriate.

The emphasis on commercialism and entrepreneurialism and the development of strong links between industry and universities have also had major impacts on the types of skills

demanded of Science graduates. Of particular importance are increasing requirements for management and business skills.

In response to employer demands for graduates to have a wider range of skills, some Science faculties have introduced components aimed at helping students to become aware of the generic skills developed in their course. University Graduate Schools also offer a wide variety of skills development programs for postgraduates, including leadership programs, information technology (IT) skills, team working and communication skills. Careers counsellors run programs to help students identify and promote their personal skills as well as their Science skills and to make them aware of the importance of having an open mind when considering employment opportunities.

While the emphasis on broadening skills is generally embraced, some cautions have been sounded. For example, there is concern that the developments not be at the expense of basic research and research education: 'Alternative career paths for scientists … must be encouraged by universities, but … it will not help our international competitiveness to have our best scientific talent developing new career profiles if our basic research effort starts to wither on the vine' (Allport 1997).

Gender issues are raised throughout this report with respect to employment outcomes. The proportion of females studying Science rose from 36 per cent in 1987 to 41 per cent in 1997. However, the proportion varies for different areas of Science, and for postgraduate courses as distinct from undergraduate. Dobson and Calderon (1999) reported that females constitute the majority of persons qualified in the natural and physical sciences amongst those aged less than 25 years and a slight majority of those aged 25-34 years. By contrast only 28 per cent of 25-34 year olds qualified at the degree level in computing were female and 18 per cent with engineering qualifications were female (p. 79). There are further variations within the broad fields of 'natural' and 'physical' sciences; for instance, in 1996, 41 per cent of chemistry students were women while only 19 per cent of physics students were (Office of the Status of Women, 1998).

In their analysis of labour market outcomes from 1996 Census data, Dobson and Calderon (1999) found that employment outcomes for females and males were similar in the same discipline. However, for each discipline, a slightly higher proportion of women than men are either not employed or not in the workforce (p. 79). As in many other areas, among managerial workers, women are under-represented compared to men.

Research scientist career paths

The trend to an extended post-doctoral period in the United States was described in a 1998 report (National Academy of Sciences 1998). The report identified an ever-growing 'pool' of post-doctoral fellows (in the Life Sciences) who were engaged in further research while obtaining further training and waiting for permanent positions. Major shifts in employment patterns of PhDs over the past three decades identified in this report were: a significant decrease in the proportion of Life Sciences PhDs who gained tenured positions in academia by ten years after graduation (historically, the largest proportion have been

4

employed in academia); the probability of industrial employment rose from 12 to 24 per cent and the probability of working in a federal or other government laboratory dropped from 14 to 11 per cent. The authors of the report talk of a 'holding pattern', whereby in 1995 as many as 38 per cent of Life Sciences PhDs either held post-doctoral positions or other non-faculty jobs in universities, were employed part-time, worked outside the sciences, or were among the steady 1-2 per cent unemployed, five to six years after graduation.

A major study of 6000 PhD holders in the United States, which included a significant proportion of PhDs in Science found, however, that post-doctoral patterns varied according to field of science and had different functions and meaning for women and for men (Nerad and Cerny 1999). This study found that biochemists had the largest proportion of untenured faculty 10 to 13 years after the PhD, because they spend a longer time in such positions — described by Nerad and Cerny as 'mandatory'. By contrast, in mathematics, where considerably fewer post-doctoral positions are available, PhDs were more likely to gain faculty positions; however, the authors note, there is a gender difference here as the finding is true for males rather than females.

Similar patterns concerning the post PhD period are evident in Australia. There has been a contraction of academic positions available for PhDs and increases in contract and grant-based employment (McInnis 2000; GCCA 1999). Overall, there is a trend towards more people spending longer periods in training in post-doctoral positions before gaining a job with some permanency.

Despite the increased number of women gaining Science qualifications, there are indications that their careers as research scientists remain different in noticeable ways from men's. A recent report (Eady 1999) found that women working in the functional area of Research Scientist/Engineer and the Research Projects area at CSIRO showed equal or greater scientific output for fewer hours spent at work. Women working at the research scientist level have similar career aspirations to their male colleagues for advancement in CSIRO, and they similarly aspire to careers in management. Also, the proportion of post-doctoral positions in CSIRO held by women (30 per cent) is consistent with the 34 per cent of postgraduate students in Science who are female. However, the major difference with respect to outcomes is that women make up only 10 per cent of people employed in the Research Scientist/Engineer functional area; they have less job security, especially those contributing directly to scientific research; and they have very low representation in senior scientific and corporate management positions.

There has long been concern about lack of opportunities for young scientists in Australia and the fact that many go overseas and do not return. Concerns about the 'brain drain' remain as widely voiced as they were some decades ago. The issue is important not only for young Australian Science graduates but also for highly regarded scientists with established reputations, who find themselves unable to continue their work because of a lack of resources. This is part of the message of the campaign launched by universities and industry bodies in October 2000 to gather public support for greatly increased resources to research and development in Australia.

It is difficult to get accurate figures on the number of Science graduates who seek work overseas, and the number who do so as a direct result of limited opportunities in Australia. However, research focused on specific fields of employment and informed estimates suggest a substantial problem. A survey by the Australian Society of Medical Research (ASMR) of members and affiliates found that most Australian (medical) researchers working overseas wanted to return to Australia but they expressed considerable concern about the 'availability of research funds, poor job security and lack of career structure and opportunities in the Australian research sector' (ASMR 2000).

An Occasional Paper of the Federation of Australian Scientific and Technological Societies (FASTS) paints a disturbing picture of the future for Mathematical Sciences in Australia, in part due to the loss of staff in universities (Thomas 2000). The paper refers to 'an irrefutable and unsustainable brain drain in the mathematical sciences' which has already had devastating effects (p. 15). It also emphasises that 'although cutting edge IT desperately needs mathematically-able people trained in both mathematics and IT, the current IT shortage is making it hard for students to resist IT overtures offering top salaries without the mathematical underpinning'. Further, it points to increasing pressure on universities to reduce mathematical requirements in, or prerequisites for, IT degrees (p. 18).

Impact of technology and demands for IT skills

The mainstream and specialised media consistently chart the unprecedented growth of jobs in information technology and the high salaries the industry offers for creative, adaptable people with the requisite skills. The labour shortage in IT has prompted public and private providers to re-think the design and delivery of training courses. At a much broader level, the demand for some level of IT skills is having an impact on a very wide range of jobs, even those that have not traditionally been thought of as having a technical component. However, this may be especially so for Science-related jobs, as new industries arise and the nature of work in many fields is transformed by technology.

Dobson and Calderon (1999) identified the trend for Science graduates to move into information technology jobs, and into areas where their generic skills could be applied. While IT skills are likely to enhance the employment of Science graduates, it has also been suggested that their employment opportunities would be broadened by humanities and business qualifications (*The Weekend Australian*, July 1-2, 2000, 'Postgraduate study opens paths', Weekend Careers). There are those like the former Minister for Science, Barry Jones, who argue strongly from a broader perspective that Science has to be leavened by the humanities and that there is a need for more creativity, speculation and intellectual challenge in both secondary and tertiary education.

Present and future employment outlook

Although many beginning and completing undergraduates have visions of a research job, most Science graduates are not engaged in research and development. They are employed

in a 'range of professional and semi-professional roles, in primary industry, manufacturing and processing, and services … and engaged in teaching, testing, monitoring and other non-research oriented professional work' (Borthwick and Murphy 1998).

Prescott (2000) carries out an annual survey of job vacancies advertised in *The Australian* for the Australian Institute of Physics. A newspaper-based survey has limitations because many more jobs are now advertised online, and some firms recruit graduates direct from universities. However, in regard to jobs for physicists advertised in 1999, Prescott concludes that the employment picture over the past five years has been looking up but the number of jobs available has remained considerably lower than in the decade 1981-1990. Work in areas where the Commonwealth government has direct responsibility remained 'firm', while areas associated with universities — research, teaching, technical positions and the Cooperative Research Centres — improved marginally. The biggest single group of jobs for physicists (27 per cent) were limited term research positions in universities. Other trends were an increase in demand for school physics teachers and very low demand in industry, commerce and geophysics.

The Skilled Vacancies Series (Department of Employment, Workplace Relations and Small Business 1999) reported that more than 40 per cent of professional vacancies were in the computing, building/engineering, and science fields, with computing the largest single grouping of vacancies, accounting for nearly one-third of advertised vacancies. This largely reflects the overall size of the sector.

Strong growth in information technology remains a key element of predicted future trends. *Australian's Workforce 2005: Jobs in the Future* (DEETYA 1995) noted that the strongest employment growth in the early years of the century is expected to be among professional occupations, especially in Computing and Business Information Systems. There is also general agreement that there are shortages of people to fill IT job vacancies, despite the increased numbers being trained and that the vacancies hardest to fill require experienced people rather than new graduates. There would seem to be an opening here for Science graduates with IT skills who have had some employment experience.

The status of Science

Commentators, in and out of universities, have called for moves to enhance the status of Science courses in schools and universities, and the status of Science in the community generally. The Chief Scientist notes that 'at the moment, science is paradoxically viewed as being for the elite and regarded as being lowly paid' (Batterham 2000, p. 23).

Salary levels are an indicator of status and the social value placed on particular knowledge and skills. Wages in the professional sector as a whole continue to grow at a faster rate than in the wider economy. However, for professional scientists, increases vary according to the discipline, with medical scientists reporting the highest increase in 1999-2000 (an average of 6 per cent) and those in the biochemical sciences reporting the lowest (3.5 per cent). Those holding Computer Sciences qualifications reported an increase of 5 per cent, the second highest increase (APESMA 2000). There was little variation in the pattern of

increases in base salary reported by those in the private and the public sector, except for increases of more than 10 per cent, which were almost exclusively in the private sector.

As expected, salaries vary by level of responsibility. They also vary according to job function, with those engaged in management functions being most highly rewarded. Management was followed by sales and marketing, and research and development functions (APESMA 2000). The common pattern was for remuneration to increase most (around 25 per cent) in the first five years of employment, but much less (5-10 per cent) over the next ten years, and to plateau in real terms after around 15 years of professional experience (APESMA, 2000, p. 4). Remuneration also varied by industry, with scientists working in the communications industry reporting the highest mean levels; food industry, chemical and mining industry employees continue to be relatively well remunerated.

What are employers looking for?

A recent study of employer satisfaction with skills of university and TAFE graduates commissioned by DETYA (ACNielsen Research Services 2000) was not able to report separate findings for university Science graduates, as insufficient numbers of employers of such graduates were included in the study. Findings relevant to university graduates in general included the following:

- The capacity for independent and critical thinking is of great importance to employers and seems to be the skill that most sets apart successful from unsuccessful applicants. Employers considered this skill to be evident in some applicants but in general, it was rare.
- The graduate skill deficiencies most commonly cited by employers were: a lack of communication skills; a lack of interpersonal skills; and a lack of understanding of business practice.
- University graduates appear to be performing best as associate professionals.
- Larger businesses consistently rated their new graduates more highly than did smaller businesses. The authors of the report believe this to be confirmation of their hypothesis that larger businesses have greater resources to put into recruitment and have a greater capacity to attract the best graduates.
- The survey confirmed that employers' main reasons for recruiting graduates (as opposed to non-graduates or those with work experience) were: to enable them to train that person in the organisation's procedures; because they are more highly trained or better educated; to provide tomorrow's managers; and to introduce new ideas or fresh thinking into the organisation.
- The need for graduates to demonstrate adaptability and flexibility in order to cope with future changes is important to some employers.

The skills for which Computer Sciences graduates received quite high ratings were time management, comprehension of business practices and academic learning. They received low ratings from employers for ability to benefit from on-the-job training, written and oral

business communication skills, initiative, leadership qualities, personal presentation, numeracy and problem solving skills.

A number of universities and faculties have been conducting their own outcome studies. One institutional survey, for example, found that employers considered interpersonal skills important for all graduates irrespective of discipline area; some differences in other skill areas were apparent according to discipline area. In the analysis of findings from that study, biological science was combined with agriculture, and the physical sciences were combined with engineering and information technology, so it is not possible to present findings for Science graduates separately. However, it is noteworthy that for biological sciences and agriculture, 'knowledge', including technical knowledge, was especially important. Oral communication skills were also thought to be important. Computer literacy skills and multi-media and internet skills were not rated as being important for these graduates. In regard to physical sciences, engineering and information technology graduates, employers rated general work skills as more important than communication skills.

Employer recruitment and selection procedures

The studies above have investigated employers' satisfaction with graduate employees. However, research on how employers recruit and select graduate employees is limited, especially in relation to factors such as the state of the labour market, firm size and industry (Wooden and Harding 1997). The available research suggests that there are some identifiable general patterns of how employers (and recruitment agencies) advertise and select people for positions. Wooden and Harding report that anecdotal evidence suggests there is also variability across organisations and different types of employers in relation to selection practices. From the perspective of the potential employee, and especially in situations where a large number of people apply for a job, there is a relatively high degree of unpredictability.

The Wooden and Harding study was not designed to examine employment in particular professions; nevertheless, two of their general conclusions are of interest in regard to Science graduates. In a series of semi-structured interviews with employers, the authors found that, while the characteristics of successful and unsuccessful applicants tended to vary across different occupations and industries, a high degree of work motivation and commitment, and the ability to contribute positively to work teams were common characteristics. They also found that firms were increasingly opting for highly formalised selection procedures when filling positions.

Summary

Science education in Australian universities shares some of problems faced by other fields of study in responding to the shift to knowledge-based economies and equipping graduates with the skills required to cope with current and future work environments and changing notions of a career structure. There are also some issues unique to Science.

Career patterns and the work activities that Science-trained graduates undertake are more diverse than in the past. The jobs available to Science graduates are being re-shaped and new jobs are being created by rapid technological developments. The trend for Science graduates to move into information technology has implications for the design and delivery of Science courses. Stronger links between industry and universities and expectations of increasing entrepreneurship on the part of teaching and research institutions have had an impact on the courses offered. Universities and Science faculties are responding to the increasing emphasis on vocational outcomes by offering a range of work-related skills courses, especially for postgraduate students.

There are fewer opportunities for those who aspire to the path of a research scientist to do so by pursuing their interests in academia. Concerns about the number of Science graduates who seek work overseas and do not return because of lack of opportunities and appropriate rewards in Australia have surfaced with increasing frequency in recent times.

Most employer surveys point to the importance of generic skills (especially problem-solving, analytical skills and team work) as well as specific subject knowledge in gaining employment. However, less is known about the actual processes of employer selection and recruitment across the whole range of enterprises, large and small, in which Science graduates are likely to be found.

2: THE RESEARCH PROJECT

The project was designed to answer the following specific questions:

- Are Australian universities producing too many science graduates?
- Is there a career structure for science graduates?
- Are many science graduates underemployed?
- Is there more than a small minority of science graduates employed in the area of science in which they were initially educated?
- Are higher degree graduates more restricted in employment avenues than those with a pass degree?
- Do science graduates find worthwhile employment in areas outside of their major discipline?
- Are the skills developed in a science degree valued by employers?
- Are Science graduates seen by employers as having better problem-solving skills than other graduates have?
- What additional training, if any, do Science graduates undertake prior to their first position?

Each of these questions is complex and raises further issues for discussion. The research provides direct answers to some questions; for others, we have used 'proxy' survey questions to identify trends and to explore perceptions, attitudes and views that, together, contribute to providing the best proximate answers. This is a reasonable outcome, given the complexity of the issues raised and the difficulties of providing answers in a single, relatively modest research study.

Methodology

The methodology included the following elements:

- a mailed survey to a sample of Science degree holders who had completed a Pass or Honours Science degree during the past ten years;
- publicity about the project through a range of groups and organisations, together with an invitation to interested people to access the same survey online;
- telephone (and some face-to-face) interviews with Science degree holders;
- telephone consultations with employers in science-related and other areas; and,
- a small number of consultations concerning employment of Science degree holders with other relevant stakeholders such as careers counsellors.

Further details of the methodology, including details of the sample selection, design of the questionnaire, efforts made to contact particular groups of Science degree holders and

comments on other methodological issues, are reported in Appendix 1(a). Here, we summarise key aspects.

Science degree holders survey

The survey was designed to explore employment and study history, nature and type of undergraduate qualification, reasons for choosing science, a range of issues concerned with current employment and other activities, details of qualifications obtained subsequent to the undergraduate degree, and how people view their science degree and employment.

Strategies to identify and contact the target population
The target population was people who completed a first Science degree in the past ten years. The major strategy for contacting respondents was through records held by universities. Six universities were selected by the ACDS to represent the broad range of Australia universities including technological, rural and small metropolitan institutions. We have called the six: Established, International, Rural, New, Innovative and Regional University. Overall, the mailed survey returns represent a return rate of around 21 per cent of deliverable surveys — varying across the six institutions from 16 to 25 per cent — which is about the predicted rate of return for a survey of this nature (Appendix 1, Table A1.2).

Reaching a representative sample of Science degree holders completing their initial degrees over the past ten years presents significant difficulties. Australian universities have limited resources to support sophisticated alumni records and, unlike the United States, graduates are less likely to maintain contact with their *alma mater*. While it is relatively easy to establish contact with a sample of people in recognised science and science-related areas, it is much more difficult to ensure that a broader range of graduates is included, especially those who are no longer, or were never, employed in a science related area.

In order to broaden the range of potential respondents, we publicised the study through a variety of organisations, groups and general contacts — most but not all of which were Science related — and asked people to contact us if they were interested in participating in the study, through interview or filling in a survey. Appendix 1(b) gives a list of the organisations and groups through which the research project was publicised. The interest and enthusiasm for the study expressed by those who contacted us was very noticeable and leads us to suggest that any future study could utilise this approach across a much wider range of sources, including perhaps advertising through major newspapers and other media.

While special efforts were made to ensure that the sample included some overseas fee-paying graduates who had returned to their home country and some Australian graduates now working overseas, we had limited success in reaching either of these two groups. Appendix 1(a) provides further comments on the efforts we made.

Limitations of the sample
Overall, three groups of Science degree holders are under-represented in respondents to the survey. They are: those who have never worked in a science-related area; international

students returned to their home country; and Australian graduates who have gone overseas to seek work. For a full understanding of employment patterns and options for people in these categories, further research focused on these groups is needed.

Notwithstanding the limitations, the total number of surveys received is sufficient to allow us to be reasonably confident in making statements about the types of Science degree holders included in the sample. It also allows us to make comparisons between Science degree holders with different major undergraduate subjects or areas of study.

Interviews with Science degree holders

Telephone interviews and a small number of face-to-face interviews were conducted with 32 science degree holders, contacted through publicising the study through the means described above. The interviews allowed individual career paths, attitudes and decision making to be explored. The interviewees included: research scientists in large organisations and academia; laboratory assistants; people involved in science publishing, data management systems, the finance industry, hospital-based work, sales (not necessarily science-related) and quarantine services; secondary school teachers; and a small number who were not currently employed. Information from the interviews is used in this report to expand on and illustrate findings from the survey.

Employer and recruitment agency consultations

We consulted with representatives from a small number of enterprises and recruitment agencies (Appendix 1(c)). The main focus of the consultations concerned qualities employers looked for in graduate employees in general and Science degree holders in particular, and the reasons they might decide to employ someone with a Science degree in a position that did not relate directly to Science. In addition, we sought general comments about employment for and of Science degree holders. The interviews were essentially exploratory. Interviewees included representatives from both large and small organisations; from other-than-science areas where it is known that science graduates are employed, e.g. the finance industry, IT and publishing; and several large employers not normally associated with science graduates. Those consulted were identified primarily through graduate employer lists, online employment agencies and newspaper articles that referred to employment trends in science and related areas.

Profile of the survey respondents

Appendix 2 provides tables setting out details of the respondent profile. Here we summarise key demographics of the main group of respondents derived from the mailed survey, a total of 1245 respondents.

- In common with similar surveys, the respondents included more females than males (64 per cent compared with 36 per cent).

- The overwhelming majority of respondents (98 per cent) completed their last two years of secondary education in Australia.
- Almost three-quarters of the respondents (74 per cent) completed their secondary schooling in an urban centre; 17 per cent in a regional centre and 9 per cent in a rural area (Appendix 2, Table A2.1).
- 82 per cent went directly from secondary school to university study, with little variation between males and females in this regard (Appendix 2, Table A2.2).
- Consistent with the above, 88 per cent of respondents said that their most usual enrolment load during their degree was full-time.
- In regard to the first undergraduate Science degree completed, 60 per cent of males and 56 per cent of females completed a Pass degree; 34 per cent of males and 40 per cent of females an Honours degree, and 6 per cent of males and 4 per cent of respondents completed a Combined degree (Appendix 2, Table A2.3).
- 37 per cent completed their undergraduate Science degree in the early 1990s (1990-1993), 35 per cent in the mid 1990s (1994-1996) and 28 per cent in the late 1990s (1997-1999) (Appendix 2, Table A2.4).
- Only 3 per cent of the sample were international students while studying for their undergraduate Science degree.
- 11 per cent of respondents completed their degree as mature aged students, ie. they were aged 27 years and over at the time of completion.

Weighting of the sample

National figures suggest that over the past ten years, the proportion of females enrolled in Science degrees varied from around 39 per cent to 42 per cent (DETYA 1999). Since the response of males from the target population (six institutions; graduating between 1990 and 1999) was quite low relative to females, this imbalance was thought serious enough to weight the male respondents by a factor of 2.2. The effect of the weighting brought the male proportion up to 58 per cent, in line with recent Science enrolment indicators.

If we failed to account for this imbalance, mean scores for all items where gender differences are significant would be falsely skewed toward the figures for female respondents. An initial analysis showed that this was most crucial in areas such as income, where the average income for full-time working males was significantly higher than that of females. The unweighted average is unduly affected by the presence of more female respondents and biased downwards; after weighting, we are more confident of a true figure of average full-time working income for all Science graduates. Weighting the sample means that generalisations and inferences about the whole population are not unduly affected by the disproportionately greater numbers of female respondents.

3: WHAT HAVE PEOPLE DONE WITH THEIR SCIENCE DEGREES?

This Chapter focuses on what respondents have done with their Science degrees. In doing so, we discuss how findings are relevant to the question of whether Australian universities are producing too many Science graduates. This is a complex question and a comprehensive response would need to take account of sometimes widely differing perspectives and interests — political, educational, social and economic.

A project such as the research reported here cannot canvass this range of perspectives. It does, however, contribute to the discussion of the issue in several ways. In this chapter we examine some economic factors, such as respondents' levels of employment, the type of employment they are in and their income levels as a result of tertiary study. We also refer briefly to respondents' contributions to their communities as a result of their Science training. In later chapters we explore other relevant factors. On the basis of findings in each of the chapters, we return to the question in the concluding chapter.

The broad picture

In general, the findings confirm that a Science degree, in common with most other tertiary qualifications, provides an effective entry into employment for the majority of degree holders, although not necessarily in an area directly related to Science. Unemployment rates are generally low, consistent with the fact that tertiary education brings a clear individual benefit, reflected in generally lower than average rates of unemployment for tertiary trained workers.

Eighty per cent of survey respondents are working full-time and 12 per cent, more women than men, are working part-time. A further 3 per cent are unemployed and 6 per cent are not in the labour force. Of the full-time workers, 19 per cent said that they are seeking an alternative job. Just under one-quarter (23 per cent) of the part-time workers are seeking full-time work with the remainder of part-time workers saying that they are content with working part-time.

Around 30 per cent of respondents said that their current (or most recent) job was their first job since completing their undergraduate science degree. For most other respondents, it was not their first job. Six per cent are in the same job they had either before or during their undergraduate Science degree, which most likely indicates that this latter group have been studying part-time while continuing in the job.

Most of the respondents appear to regard their employment as having some career orientation, although only 41 per cent said their job was a 'desired career position', suggesting that respondents' careers are still 'in process' (a point we discuss in some detail in the following Chapter). A slightly larger proportion (44 per cent) said that their job was

a 'stepping stone to a desired career position', and the remaining 15 per cent said their employment was an 'interim job not leading to a career position'. Differences between male and female respondents were minimal in this regard.

Science and other than Science-based employment

Respondents are relatively evenly distributed between people who said they work in a Science-based organisation (35 per cent); in an organisation that is broadly Science-based (33 per cent) and in an organisation that is not Science-based (32 per cent). There are no differences between males and females in this regard. The finding reflects the variety of types of organisations in which Science degree holders find employment.

We categorised occupations according to:
- level (manager, professional, technical) and
- broad areas of work, with an emphasis on those of special interest to this project (Science, IT, Medical/Health, Science Education, Other).

Of all respondents employed, full-time or part-time, 39 percent are working in a Science job at manager, professional or technical level. As might be expected with the age group, most Science jobs are at the professional level. Almost as many people overall are in managerial, professional or technical jobs in other areas (33 per cent), and 16 per cent are in IT jobs (most at the professional level). Table 3.1 shows that there are minimal differences in the distribution for all those who are employed, and for those employed full-time.

Despite many similarities, there are several key differences between the types of positions held by males and females:

- Full-time employed males are much more likely than females to be IT professionals and females are more likely to be Medical/Health professionals;

- Females are more likely than males to be working as professionals in areas other than Science, IT and Medical/Health;

- Females are a little less likely than males to be working at a professional level of any sort, and slightly less likely than males to be working in a Science area (Table 3.1).

16

Table 3.1: Current occupations of employed male and female respondents (%)

Occupation category	Employed (FT and PT) N=1154		Employed FT N=958	
	Males	Females	Males	Females
Science Manager	4	4	5	4
IT Manager	1	1	1	1
Other Manager	6	8	7	9
Science Technical	6	7	6	7
Other Technical	8	11	8	11
Science Professional	25	21	25	22
IT Professional	19	8	20	10
Medical/Health Professional	5	11	6	10
Science Education Professional	5	5	4	5
Other Professional	15	20	15	20
All other work	5	5	4	2

Employment rates

Overall, 93 per cent of males and 90 per cent of females in the survey group are employed. Calculation of employment rates includes in the total population people who are not in the labour force. Unemployment rates, discussed later in this Chapter, exclude those not in the labour force. Employment rates for males and females who completed their first degree in the early, mid and late 1990s are as might be expected. There is no gender difference for those who graduated in the mid-1990s. However, there is a lower rate of employment for women graduating in the early 1990s (consistent with the fact that more women than men are engaged with child-rearing responsibilities); and a lower rate for more recently graduated women, suggesting that women find it somewhat more difficult than men to find their first job.

Major areas of study

Respondents were asked to identify up to two main subjects or areas of study in their undergraduate Science degree. Major areas of study may include one subject area only, e.g. Life Sciences, indicating that one or both main areas were Life Sciences, or two areas, e.g. Life and Physical.

The highest employment rates were recorded for those whose major area of study were Computer Sciences (99 per cent), Mathematical Sciences (93 per cent) and Computing and Maths (94 per cent). The lowest rates were recorded for those whose major areas of study were Life and Medical/Health (86 per cent), Maths and Physical (88 per cent), and Life and Physical (88 per cent). Other combinations were around the mean of 92 per cent. Females had a lower employment rate than males for all areas except Computing and Maths, Life and Physical, and other Science combinations (Appendix 3, Table A3.1).

Income levels

Overall, one-half of all part-time and full-time employed respondents (the 'middle' half) were earning between $25,000 and $75,000 annually. A further 25 per cent were earning less than $25,000 and the other 25 per cent were earning more than $75,000. Most of the following tables concerning income levels refer to full-time workers only.

Table 3.2: Median (gross) annual incomes of full-time employed respondents with different major areas of study in their undergraduate Science degree, N=958

Major area of u/g Science degree	$
Computer Sciences	75,000
Computing and Maths	62,000
Maths and Physical Sciences	56,000
Mathematical Sciences	50,000
Medical/Health Sciences	50,000
Physical Sciences	47,000
Life and Physical	47,000
Life Sciences	45,000
Life and Medical/Health	45,000
Science Combinations (other than those listed)	42,000

General Science (inc. Psychology, Geography)	42,000

Table 3.2 shows the annual median income of respondents employed full-time according to their initial major area of study. The higher salaries of respondents who did computer-related studies are clearly evident.

In a further analysis, we divided respondents into three groups according to income, with approximately equal numbers in each group. We refer to these as the 'bottom third', 'middle third' and 'top third' income quantiles. The terms bottom, middle and top are relative; overall, respondents' median income is high compared to the total Australian population.

It proved difficult to divide the full-time income data into three equal categories of 33.3 per cent each as there are several income 'spikes' (nine per cent of respondents reported an income of exactly $40,000 and nearly ten per cent of exactly $50,000). Since the 33.3 and 66.7 percentiles fall close to the spikes, the decision as to which category the amounts fall into is arbitrary. Tables which include income quantiles therefore use the best approximation of equal categories. In the following sections, we are confident of our general conclusions as the overall patterns did not vary significantly, despite slight variations in the proportion of respondents included in each income category.

Gender

Table 3.3 gives the income distribution for males and females working full-time. Females working full-time are over-represented in the bottom third income group (42 per cent compared with 31 per cent) and under-represented in the top third income group (25 per cent compared with 38 per cent) (Appendix 3, Table A3.3). This discrepancy is apparent for those completing their degree in the early, mid and late 1990s. An analysis of variance showed that the difference were statistically significant for each of the three time of degree completion periods.

Table 3.3: Income distribution of males and females working full-time (%), N= 958

Income	Males	Females
Up to $20,000	3	2
$20,001 to $30,000	5	6
$30,001 to $40,000	19	31
$40,001 to $50,000	29	30
$50,001 to $60,000	14	14
$60,001 to $80,000	15	12

$80,001 +	16	6

Time of degree completion

As might be expected, those who completed their degree in the early 1990s had a higher median income ($51,000) than those completing in the mid 1990s ($50,000) and the late 1990s ($43,000). There is evidence of a general progression from a lower to a higher income across the ten years for full-time employed respondents (Table 3.4); however the Table also shows that 20 per cent of those who completed their undergraduate Science degree in the early 1990s were in the bottom third income group and 21 per cent of those who completed in the late 1990s were in the top third income group. The discussion of career patterns in Chapter 4 indicates that a number of factors contribute to this diversity, including the types of jobs people go into, the area of Science in which they are employed and the timing of decisions to undertake further study.

Table 3.4: Income levels of full-time employed respondents who completed their undergraduate Science degree in the early, mid and late 1990s (%), N=958

U/g degree Completed	Bottom third income group	Middle third income group	Top third income group
1990-1993	20	37	43
1994-1996	37	32	31
1997-1999	56	23	21

Level of qualifications

If we compare the incomes of respondents with undergraduate Pass degrees, Honours degrees and Combined degrees, those who did a Combined degree are most likely to be in the top third income quantile, and Pass degree holders are somewhat more likely than Honours degree holders to be in the top third (Table 3.5). Combined degrees including Science are relatively new and hence the group with a Combined undergraduate degree is small compared with Pass and Honours students. It will be important to monitor the employment patterns and destinations of Combined and double degree holders in the future.

Table 3.5: Income levels of full-time employed respondents with Pass, Honours and Combined undergraduate degrees (%), N=958

U/g degree Completed	Bottom third income group	Middle third income group	Top third income group
Bachelor Pass	35	31	34
Bachelor Honours	38	33	29

Combined degree	23	30	47

Table 3.5 does not take account of any subsequent qualifications undertaken in Science or other areas, and the Pass degree graduates group includes some who are likely to be in well-paying IT positions. The following Tables (3.6 to 3.9) help to tease out the impact of these factors. We have excluded from the analysis a small group who are still in the process of postgraduate study, in order to avoid possible bias by including them in either the undergraduate or postgraduate group.

First, respondents with undergraduate Science qualifications only (Pass, Honours and Combined degrees) and those with postgraduate qualifications in other than Science are most likely to be in the top third income group. Respondents with postgraduate Science qualifications and postgraduate qualifications in both Science and other than Science areas are least likely to be in the top third income group (Table 3.6). The difference between the two groups of special interest here, those with undergraduate Science degrees and postgraduate Science degrees, is statistically significant.

Table 3.6: Income levels of full-time employed respondents with undergraduate Science degrees and postgraduate qualifications (%), N=790

Qualifications	Bottom third income group	Middle third income group	Top third income group
U/g Science qualification only	35	23	41
P/g Science qualification	27	43	29
P/g qualification other than Science	34	29	37
P/g quals. Science & other than Science	41	29	30

Second, if we exclude from the analysis respondents who have done Computer Sciences as a major area of undergraduate study (because we know that their incomes are likely to be higher), outcomes for respondents with undergraduate Science degrees and postgraduate Science qualifications are somewhat different from those indicated in Table 3.6.

Table 3.7 shows that, with the exclusion of Computer Science graduates, respondents with undergraduate Science qualifications are only slightly more likely to be in the top third income group and considerably more likely to be in the low third income group, compared with those with postgraduate Science qualifications. Overall, the findings suggest that a postgraduate Science qualification operates to keep people out of the lowest third income group, but it does not necessarily place them in the highest third income group. In fact, our four qualification groups were about equally likely to be in the top third income group. Respondents with undergraduate Science qualifications only tend to be more dispersed as far as income is concerned, and more likely to be in either the top or the bottom third income group. (It needs to be noted that the three income categories have been re-

21

calculated for Table 3.7 and the cut-off points are slightly different from those in Table 3.6.)

Table 3.7: Income levels of full-time employed respondents with undergraduate Science degrees and postgraduate qualifications, excluding those with Computer Sciences as a major area of undergraduate study (%), N=679

Qualifications	Bottom third income group	Middle third income group	Top third income group
U/g Science qualification only	42	24	34
P/g Science qualification	29	39	32
P/g qualification other than Science	37	30	34
P/g quals. Science & other than Science	42	26	31

Table 3.8 (using the same income cut-off points as Table 3.6) shows the relationship between level of qualifications and level of income for full-time employed respondents who completed their degree in the early and mid 1990s. Those who have postgraduate qualifications in both Science and in another area have been excluded from this analysis. The Table shows that respondents in the top third income group are more likely to have graduated in the early 1990s than the mid 1990s. For respondents completing in the early 1990s, 59 per cent with undergraduate Science degrees only are in the top third income group. For those completing in the mid 1990s, the figure is 47 per cent. People with postgraduate qualifications in other than Science-based areas who completed their undergraduate Science degrees seven years or more ago, also fare relatively well.

Table 3.8: Income levels of full-time employed respondents completing their undergraduate degree in the early and mid 1990s (%), early 1990s N=278; mid 1990s N=260

Qualifications	Bottom third income group		Middle third income group		Top third income group	
	1990-1993	1994-1996	1990-1993	1994-1996	1990-1993	1994-1996
U/g Science qualification only	18	32	23	21	59	47
P/g Science qualification	11	41	54	34	35	26
P/g qualification other than Science	21	39	29	33	49	28

There are a number of factors that may contribute to these findings. Some of the high income Pass and Honours degree holders are likely to have worked their way up from

lower incomes, gaining considerable experience and being promoted over a period of years. This group again includes some respondents who have undergraduate degrees in Computer Sciences who command high incomes. The group with other than Science postgraduate qualifications includes a proportion of people in high income areas such as Business and Management. On the other hand, some respondents with postgraduate Science qualifications are Post-doctoral Fellows on relatively modest incomes.

Finally, in this series of Tables concerning level of qualifications and income levels, Table 3.9 shows income levels of a selected group of respondents. Respondents with Computing Science as a major area of undergraduate study are excluded. In addition, the group either graduated in 1997 or earlier, or if they have done a postgraduate degree, they completed it in 1997 or earlier. They have, then, had between three and seven years to establish themselves in employment, even if they have studied since they graduated.

Table 3.9 again shows that respondents with postgraduate Science qualifications are least likely to be in the lowest income group but their qualifications do not necessarily put them in the highest income group. The comparative success (as far as income levels are concerned) of respondents with undergraduate Science qualifications and, it needs to be stressed, some years of workforce experience, is evident. Forty-four per cent of respondents in this group were in the top third income group, compared with 32 per cent with postgraduate qualifications in Science and 38 per cent with postgraduate qualifications in other than Science areas (Table 3.9). Differences between median incomes for the three groups are, however, not great. The median income for those with basic Science qualifications only is $50,000; for respondents with postgraduate Science qualifications it is $48,000 and with postgraduate qualifications in other than Science areas, $45,000.

Table 3.9: Income levels of full-time employed respondents (excluding those with Computer Sciences as a major area of undergraduate study) with three years or more employment since undergraduate or postgraduate completion (%), N=463

Qualifications	Bottom third income group	Middle third income group	Top third income group
U/g Science qualification only	30	26	44
P/g Science qualification	25	43	32
P/g qualification other than Science	30	32	38

Major areas of study

Respondents whose undergraduate study was in Computer Sciences, Computers and Maths, and Maths and Physical Sciences are most likely to be in the comparatively high income group. Conversely, people from a Life and Medical/Health Sciences major area of

study were least likely to be in the top third income group. Forty per cent or more of those who studied Life Sciences, Medical/Health Sciences, and Life and Medical/Health Sciences are in the comparatively low income group.

The high percentage of respondents in the top third income quantile who had studied Computer Sciences at the undergraduate level held good for females as well as males. However, there were other variations according to gender. For example, in the Life Sciences, a major area of study which attracts more females than males, 51 per cent of females, but only 36 per cent of males were in the bottom third income group.

Unemployment rates

Unemployment rates were relatively low for most categories of respondents. (In the calculation of unemployment rates, those not in the labour force are excluded from the total population.) The overall unemployment rate was 3 per cent for both males and females. As we might anticipate, more recent graduates (1997-1999) had a higher rate of unemployment than those who completed their undergraduate degree in the early 1990s (4 per cent compared with 2 per cent). The 'mid-1990s' group (completing 1993-1996) had an unemployment rate of 3 per cent. No gender differences were apparent for those completing at different times during the 1990s.

Unemployment and type of course

We found that respondents who said their undergraduate degrees had one major area of study had a lower unemployment rate (1 per cent) than those who said their degrees had two or three main areas of study (4 per cent), suggesting that more focused degrees led to lower unemployment. Respondents who judged their degree to be 'generalist', i.e. taking courses from all over the faculty, had an unemployment rate of 2 per cent. The lower rate for those who judged their degree to have one major area of study compared with two or three areas was evident for graduates who completed in the early, mid and late 1990s.

There was no discernible difference in unemployment rates between those who said their degree was 'a tightly structured course with limited subject options or few electives' and those who did not. Given the previous finding that respondents who said their degree was focused on one major area had lower unemployment rates than those with degrees with two or three major areas of study, it might be expected that those who saw their degrees as 'tightly structured' would have a lower unemployment rate than those who did not. However, the finding of no difference between unemployment rates accords with a further analysis that showed no consistent relationship between respondents' perceptions of the extent of focus in their degree and whether it was tightly structured or not.

Unemployment and major areas of study

To explore whether the initial area of study has any impact on unemployment, we compared unemployment rates for different initial major areas of study in the

24

undergraduate degree, based on respondents' identification of their one or two major areas of study as previously explained. The results are given in Table 3.10.

The Table shows lower than average rates of unemployment for Computer Sciences, Mathematical Sciences and Life and Physical Sciences. Although quite high rates of unemployment for some groups are indicated (notably females with a Physical Sciences/Maths background and males with a Computing/Maths background, the number of respondents in both these groups is relatively small and the findings should be treated with caution.

Table 3.10: Unemployment rates for males and females, according to major area of study of undergraduate Science degree (%), N=1245

Major area of u/g science degree	Males	Females	Total
Computer Sciences	0	2	1
Life Sciences	4	2	3
Mathematical Sciences	0	3	1
Physical Sciences	4	2	4
Medical/Health Sciences	0	5	3
Computing and Maths	9	0	6
Life and Physical	3	2	2
Maths and Physical	0	10	3
Life and Medical/Health	6	4	4
Science Combinations	0	9	4
General Science	5	3	3

Median incomes and unemployment rates

The following set of Figures shows both median incomes and unemployment rates for selected demographic groups. Figure 3.1 shows the similar rate of unemployment for males and females but the higher median income of males.

Figure 3.1: Median income and unemployment rate: males and females
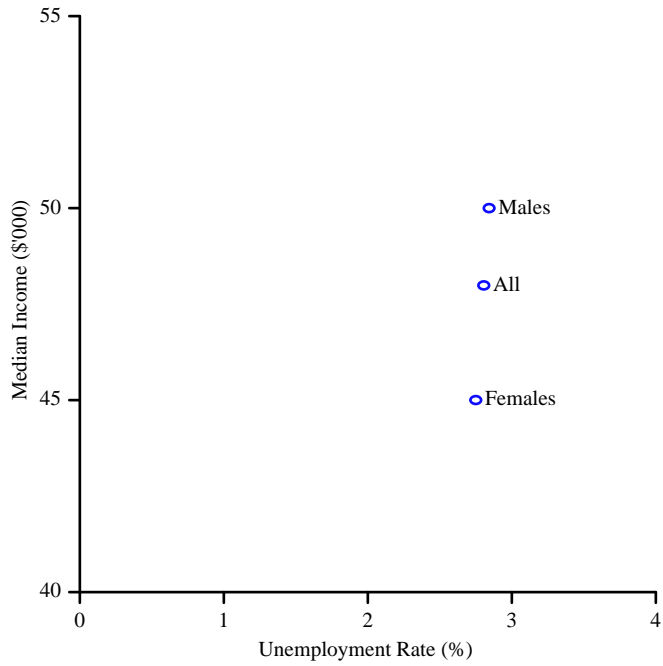
Figure 3.2 Median income and unemployment rate: gender and time of degree completion
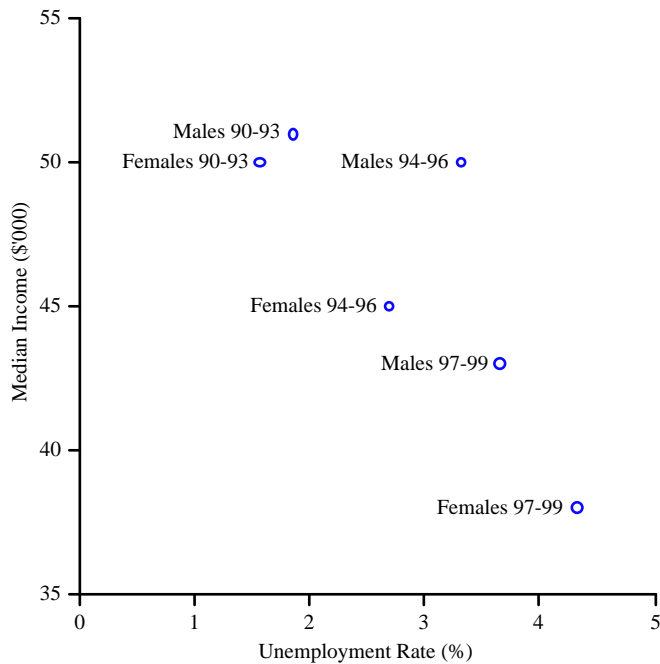
Figure 3.2 shows the higher median incomes and low unemployment rates for both males and females graduating in the early 1990s, compared with lower median incomes and higher rates of unemployment for more recent graduates, especially females. It also indicates the discrepancy referred to earlier between male and female incomes for those graduating in the mid and late 1990s.

Figure 3.3 shows higher than average median incomes for respondents with Combined degrees, compared with Pass and Honours degrees, and lower than average unemployment rates for degrees that respondents perceived as concentrating on one major or area of study, compared with undergraduate degrees that had two or more main areas of study, or self-defined generalist degrees where courses are taken from all over the faculty. It will be remembered that these categories are derived from responses to a question concerning the nature of respondents' undergraduate degree.

Figure 3.3: Median income and unemployment rate: type of undergraduate degree (respondent-defined)

27
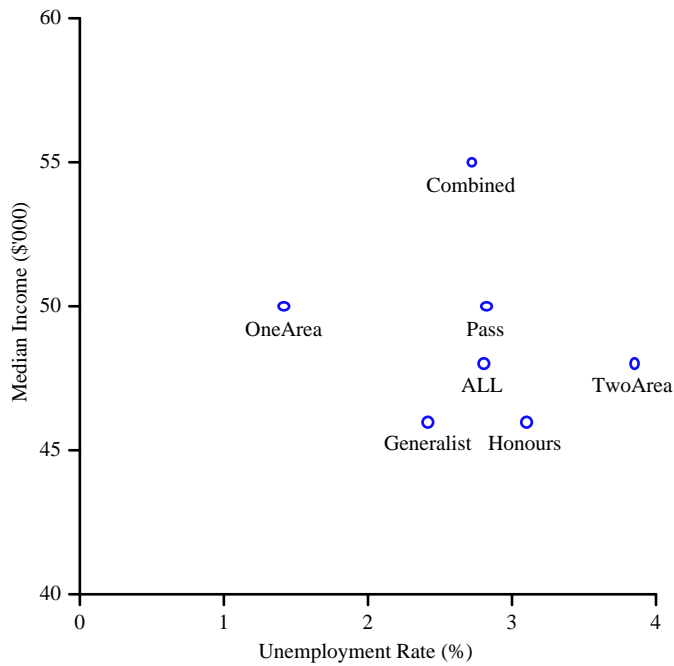
NB: 'Generalist', 'one area' and 'two areas' categories are respondent-defined and based on responses to a survey question concerning how they perceived their undergraduate degree.

Finally, Figure 3.4 clearly shows the higher median income for respondents from a Computer Sciences major area of study in their initial Science degree.

Figure 3.4: Median income and unemployment rate: areas of undergraduate study
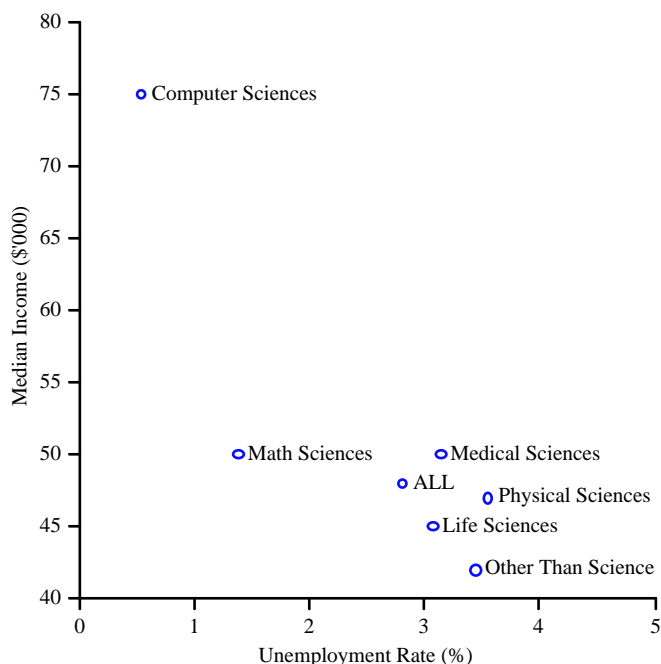
NB: 'Other than Science' includes areas of undergraduate study not listed under Science in the ABS categories but which come under Science faculties in institutions.

Professional and community involvement

There is a broader aspect to what people 'do' with their Science degrees that goes beyond employment. Some graduates contribute their specialised knowledge through professional and community involvement, as well as through their working life. We were interested to explore the extent of respondents' involvement in such activities. Just under 40 per cent of respondents are members of a Science-related professional organisation and 34 per cent have attended a conference of a Science-related organisation in the last 12 months.

We also asked respondents whether they belonged to, or have ever been involved with, any community or voluntary organisation that benefits or could potentially benefit from their science training. Twenty-three per cent of respondents answered 'yes', with a slightly greater percentage of females than males acknowledging such community involvement. Respondents graduating in the early 1990s were more likely to be involved than those who had graduated more recently.

A very wide range of groups, organisations and activities were included, and it was apparent from the comments made that the activities were a very important part of the lives of some respondents. Included were the large, well-recognised groups such as the Australian Conservation Foundation, Greenpeace, the Australian Wilderness Society and the Australian Trust for Conservation Volunteers; bush re-generation and landcare groups; anti-nuclear groups; Friends of the Zoo, field naturalist groups, astronomy groups, National Parks volunteers, School Councils, welfare groups, rural fire brigades, and a host of other voluntary and community groups, not necessarily directly related to any field of Science

but to which respondents obviously believed they brought special expertise as a result of their interest in Science and the skills and knowledge they had gained in a Science degree.

Summary

The findings confirm that a Science degree provides an effective entry into employment, although not necessarily to a Science-related area. Unemployment rates in the group sampled are generally low. This accords with the general benefit of doing tertiary study, compared to lower levels of qualification. The highest employment rates are for those whose major area of undergraduate study was Computer Sciences, Mathematical Sciences and Computing and Maths. The lowest are for those who combined Life Sciences and Medical Health Science, Maths and Physical Sciences, and Life and Physical Sciences. Not surprisingly, the unemployed group were more likely to be recent graduates.

Most of the respondents are working full-time, and of those who are part-time, most are women. A high proportion of those surveyed—about a third—are not working in Science-based organisations. For most of the respondents their position was 'a desired career position' or a 'stepping stone' to a desired career position: a minority regarded their job as 'interim'. The responses illustrated the great diversity of possible activities in which Science graduates are involved. Those in Science occupations are generally at the professional or technical level, while those in broadly-based Science fields are more likely to be in managerial positions in addition to professional and technical level positions. The sub-group of IT workers are mostly in professional positions.

Gender differences are marked in some important respects with females more likely than males to be Medical/Health professionals, or working in a professional area other than Science, IT or Medical/Health. Females are under-represented at the higher income levels and over-represented at the lower levels, irrespective of whether they completed their degree in the early, mid or late 1990s.

Unemployment rates were generally low for most of those surveyed. Graduates in Computer Sciences, Mathematical Sciences and Life and Physical Sciences had lower than average rates of unemployment. Not surprisingly, the unemployed group were more likely to be recent graduates.

Overall, income levels are related to the time at which the undergraduate degree was completed, with a general progression from a lower to a higher income level over the ten year period for full-time workers. However, there were noticeable variations to this pattern. The area of undergraduate study, the presence of additional qualifications, and the number of years since any additional qualification, were important determinants of income level. The study confirmed that those who did Computer Sciences at the undergraduate level generally had a higher median income than did respondents with other main areas of undergraduate study.

4: CAREER PATHS FOLLOWING A SCIENCE DEGREE

This Chapter begins with a brief comment on the reasons why respondents chose a Science degree, since they are likely to have an impact on overall work and career orientation at an individual level. We then discuss findings that contribute to an understanding of career structure. Finally, we draw on survey and interview data to identify career patterns.

Choosing to do a science degree

The great majority of respondents enrolled in a Science degree because they had a genuine interest in Science. This finding is in accord with reasons for enrolling in university study in general, reasons that appear to have varied little over time. A recent study of first year students across all fields of study found that interest in a field of study was cited as important by 96 per cent of students (McInnis, James and Hartley 2000). The present study indicated that Science degree graduates were less certain that wanting to work in a Science-based profession was an important reason for choosing to study Science, although around two-thirds agreed that it was.

Around 70 per cent of respondents said that the undergraduate science course they did was their first preference when commencing university study. For a further 20 per cent, it was their second choice. Courses in the Medical/Health area predominated as preferred courses for those who did not have Science as their first choice. Medicine was the single most frequently preferred course, with approximately 21 per cent wanting to study Medicine; 17 per cent would have preferred an Engineering course and 8 per cent wanted to do Physiotherapy.

Information from the interviews is consistent with the survey findings. Interest in Science and wanting to work in a Science-based profession were major motivations for enrolling in a Science degree and less than half of the interviewees started out with a specific job in mind. Interest in Science or in a particular field of Science was sometimes coupled with the fact that they had enjoyed the subject at school and done well in it. The influence of positive school experiences in young people choosing to study Science reinforces the importance of creative and challenging Science teaching in schools. Interestingly, several interviewees said that they specifically chose a Science degree because of its general nature and because it therefore offered a wide range of career options. Despite general interest in Science being a strong motivator for choosing science at university, and most *not* having a clear idea of what they wanted to do when they graduated, some of the interviewees nevertheless revealed strong and clear occupational goals.

The first job

Some 30 per cent of our respondents were in their first job since completing their undergraduate Science degree. Around 42 per cent of them said their job was a 'desired

career position'; 47 per cent regarded their position as a 'stepping stone to a desired career position'; and 10 cent said it was an 'interim job not leading to a career position'. While we do not know what implications the word 'career' has for each individual — contemporary meanings of the word could well be a research project in itself — the finding suggests that most respondents have at least stepped into some kind of job progression.

Forty per cent of these 'first-jobbers' were in Science positions, the largest proportion (27 per cent) in a Science professional position. Fourteen per cent were in IT positions and 15 per cent were in other than Science or IT positions.

We know from the Graduate Destination Surveys (e.g. GCCA 1998) that a significant proportion of Science graduates with a Pass degree initially go into employment which is not Science related, although there are variations according to the course of study undertaken. Such graduates are under-represented in the present survey. Our interviews with Science degree holders revealed diverse experiences in getting a first job and included several who say they had great difficulty in getting an initial job other than casual and fill-in work often unrelated to their Science training. Luck and having the right networks were important for some; strong career goals played a part for others. Two brief case studies illustrate difficult beginnings.

Box 4.1: Filling in time
The employment market for teachers, severely affected by government policies in Victoria in the early 1990s, had a major impact on Kirsty's initial job experiences. Kirsty had always wanted to be a teacher but she chose to do a Science degree first rather than a four year Diploma of Education, in order to allow herself more options. When she started the degree in the early 1990s, employment prospects in teaching were good but by the time she completed her degree, the only jobs available were short term teaching contracts, sometimes only two or three months long, and emergency teaching. Fortunately, she has had only a short period of unemployment since she graduated but for much of the time she has had to fill in the time between teaching contracts with sales jobs. She graduated in 1993 and only in 1999 did she obtain a relatively long term teaching contract. She has found the experience very frustrating but has stuck at teaching because she really loves it.

Major areas of study

The following series of Figures show the areas of current employment of respondents who studied in selected subject areas in their undergraduate degree. Figure 4.1 shows the strong relationship between Computer Science studies and IT professions.

Figure 4.1: Occupation outcomes for Computer Sciences graduates (% of all employed Computer Sciences graduates) N=111

34
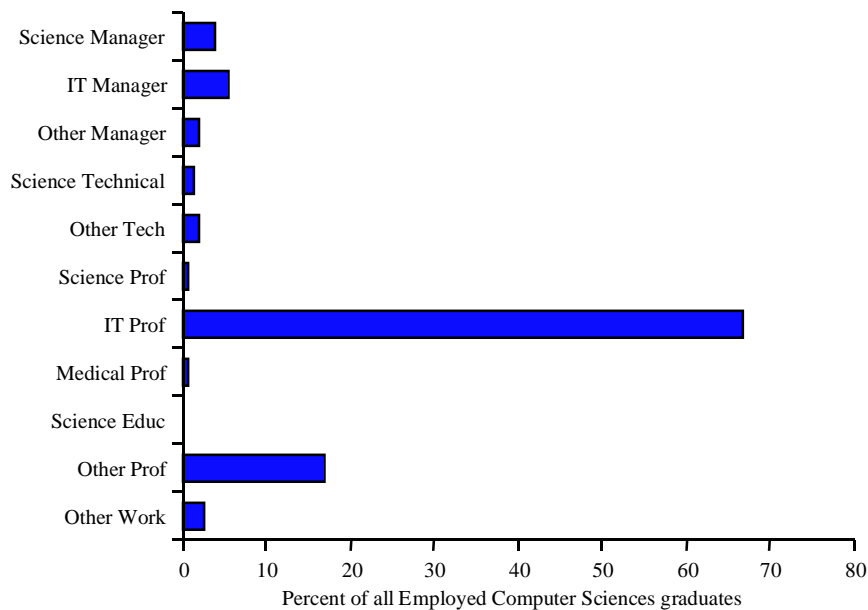
Figure 4.2 shows that respondents from the Life Sciences major area of study were in a much wider range of work across managerial, professional and technical levels.

Figure 4.2: Occupation outcomes for Life Sciences graduates (% of all employed Life Sciences graduates), N=373

Percent of all employed Life Science graduates
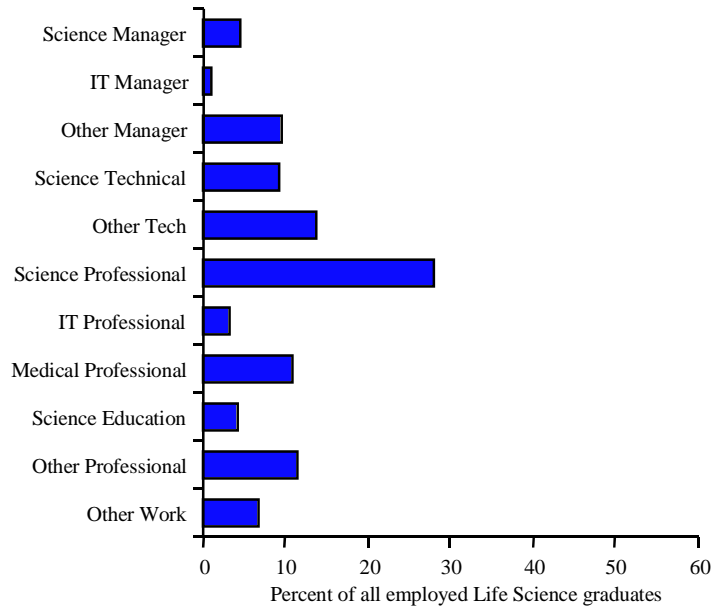
Figure 4.3: Occupation outcomes for Physical Sciences graduates (% of all employed Physical Sciences graduates), N=177

Percent of all employed Physical Science graduates

35
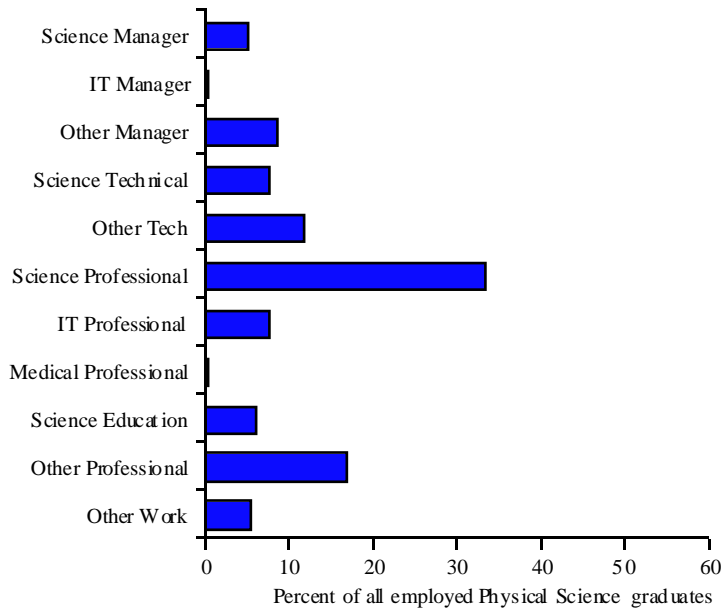
Physical Sciences graduates were predominantly in professional Science jobs, but were also spread across areas and levels of responsibility (Figure 4.3).

Figure 4.4: Occupation outcomes for Mathematical Sciences graduates (% of all employed Mathematical Sciences graduates), N=49

Percent of all employed Mathematical Science graduates
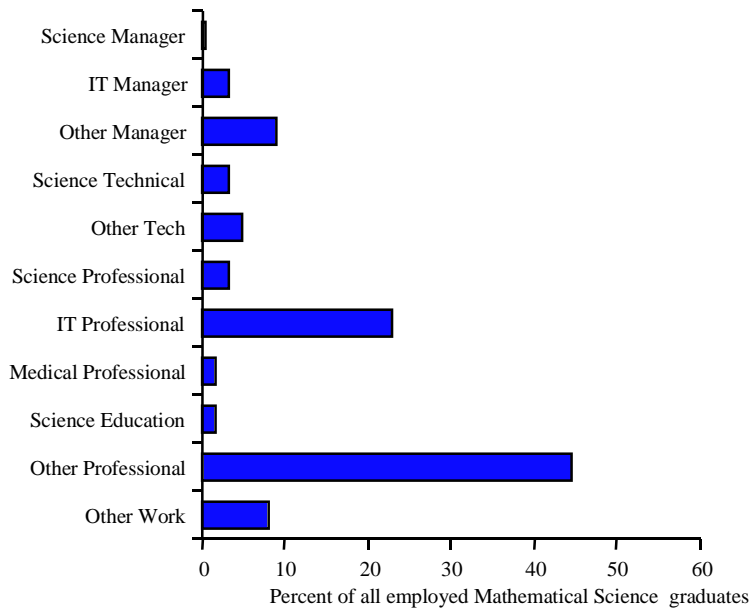
Figure 4.5: Occupation outcomes for Medical/Health Sciences graduates (% of all employed Medical/Health Sciences graduates, N=49

Percent of all employed Medical/Health Science graduates

36
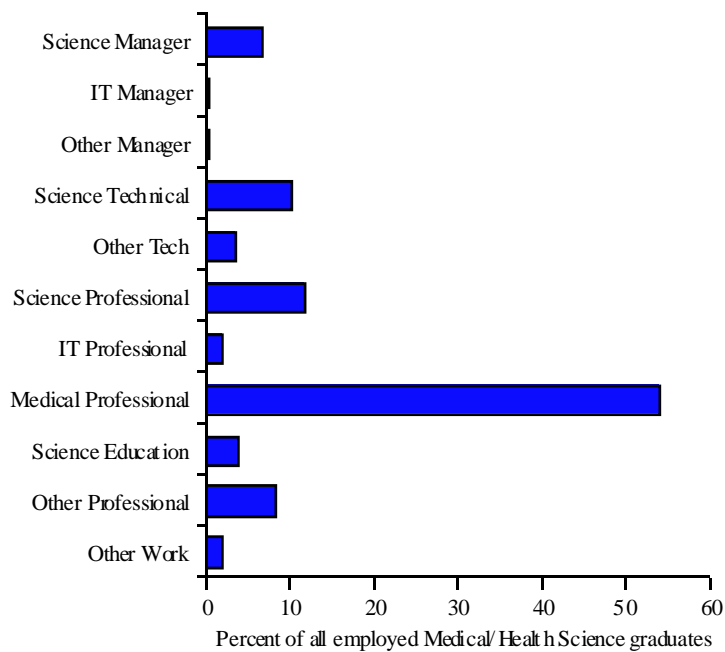
Respondents from the Mathematical Sciences were predominantly in professions other than Science, IT, Science Education and Medical/Health, and thinly spread across other areas (Figure 4.4). Medical/Health Sciences studies led to Medical/Health professional jobs in the main (Figure 4.5). Finally, General Science graduate respondents (the category includes those studying Psychology and Geography) had positions in professional and managerial areas other than Science, IT, Science Education and Medical/Health (Figure 4.6).

Figure 4.6: Occupation outcomes for General Science graduates (% of all employed General Science graduates), N=92

Percent of all employed General Science graduates
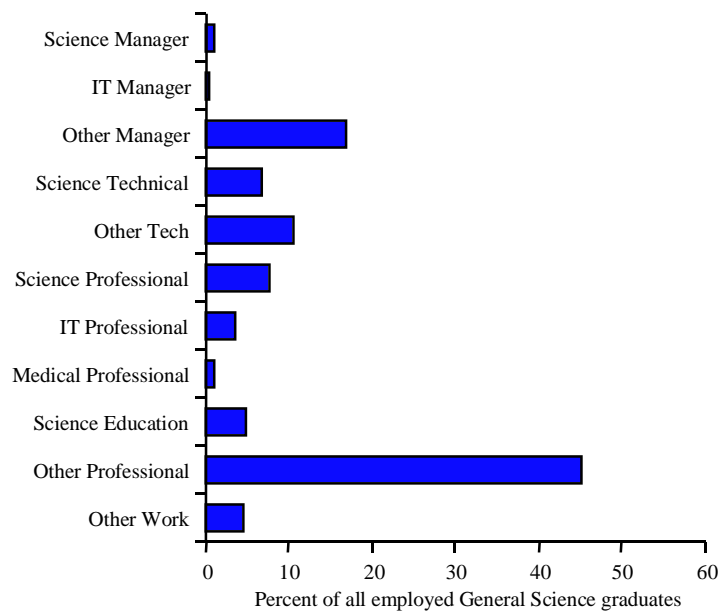
Desired career position or stepping stone?

Being in a desired career position appears to be related to both the level and type of a respondent's position. Over 60 per cent of IT Managers, IT professionals, Medical/Health professionals, and Science Educators say they are in a desired position and around 50 per cent of professionals in areas other than Science, IT and Medical/Health say they are.

Just over 50 per cent of Science technicians regard their jobs as a stepping stone to a desired career position, which is perhaps to be expected. However, nearly 60 per cent of Science professionals are also in the 'stepping stone' category, indicating they expect to move to a better, more rewarding or different position in the future. Occupation groups which include significant proportions of people who see their job as an 'interim job not leading to a career position' are Science technicians, and technicians in other than IT, Science and Medical/Health areas.

Identifying career patterns

One of the problems with any analysis of career pathways is that the pathways and patterns are likely to change over time, especially with changes in the labour market. There is no guarantee that the career patterns of graduates in the future are going to be the same as those of respondents described here. We can only assume that there will be similarities.

The survey and the interview data provide a number of approaches to identifying whether there are discernible patterns in respondents' careers to date.

1. Distribution of professional areas and levels

Figures 4.7 to 4.12 show the percentage of respondents at different job levels across the ten years since graduation. In these figures, all employed (full-time and part-time) respondents are included in the findings for the first year, and at each subsequent year, the total number of respondents is smaller. This is because all our respondents have a first year post their undergraduate degree, but far fewer have a tenth year post their undergraduate degree. (It will be remembered that approximately equal proportions of respondents completed their undergraduate degree in the early, mid and late 1990s.)

Figure 4.7: Employment distribution of SCIENCE GRADUATES by time since graduation
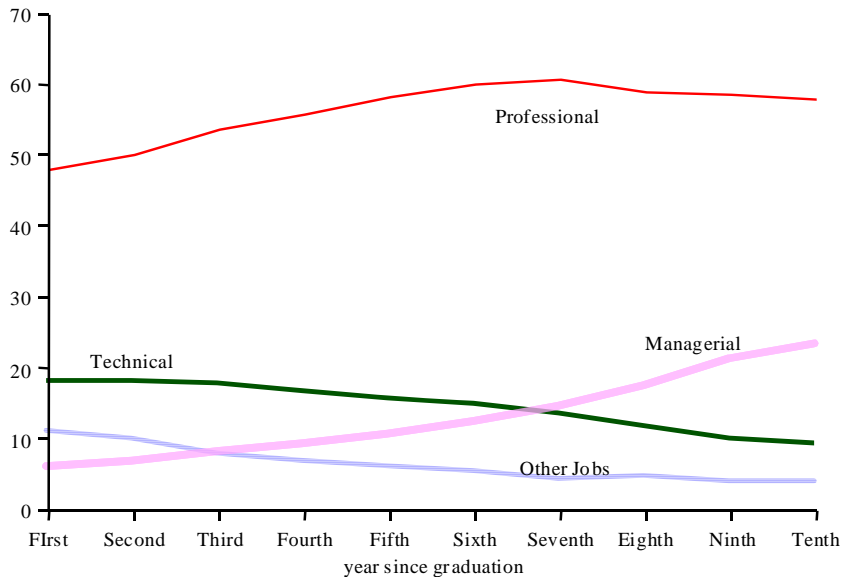
Figure 4.7 shows evidence of a general career progression for Science graduates. While the percentage of respondents in professional jobs was initially relatively high and tended to rise slightly and then level out across a ten year period, the percentage in managerial positions increased at a greater rate but remained a lower proportion of jobs overall, and the percentage of those in technical jobs decreased.

Figure 4.8: Employment distribution of MALE Science graduates by time since graduation
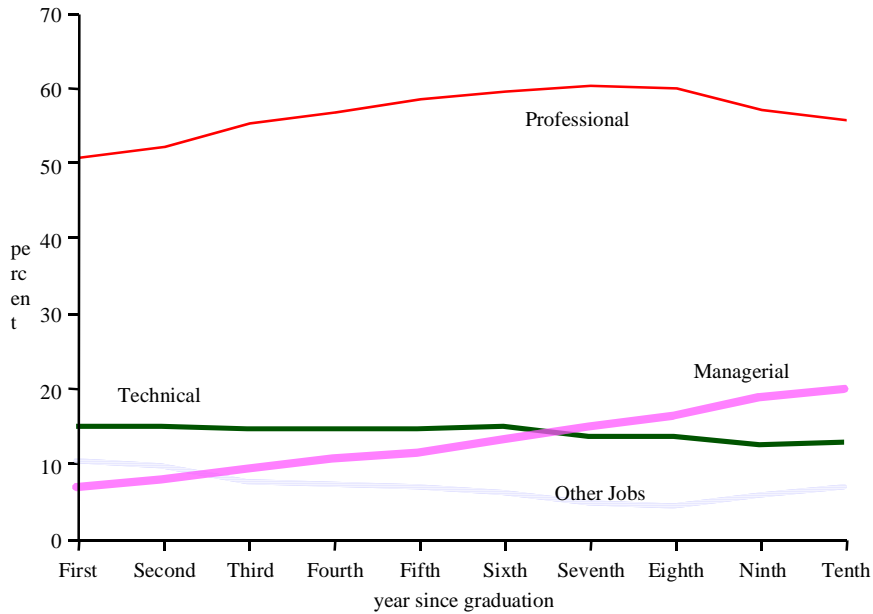
Figure 4.9: Employment distribution of FEMALE Science graduates by time since graduation
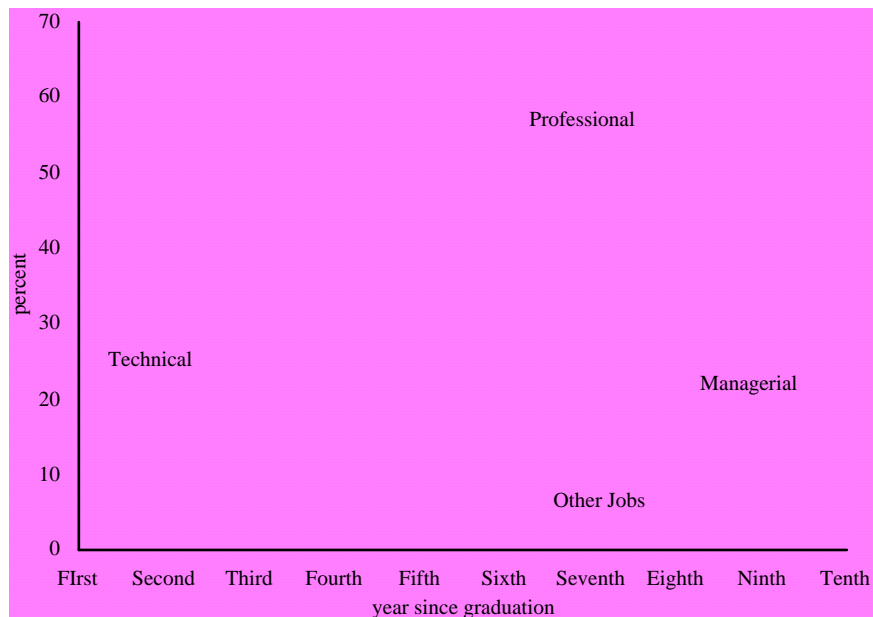
The graphs for males and females had the same very general pattern but differed in detail (Figures 4.8 and 4.9). Slightly more males than females were initially in professional jobs, and across the ten years, the proportion of women in such jobs continued to rise, while the proportion of men rose then fell slightly. The pattern for managerial positions was quite similar. More women were initially in technical jobs and the proportion fell away with more years after graduation to a point lower than the proportion of men in technical jobs.

Figure 4.10: Distribution of SCIENCE GRADUATES by time since graduation: employment in Science and other positions and full-time study
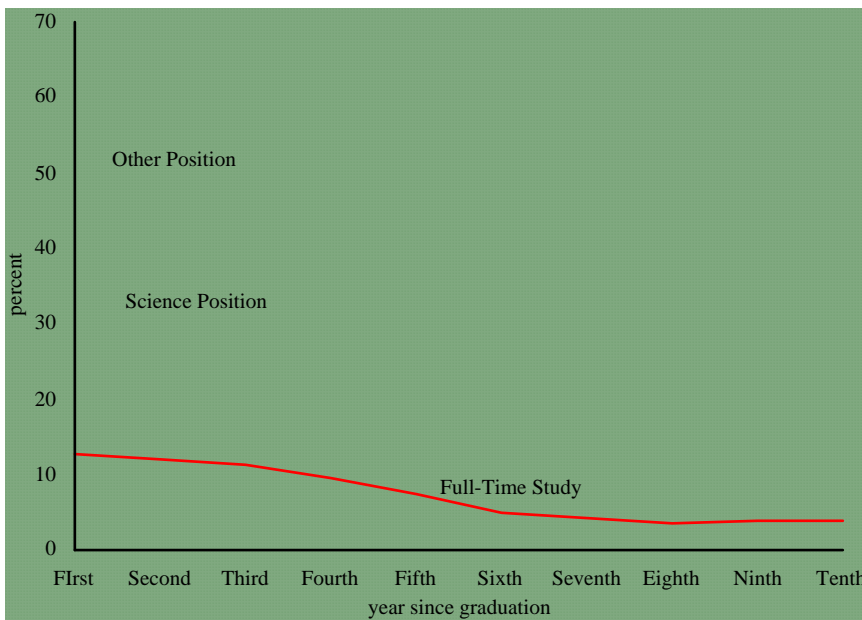
Figures 4.10 to 4.12 show change over time for those in Science positions, other positions and full-time study. The percentage in Science positions rose and the percentage in full-time study dropped, while the proportion in other positions tended to remain fairly constant (Figure 4.10). As we indicated earlier, slightly more women than men were initially in Science positions and more men than women were in other positions (this would include the much greater proportion of men going into IT positions) (Figures 4.11, 4.12). The proportion in full-time study falls right away by the tenth year out, but is maintained at a somewhat higher rate for males than females in the first five years or so.

In this series of graphs, it appears that a trend is occurring around about the seventh year out. We can speculate that this is perhaps a time when psychological and personal shifts have been made, when there is some consolidation and integration of a professional self. It is long enough for many to have completed further study, and for respondents to be clearer about where they want to go next.

40

Figure 4.11: Distribution of MALE Science graduates by time since graduation: employment in Science and other positions and full-time study
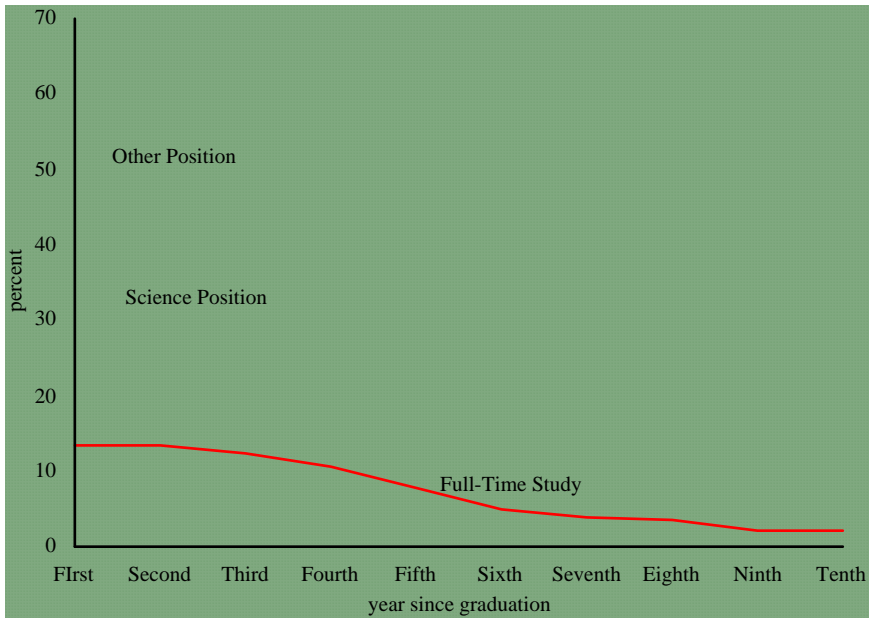
Figure 4.12: Distribution of FEMALE Science graduates by time since graduation: employment in Science and other positions and full-time study
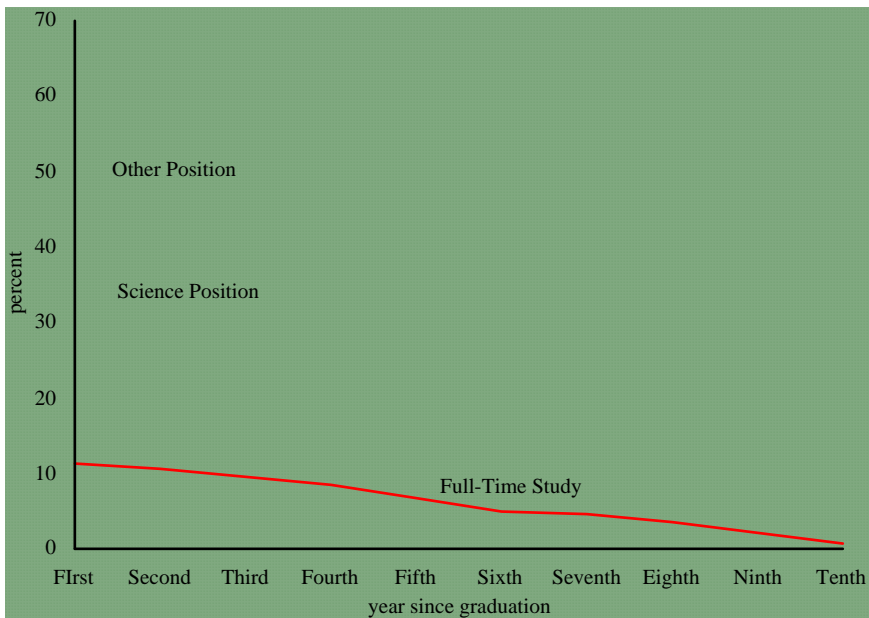
2. A longitudinal look at careers

The second approach to career patterns uses longitudinal data on respondents' main work and study activities since completing an undergraduate degree. The following summary refers to a group of survey respondents for whom we have information over a period of seven years, a period which, as noted above, seems to be significant in the first phases of a career. While the analysis of the seven-years-out group does not perhaps reveal distinct patterns that differ in fundamental ways, we can make some general statements about the group.

- In the first year after their undergraduate degree, almost 60 per cent of this seven-year-out group were engaged in work only, while an additional 16 per cent were working and studying together (in any combination of full-time or part-time work and study). Eighteen per cent were studying only; 7 per cent were engaged in 'other' activities (our categories included such things as travel, holidays, casual or volunteer work), and 1 per cent were engaged in 'domestic' activities, which included family responsibilities. There were two notable differences between males and females. Males were more likely to be studying only in their first year after the undergraduate degree, and only females were engaged in domestic activities in the first year following the undergraduate degree.

- When we looked at progression over time, although the majority of respondents had been employed (not necessarily full-time) for the whole seven years, only one-quarter of them had spent the seven years working only. The more common pattern was to combine periods of work, work/study and study only, in a wide variety of possible sequences over the seven-year period. Male careers were much more likely than those of females to follow this pattern. The period of work/study was often after two, three or four years of work only.

- Around 46 per cent of respondents went straight into a professional or managerial job in the first year after completing their undergraduate degree (most into professional rather than managerial positions); 20 per cent found work at the technical level; 10 per cent had other jobs. Following the first year, movements between professional and technical positions were varied, and not all one way.

- In this seven-year group, more respondents were in other than Science jobs than in Science-related jobs in the first year following the undergraduate degree, with females somewhat more likely than males to be in Science work.

In summary, the largest group, around one-quarter of respondents, moved directly to employment and were in employment for the seven years. Amongst the others, three somewhat predictable progressions emerged: a group that worked then worked and studied later; a group that worked and studied after their undergraduate degree, then worked only; and a third group roughly the same size as the other two that studied full-time after their

undergraduate degree, then moved to employment. Just under half of the seven-years-outers went into a professional or managerial job following graduation. First jobs were as likely to be in an area other than Science than in a Science-related area.

The following case studies show the variety of individual situations included in this summary of trends, and the varied factors that contribute to people following a particular pathway.

Box 4.3: An employment-related decision

Ellie completed a Pass degree in Applied Maths with some Physics in the early 1990s. When she began her degree, she didn't know what career she wanted. She did well at Maths and thought that the degree in Applied Maths would be a good grounding. Her goal was to work in business with a Maths focus. By the end of the degree, her aspirations hadn't changed all that much. She knew something more about career prospects and felt that a generalist non-Honours degree wasn't all that useful, so she decided to do a Graduate Diploma in Economic Studies, a decision she says was directly related to employment opportunities. Econometrics was a 'convenient commercial area' to go into. She is now in her third job since completing the Graduate Diploma, all of which have involved financial modeling and econometrics. She currently works in the energy trading area and may in the future go into corporate finance, which will probably require doing an MBA.

Box 4.4: Taking the MBA pathway

Peter completed a BSc in Biomedical Science in the early 1990s and worked for the following five years as a hospital scientist. Several years ago, he decided to undertake an MBA part-time. On the basis of his study so far, he was able to make a career change and now works as a product manager for a private firm.

Box 4.5: Finding a direction

Lauren was working as a technical officer at CSIRO when she began her degree part-time. After she completed her degree in Zoology, she continued to work at CSIRO but in a capacity more closely related to her degree. She has recently decided to do a Masters in Biotechnology because, she says, she needs intellectual stimulation; biotechnology is a strong growth area and she is interested in broadening her skills and her scientific base.

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3. Patterns from the interviews

The interviews in general reflect the patterns above but they also provide a more 'narrative' view of career movements. They indicate sometimes uncertain beginnings, mixed motives and periods of change as respondents try to find a position that suits and satisfies them. We have identified four broad groups from the qualitative interviews. As indicated earlier, all respondents are still 'in process'. For this reason, we have included

where possible their comments about future employment hopes and plans to convey a sense of continuation into the future..

Pattern I: The undergraduate Science degree as a jumping off point

The first group includes those who, after leaving university had one or more short-term, sometimes casual jobs, often unrelated to Science or unrelated to the areas in which they studied, and who then found somewhat more stable employment in areas where the generic skills gained in a degree were useful and where their Science-related knowledge was of more or less use depending on the job.

Box 4.6: Minimal use of Science skills

Helen chose to do a Science degree because growing up in the bush gave her a keen interest in the environment and she loved Science at school. Interest in a specific career was not a motivating factor and she was realistic enough to recognise that her broadly-oriented pass degree with majors in Botany and Zoology would not necessarily lead to a particular job. She nevertheless wanted to pursue her love of Science and thought that perhaps later she would become interested in research.

The early 1990s were, according to Helen, 'not a good time to graduate'. She had to compete with many experienced people for the available jobs. Her first job, gained through personal contacts, was as office manager/receptionist for a team of environmental consultants. Although they wanted a Science graduate, and her Science knowledge was possibly an asset, Helen's work was not directly Science-related. She did then get a Science-related job (a part-time technical assistant on a funded research project) but rather than being the result of a considered career choice, it came about almost by accident when she went with her boyfriend to another state where he had a job. At the same time, she also had part-time work in a supermarket.

Returning to her home state a year or so later, she joined the quarantine service. Her job doesn't require a Science degree, especially since her promotion to a largely administrative position. Helen has mixed feelings about her job. The positives are that she believes in what she does and is grateful that the job offers security and a career path, factors that are important, given that she has 'never known what she really wanted to do'. She plans to stay with the same employer but try to move back into a more 'hands-on' job. Seeing new graduates come into the service, Helen believes that many will be disappointed because they have unrealistic expectations about the types of work available to them.

Pattern II: A conscious decision to change direction

The second pattern we have identified generally reflects a conscious decision to pursue a specific path. Here, we include people who complete a Pass or an Honours Science degree and then decide, either for interest or for directly employment-related reasons, to get another qualification (something other than a PhD in science). They may undertake study immediately following their initial degree, or a little later, after having some employment experience and becoming clearer about what it is they are interested in. Interviewees had

pursued additional qualifications in a variety of fields including sales/marketing, finance, science communication, economic studies, information technology, and teaching.

Box 4.7: Following one's interests

Petra completed an Honours degree in biochemistry in the mid-1990s. Her reasons for doing Honours were not entirely thought out. She said she got the marks to be accepted, 'didn't know what else to do' and believed that it would put her 'a step ahead' of Pass degree students. She enjoyed her Honours year but by the time she had completed it, she knew that she did not want to go ahead with a PhD, even though it was suggested that she should. The desire to start earning reasonable money, and not wanting to go through the stress of doing a PhD, were prime considerations at this stage. She was introduced to the pharmaceutical sales area through a careers day she went to in her final year. It was something she found she was interested in and thought she could do well at. So, following her Honours year, Petra spent 12 months in telemarketing before securing a position in sales with a pharmaceutical company. She may well have remained with the company for longer than the three years she did, but she found that the options for promotion and new challenges were limited, so decided to move on. She has moved further away from her Science background and currently has a position where her chief job is business development in a small to medium enterprise. Petra believes that while it may not be THE job she is looking for, she is satisfied at present with having a new challenge and developing new skills. She is likely to stay in the sales and marketing area, and may take a business qualification in the future. She certainly doesn't regret her Science degree, and believes that the greatest challenge is to be able to sell yourself and your skills, a skill that she did not get from her Science degree.

This project has a special interest in any movement of Science degree holders into employment in the IT area. Greg is one of several people interviewed who chose this path.

Box 4.8: Grasping opportunities in IT

Greg hadn't completed his BSc, majoring in Biology, when he saw the possibilities of moving into IT. He started work with a small company in his third year and enjoyed it so much that three years later, he is in a management role in the same company. He is totally focused on information technology and is constantly looking towards innovation in the company and alert to the possibilities of new product development. He believes he is likely to stay in IT for some years to come.

Pattern III: A professional science or science-related career

This is perhaps the largest group in the survey population. Interviewees went into a variety of Science-related professions.

Box 4.9: Settling for security

Robert completed a BSc Honours in 1992, majoring in ecology, worked for several years as a research assistant with the National Parks and Wildlife Service, then decided to do a PhD full-time. During this time, he did some part-time university tutoring. At the end of the PhD he secured a position as a research officer with the

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National Parks and Wildlife Service where he conducts original research. He's reasonably satisfied in his job because the work is interesting and it is relatively secure but he's aware of dissatisfaction sometime with his salary level and feels he has opted for security over a high salary.

Box 4.10: A Science publishing career
Sally began a Science degree with no clear goal in mind beyond the belief that a BSc would be a good beginning and offered a range of choices. When she completed the degree, she thought she would get a job straight away but was surprised at how difficult it was to get even a non-Science job. She found it difficult to convince potential employers that her Science degree was relevant to a variety of jobs. After graduation, she had a series of casual jobs, all lasting a matter of months, followed by two short-term jobs in Science-related areas. She considered enrolling for a PhD but was put off by the long years of study required and the fact that she was not interested in working in a laboratory. Several research assistant positions followed, one for over 12 months, until she finally found a position in Science publishing, where she feels she is using a lot of her Science skills.

A position in a Science-related organisation does not necessarily bring satisfaction. Linda gave the impression she was marking time.

Box 4.11: Unfulfilled research ambitions
Linda would like her career to be much more focused on Science than it is at present. She works in CSIRO. She likes some aspects of her job (running workshops and communicating with the public), but most of it is not directly Science-related. She is generally not satisfied with what she is doing and would like to be involved in research. She completed a Bachelor of Applied Science in the mid 1990s. Two years later, she went back to do Honours in Zoology to increase her employment options. Her initial decision to do Science was based on a strong interest in the natural world but she had no clear idea about what she wanted to do. She says that 'to be a scientist, the minimum is a PhD' but she wants to sort out where she is going in her before deciding to do a PhD. Part of her concern is about the direction of research. She would like to be involved in 'field trials and practical aspects of science in real life situations' whereas she says there is a trend for less field trials, more modeling work and more pressure on scientists to take on projects because someone is going to pay you for it'.

A PhD does not necessarily ensure a research position, as Con's experience shows.

Box 4.12: Teaching as a second-best option
Con completed a combined Science and Engineering degree, did Honours and decided to go on with a PhD (in Physics) as he wanted to get into university teaching and research. He secured a post-doctoral contract but found at the end of the period that there were no positions in universities available. His solution was to do a Diploma of Education. He is currently teaching Mathematics in a secondary school, a job that he finds satisfying. However, it is still a second best option as he remains deeply interested in Physics research and has plans to move back into this area if any occasion arises.

46

Philip decided to go into IT rather than the area of Science he trained for, but his story is included to illustrate that movements between Science and IT may occur both ways

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Box 4.13: The difficulties of changing direction

At the end of his PhD (in Chemistry) Philip was recruited into a large international company. His goal had always been to complete a PhD and he watched as most of his peers left university after Honours to go into industry. The company he joined offered opportunities in both a Chemistry and IT stream. Pursuing his interest in Chemistry would have meant going overseas, and for personal reasons, Philip was not able to do this at the time. So he chose to go into IT and has remained there, being promoted into new areas of responsibility. Professional development and inservice training have been an important part of his working experience. Philip has been largely satisfied with his career so far and he enjoys his work. However, lately he has been feeling that he wants to get back into the 'science' side of things, which may present a difficulty because of the company's job categorisation and linked salary structure (IT jobs typically pay considerably more than 'Science' jobs), and because the company's engagement in directly Science related jobs is extremely limited in Australia.

Pattern IV: The research scientist pathway

Finally, there were those who have completed a PhD and are pursuing a research career in either academia or a research organisation — what might be considered the traditional research scientist career structure.

Box 4.14: The post-doctoral fellow pathway

Katie is a post-doctoral fellow working in a university. She completed an Honours degree in the early 1990s, continued into a PhD because she enjoyed the research and the project she did in her Honours year. In fact she has always been interested in research, although a realistic appraisal of the job prospects in her original area of interest — marine biology — led her to switch to the medical faculty for her PhD. Her teachers, she says, were both models of interest and dedication and showed her the pressures associated with an academic research position. She has spent three years in the US and currently has a four-year Fellowship position in a university with a very prestigious three-year grant. Her work is highly respected and interests her greatly. However, because of the uncertainty of her future, she is considering teaching or a job where she has her own salary and she is not reliant on a grant.

Katie's interview revealed some of the difficulties faced by post-doctoral fellowship holders, some of which echo several unsolicited comments from survey respondents: 'Research-only staff are between a rock and hard place. You have to continue to attract grants and this is difficult, as the success rate is less than 25 per cent. There is a great deal of uncertainty and a lot of pressure in fixed term appointments when salaries are derived from grants.'

47

Summary

The career paths our respondents took following their undergraduate Science degree revealed multiple and sometimes complex patterns. It must be remembered that most of the sample are between 25 and 35 years of age—early days in terms of their likely working lives. They vary according to their areas of undergraduate study, decisions to do additional qualifications, in Science or in other areas, and the time at which these additional qualifications were done. The notion of a linear pathway based on area of initial study is no longer as valid as perhaps it was in the past.

Career 'patterns' can be pictured in various ways. As far as progression in a professional area and level of employment is concerned, we found a general movement from technical to professional positions across the whole group of respondents, with some variations between males and females. Slightly more men than women went into professional positions initially, and slightly more women than men went into Science positions (a result of more men going into IT).

A longitudinal analysis of respondents seven or more years out from their undergraduate degree found that the largest group, around a quarter, moved directly to employment and were in employment for the seven years. The rest combined periods of work, work and study, and study in very varied ways. The most frequent patterns were: work followed by work and study later; work and study after the undergraduate degree, then work only; and full-time study after the undergraduate degree, then a move to employment. Just under half of the seven-years-out group went into a professional or (less frequently) a managerial job immediately following graduation. First jobs were as likely to be in an area other than Science as in a Science-related area.

The interviews suggested another approach to understanding early career patterns and four somewhat different sets of experiences emerged from the analysis:

- The undergraduate degree as a jumping off point, the first step of which was entry into one or more short-term often casual jobs, often unrelated to Science or the particular areas in which people studied. After a period, these people found more regular and stable employment in an area where their generic skills were generally being used, and were able to apply at least some of their specific Science skills;
- A conscious decision to change direction, sometimes completely from the original Science degree, but more often into a somewhat related area where some of the skills of the undergraduate degree were being used. The changed direction often involved additional study, and came about because of interest in an area, or a decision based on employment prospects;

- A professional Science or Science-related career, where a postgraduate qualification is undertaken, or the person moves gradually up the ladder in an organisation or across organisations;
- The research scientist pathway – in academia or a research institute. The difficulties associated with this often contract based employment were a feature of the responses.

5: UNDER-EMPLOYMENT OF RESPONDENTS

Under-employment

There are a number of issues concerning the concept of 'under-employment'. It might be considered that anyone not using the highest level of skills for which they are trained is 'under-employed'. However, this takes no account of a range of factors including the individual's views about participating or not in paid work, and their reasons for undertaking or not undertaking work at the highest level of their skill development.

The Australian Bureau of Statistics uses as a measure of under-employment responses to a question about whether respondents working less than full-time are seeking full-time work. We included such a question in the survey. Therefore, the following observations refer to the group of respondents who are seeking full-time work. As reported in Chapter 2, 12 per cent of the sample, more women than men, are working part-time and of these, 22 per cent are seeking full-time work. The under-employment rates reported in this Chapter are the proportions of the labour force (i.e. full- and part-time workers and unemployed workers) who are working part-time and seeking full-time work.

Part-time workers who are seeking full-time work are somewhat more likely to be male than female; they are about equally likely to have graduated in the early, mid and late 1990s. The following findings concerning under-employment of respondents are noteworthy:

- The rate of under-employment overall is 3 per cent for both males and females. However, there are gender variations according to when the degree was completed, most noticeably for most recent graduates (1997-1999), where females have an under-employment rate of 7 per cent compared with 2 per cent for males.

- Overall, respondents completing their degree in the late 1990s (1997-1999) have a somewhat higher rate of under-employment than respondents completing in the early 1990s; within the group of recent graduates, Pass degree holders have a higher rate of under-employment than do Honours degree holders (5 per cent compared with 2 per cent).

- Those who perceived that their degree was relatively focused (i.e. they said that it had one or two major areas of study) had a lower rate of under-employment than respondents who said their degree was 'generalist' (i.e. they agreed that it was a degree in which they could take courses from all over the faculty), irrespective of whether they completed their degree in the early, mid or late 1990s.

- The major study areas of Computer Sciences, Mathematical Sciences and Physical Sciences have lower than average rates of under-employment, while for Life Sciences

and Medical/Health Sciences the rate is slightly above average. This reflects other findings concerning job opportunities in these areas.

- Under-employment rates for people with Science qualifications in addition to a Pass or Honours degree are especially interesting. While (thesis) Masters and PhDs have about average rates of under-employment, people who have done Associate Diplomas, Graduate Diplomas and Coursework Masters have higher than average rates.

- Those who have added a qualification other than a science qualification to their initial degree, in general have low rates of under-employment, except for people who have a Graduate Diploma.

- Under-employment rates of around 9-10 per cent were recorded for people with an additional TAFE qualification, although the number of people in this category is relatively small and the finding should be treated with caution.

Comments about unemployment and under-employment

Although the survey was predominantly quantitative, several people took the opportunity to include detailed comments about their experiences. One such respondent expressed two themes that do not emerge strongly from the quantitative survey: disappointment at not finding a job in Science, and poor job prospects in Australia compared with some overseas countries. The quantitative survey was not designed to elicit such information, especially about the second point, and as we have noted, it is possible that very disappointed Science graduates are under-represented in our survey. However, we heard observations similar to the following reflection in the interviews, in people's comments about friends who had gone through a course with them, in general consultations for the project, and in a small number of unsolicited comments noted on the survey forms.

> **Box 5.1: A reflective response**
> *I am a biomedical science graduate from 1996, and since completing my degree I have not once been employed in the scientific industry. I gained a lot of skills during my four years at university, although the skills I require for my present job were not gained from my degree, but from extra-curricular activities (the respondent is a marketing campaign manager in an area other than Science). I chose to study biomedical science as I was always interested in it.. I had intended to continue my studies in the Graduate Medical Programme, however I was not selected. My opinion of the scientific industry in Australia is quite poor. General laboratory and hospital staff are paid relatively low wages; they are expected to work under high demand (I was employed by a leading Pathology laboratory in my final year.) I attempted to find employment in the USA, with the intention of beginning a Science career there, and continuing my studies at an American institution. I found a position and secured a visa, however, due to personal reasons I could not take up the position. Now, back in Australia I am reluctant to pursue a Science career. The prospect of working in microbiology in the USA was exciting and hopefully lucrative, the thought of working in Science in Australia is extremely unappealing. And my undergraduate degree won't get me a job at a reasonable level…*

51

In a somewhat similar vein, a father sent us an email about his son, who has a PhD in theoretical chemistry and works as a postgraduate fellow in a university in the United States. The father noted that his son 'seems to be marooned in America because of a severe lack of opportunities in Australia'.

A survey respondent explained how she had graduated in 1995, found it difficult to get a job, and then decided to do an accountancy qualification at a TAFE institution. She had subsequently been able to get a range of bookkeeping and accounting jobs, but noted that her science degree got her nowhere, and she was frustrated that her initial training was not being used.

A small number of respondents expressed extreme disappointment and sometimes anger at their inability to get a job that used their Science skills.

> *Thank you for doing this research project. It is well overdue in today's Australian society. I did my Science degree because I grew up loving Science, however, with job prospects being zero when I finished, I had to retrain myself in order to get a job. And did I ever get Austudy? No. What did I do with my Science degree? Nothing that got me a job!* (comment on a survey from a female who graduated in 1994).

> *Despite attaining high distinctions, never failing any subjects and a scholarship to a very highly regarded institution in the USA I have managed just two job interviews by people interested enough to meet someone with initiative and a varied background not exclusively science-based.* (part of a comment on a survey from a female who graduated in 1996).

Summary

Those who were under-employed were more likely to be recent graduates. The findings on the impact of additional Science qualifications on under-employment are of particular interest. It appears that people who have completed qualifications that do not build sequentially on the undergraduate course in the traditional pattern of postgraduate research programs, are more likely to be under-employed. This suggests perhaps that they have needed to complete an additional qualification to make themselves more employable, but have had difficulty finding a suitable full-time position. It was also the case that graduates from more focused courses had lower rates of under-employment. Comments from some respondents showed considerable frustration and anger at not being able to find a job using their science skills.

6: INITIAL TRAINING AND SUBSEQUENT EMPLOYMENT

In this Chapter employment outcomes for respondents with different initial areas of study are discussed, and in doing so, we address the question of whether there is 'more than a small minority' of Science graduates employed in the area of Science in which they initially trained. Dobson and Calderon (1999) point to the difficulties of 'matching' qualifications to areas of employment using Census data, given that most Science degrees do not have a specific vocational focus.

We remind readers that our respondents were about equally distributed between Science-based organisations, broadly Science-based organisations and other than Science-based organisations. Around half of the Computer Sciences and Computing and Maths graduates were not in Science-based organisations. One quarter of the Life Sciences people and 28 per cent of the Physical Sciences people were working in an organisation that was not Science-based.

Relationship between the undergraduate degree and current occupation

In Chapter 4, we reported that the jobs into which graduates from Life, Physical, Mathematical and Medical/Health Sciences areas of study go, varied considerably, while the employment of those who did Computer Sciences had a clear connection with IT-related employment. In addition to direct employment outcomes, the study provides information about respondents' perceptions of the relationship between their Science training and their employment, and whether Science skills are recognised and valued in their current job.

The undergraduate degree: broadly or narrowly focused?

Over half of the respondents (53 per cent) agreed that their undergraduate degree concentrated on 'two or three majors/areas of study'. An overall 30 per cent agreed that their degrees concentrated on 'only one major/area of study' and 16 per cent said that their degree was 'generalist', i.e. courses were taken from all over the science-related faculty or school.

We acknowledge there is some imprecision in the above descriptions of undergraduate degrees and they may well have different meanings for academics and respondents; nevertheless, given the variety of Science degrees now available, we believe there is value in focusing on respondents' perceptions of the nature of their degree, especially in the present context.

A much higher than average percentage of respondents (50-60 per cent) whose main areas of study were in Computer, Mathematical, Physical or Medical/Health Sciences saw their degrees as concentrated on one area of study. Those who did Life Sciences generally

perceived their degrees as concentrating on two or three main areas of study. The main areas of study of degrees that were seen by respondents as 'generalist', were combinations of Computing and Life Sciences, Life Sciences and Maths, and Medical/Health Sciences and what we have termed 'General Science' (areas such as Psychology and Geography).

Respondents with undergraduate degrees concentrated on one major area of study tended to use the skills acquired in their degree more so than did those with degrees concentrated on two or three major areas of study, or with degrees they judged to be 'generalist'. Respondents who agreed that their undergraduate degree was 'tightly structured with limited subject options' also tended to use their undergraduate Science skills more so than those whose courses were more open. However, in both these instances, the mean rating for use of Science skills did not reach 4 on a scale of 5 in response to the item: 'My job gives me the chance to use the skills and abilities acquired in my undergraduate Science training'.

Are occupations related to the undergraduate degree?

At least some respondents from all major study areas said that their job was not related at all to their undergraduate degree; however, this varied from quite a small proportion (between 5 and 10 per cent) for Computer Sciences, Medical/Health Sciences, and Computer and Mathematical Sciences, to almost 40 per cent for Mathematical Sciences. A further analysis of the Mathematical Sciences group indicated that although the undergraduate degree was often not seen as directly related to their current position, subsequent qualifications were much more likely to be seen as 'directly related'. We also have some clues from the interviews. Some interviewees observed that they were using their general understanding of mathematics and broad calculation skills in their job, but not some of the detailed mathematical procedures from their undergraduate degree.

Three-quarters of respondents said that their undergraduate degree was 'essential' for, or had 'contributed a great deal' to obtaining their current or most recent job. Respondents from the Medical/Health Sciences and Medical/Health and Life Sciences areas were most likely to say it was essential. Around a third of respondents from a Mathematical Sciences, Maths and Physical, and General Science (e.g. Psychology, Geography) background said that it did not contribute at all to obtaining their current job.

Are undergraduate Science skills being used?

Overall, almost 60 per cent of respondents agreed that their job gives them the chance to use the skills and abilities acquired in their undergraduate Science training; 30 per cent disagreed and 11 per cent were unsure. Agreement ranges from highs of 70-90 per cent for the Computing and Maths, Computer Sciences and Medical/Health Sciences area to a low of 36 per cent for Science combinations other than the ones we have specified. Those most likely to disagree (and therefore say their job does *not* give them an opportunity to use their Science skills) are from the Maths and Physical Sciences area (Table 6.1).

Table 6.1: Responses to the item: 'My job gives me the chance to use the skills and abilities acquired in my undergraduate science training' by major area of the undergraduate degree, (% of respondents) (5 point scale collapsed to 3 points), N=1154

Major area of u/g science degree	Agree	Unsure	Disagree
Computer Sciences	71	9	20
Life Sciences	58	13	29
Mathematical Sciences	50	11	40
Physical Sciences	56	11	33
Medical/Health Sciences	71	7	22
Computing and Maths	88	-	12
Life and Physical	60	11	29
Maths and Physical	48	3	49
Life and Medical/Health	57	6	37
Science Combinations	36	18	46
General Science	61	10	30

We asked respondents whether they agreed that their Science skills are not being recognised in their current job. Overall, 57 per cent disagreed and 27 per cent agreed. Consistent with other findings, those most likely to disagree (and therefore to say that their Science skills *are* being recognised) are respondents from a Computer Sciences, Medical Sciences and Computing and Maths area in the undergraduate degree. Almost one-third of Life Sciences respondents and 30 per cent of those from a Physical Sciences area of study in their undergraduate degree, believe that their Science skills are not being recognised.

Use and value of Science skills

The items in Table 6.2 form a scale we have called 'Skill recognition and use'. The findings are consistent with other findings that around 60 per cent of respondents say their job gives them the chance to use the skills and abilities acquired in their undergraduate Science training, and about one-third of respondents are not working in a Science based organisation.

Table 6.2: 'Skill recognition and use' (% of respondents), N=1154.

	Agree	Unsure	Disagree
I feel my Science skills are not being recognised in my current job	27	16	57
I feel frustrated that my Science skills are not used in my job	15	12	73
My employer values my scientific knowledge and skills	61	18	20

The highest mean ratings on the scale of 'Skill recognition and use' were evident for those with PhDs, whether the PhD was in Science or another area. This strongly suggests, then, that Science skills are being used and being valued by the employers of the most highly qualified respondents, irrespective of whether that qualification is in Science or not. (It should be noted that the number of respondents with a PhD in an area other than Science was very small.) Respondents with PhDs were the only group whose mean rating on this scale was over 4 on a scale of 5. The mean rating for the entire population was 3.6, i.e. just over mid-way between an unsure response and agreement with the statement. Other groups with a rating above the average were those:

- whose highest Science qualification was a Coursework Masters;
- with Honours and Combined degrees as opposed to a Pass degree;
- with an undergraduate degree which they said concentrated on one major area of study.

The use of science skills: reflections from the graduates

Interviewees were asked about the extent to which their current jobs were related to their undergraduate degree, and to their postgraduate degree if they had gone on to a higher degree. Only a minority said that their current job was *closely* related to either their undergraduate or their postgraduate degree. Everyone in this minority group either had a PhD or had opted to do other postgraduate qualifications to pursue a career or an area of interest. They included a post-doctoral fellow in a university, working directly in the area of her PhD studies; someone working in the information and training services section of a Cooperative Research Centre; a person working exclusively in the area of Science communication; and a person working in scientific publishing.

Most of the interviewees were using parts of their major areas of study and/or they were using the generic skills gained during their undergraduate degree. They included:

- a secondary school teacher who was using the Maths skills from his undergraduate degree but not using anything from his PhD studies;
- a web site developer/database administrator who said that she was using transferable skills such as logical thinking, problem solving, organisational skills and written communication skills from her Science degree, but that as far as her technical and Science knowledge based skills were concerned, the job was 'a waste of her education'

(she was, however, relatively satisfied with her job because of the good pay and good working environment);

- someone working in a semi-government organisation who said that he was using his broad scientific and biological knowledge in his position but certainly not his specialised knowledge;
- a person working in a stockbroking firm who does not use her BSc Physics major at all but uses some of the skills gained in her second undergraduate degree in Computing and Mathematical Sciences;
- a person working for a privatised electricity company in the energy trading area who is using some general quantification skills from her Applied Maths degree.

This pattern of partial use only of university-gained skills and attributes is perhaps not surprising, given the variety of areas in which interviewees were employed. A very close match between university and employment experience is relatively unlikely, except in highly vocationally specific areas, and even then, diverse employment situations make for variation and partial matches only. It is also the case that constant change and the capacity to adapt to change is a key aspect of the current work environment. Jobs themselves change, and new or transformed skills are often demanded of employees.

A small minority said they were not using their undergraduate skills at all (or were perhaps using generic skills in the broadest sense only). They included: a young woman working in a hospital-based setting organising clinical trials; a young woman whose choice of jobs has taken her progressively further away from her Honours degree in Biochemistry because she has decided she is really interested in sales and marketing; and another young woman working in a management/supervisory position in quarantine services (although in her previous job with the same employer, some of her broad scientific knowledge was of use).

Interviewees who were only partially using their Science-related skills and who were not satisfied with their jobs were dissatisfied for a variety of reasons, not always related to whether or not they were using their Science skills. For example, some were clearly dissatisfied that they were not working in the area of their interest; others felt their work was not challenging enough; one enjoyed her work but was dissatisfied because she believed her boss was an inadequate manager; and another (who had a PhD) had worked in an IT area for some years and wanted to get back to his area of scientific interest. This reminds us that job satisfaction is a complex matter, dependent on a range of employer, work, and employee-related factors.

Summary

The difficulty of matching qualifications to areas of employment was noted from the outset of this chapter. We can say from the data presented earlier in Chapter 4 that graduates with IT and Medical/Health qualifications are in jobs more closely related to their initial degrees. This suggests that once employed in these fields, graduates tend to stay there and to develop their careers accordingly. It is also the case that those with postgraduate Science qualifications are likely to find employment in Science.

The overall impression is that most graduates were working in jobs that were related to their initial Science qualification. Indeed, at least three-quarters thought their undergraduate degree was a key factor in getting their current or most recent job. Nevertheless, a substantial proportion of the respondents—about one in five—said that their job was not at all related to their undergraduate degree. However, this tended to be the case also for around 16 per cent of respondents in relation to any postgraduate qualifications. This suggests perhaps that similar findings may be repeated across other fields of study.

Likewise, a clear majority said their undergraduate Science skills were used in their work. This was most obviously the case for those who had gained a PhD, although not necessarily in Science. We noted also that the highest rating of skill recognition and use tended to come from those with Science Coursework Masters qualifications, Honours or Combined degrees, and those with a single major concentration of study in the undergraduate course. There is substantial variation in these responses according to the area of undergraduate study. One third of Life Sciences and some 30 per cent of those with Physical Sciences backgrounds thought their skills were not being utilised. As with unemployment and under-employment, graduates from more focused degrees were more likely to use their skills than those from self-described 'generalist' degrees. This is not an especially surprising finding, but one which needs to be recalled in any discussion of course structures and curriculum development.

7: THE IMPACT OF ADDITIONAL QUALIFICATIONS

In this Chapter the focus is on the types of additional qualifications respondents have undertaken and their impact on employment. It includes findings that contribute to answering the question of whether higher degree graduates are more restricted in their employment avenues than are people with a Pass or Honours degree only.

Qualifications in addition to an undergraduate degree

In our sample, 45 per cent of respondents had a basic Pass or Honours Science degree, 28 per cent had an additional Science qualification, 19 per cent an additional qualification in an area other than Science, and 8 per cent had additional qualifications in both Science and an area other than Science. Around 56 per cent of respondents had, therefore, undertaken some further study following their initial Science degree.

The highest percentages of subsequent Science qualifications were PhDs and Graduate Diplomas (22 per cent and 24 per cent respectively of respondents who had done a subsequent Science-based qualification). In contrast, the pattern for additional qualifications in an area other than Science was quite different. Around 30 per cent were Graduate Diplomas; there were very few PhDs and around 15-16 per cent each of undergraduate Bachelor degrees (in areas other than Science), Coursework Masters, TAFE courses and other courses such as professional and industry based qualifications. TAFE courses included both specific vocational courses and broader qualifications.

Not surprisingly, irrespective of the type of additional qualification, respondents with additional qualifications were more likely to have completed their undergraduate Science degree in the early 1990s than the late 1990s (Table 7.1). Conversely, respondents with no additional qualifications were more likely to have completed their undergraduate degree in the late 1990s. Again, not surprisingly, since additional qualifications take time especially if they are done on a part-time basis, just over half of all respondents with additional qualifications in both Science and an area other than Science completed their undergraduate degree in the early 1990s (Table 7.1).

There were some interesting variations in the patterns of undertaking additional qualifications in Science and in areas other than Science. Just over two-thirds of those doing a subsequent Science qualification studied full-time, and only 31 per cent of the group were already engaged in a job related to their subsequent study when they commenced the additional qualification. In contrast, a greater percentage of people undertaking subsequent qualifications in an area other than Science were already engaged in a job related to the area of their study (44 per cent) and only 46 per cent of them studied full-time. This is consistent with our previous finding that a significant proportion of the additional Science qualifications were PhDs undertaken full-time.

Table 7.1: Level of qualifications by time of degree completion (% of respondents), N=1245

Qualifications	Early 1990s (1990-1993)`	Mid 1990s (1994-1996)	Late 1990s (1997-1999)
U/g Science degree only	27	34	39
Additional Science qualification	46	35	19
Additional qualification. other than Science	41	39	20
Additional quals. in Science and other than Science	51	34	15

The additional qualifications undertaken by respondents in other than Science areas were quite varied, although some broad areas emerged as relatively common. For example, 27 per cent were in Business Studies, 19 per cent in Arts (including Psychology) and 18 per cent in Education. Law and Business postgraduate qualifications tended to lead to higher incomes than did postgraduate Science qualifications, especially for those graduating in the early 1990s.

Reasons for undertaking a subsequent science qualification

The importance of both intrinsic and extrinsic motivations evident in undertaking an initial Science degree are reflected in the reasons respondents gave for undertaking a subsequent Science qualification. Interest in the area for its own sake and a desire to enhance career advancement prospects were of almost equal, and high, importance, with 83 per cent agreeing that intrinsic interest was a reason and 80 per cent acknowledging that career prospects were important (Table 7.2). Sixty per cent also agreed that they undertook the qualification because the area was cutting-edge and exciting.

We examined whether there was any variation over time in the reasons respondents gave for undertaking a subsequent Science qualification. The importance of intrinsic interest sorts of reasons, and unemployment and under-employment as motivating factors did not change. However, an analysis of variance showed that there were differences on a scale of two items we called 'enhancement of career prospects', and on two other separate items which did not form part of a scale.

Table 7.3 shows the mean ratings on a scale of 5 (where 5 equals 'strongly agree') for items where there was a significant difference over time. It should be noted that Table 7.3 refers only to additional Science qualifications.

Table 7.2: Reasons for undertaking a subsequent Science qualification, (% agreeing with an item, i.e. ratings of 4 or 5 where 5=strongly agree), N=480

	% of respondents
I was interested in this area of study for its own sake	83
I needed the qualification because it would enhance my career advancement prospects	80
I commenced this qualification because this area of study was cutting-edge and exciting	60
I was definitely motivated by the prospect of getting a better paid position	59
I was encouraged to pursue this study by academic staff at university	35
I commenced this course of study because I was bored or tired of what I was doing previously	28
I commenced this course of study because I was unemployed or under-employed at the time	22
I needed the qualification to keep my present position	15

Table 7.3: Reasons for choosing a subsequent Science qualification: respondents completing an undergraduate science degree in the early, mid and late 1990s (mean ratings; 5=strongly agree), N=480

	Early 1990s	Mid 1990s	Late 1990s
+I needed the qualification because it would enhance my career advancement prospects	4.0*	4.0*	4.4*
+I was definitely motivated by the prospect of getting a better paid position	3.3*	3.4*	4.0*
I needed the qualification to keep my present position	1.8*	1.5*	1.8
I was encouraged to pursue this study by academic staff at university	2.7*	2.3	2.4*

+items forming the scale: 'enhancement of career prospects'

*indicates a statistically significant difference between ratings on that item

In relation to changes over time, we can say then that:

- more recent graduates are more likely than earlier graduates to undertake an additional science qualification because they believe it will enhance their career prospects;

- more recent graduates are more likely than earlier graduates to be motivated to undertake additional qualifications by the prospect of getting a better paid position;

- early 1990s graduates are more likely than mid 1990s graduates to undertake an additional Science qualification in order to keep their current position; however, overall, keeping a job is seen as of little importance in undertaking additional study;

- early 1990s graduates are more likely than late 1990s graduates to undertake additional qualifications because they were encouraged to do so by academic staff at university.

Occupations according to highest Science qualification

We examined respondents' current occupations according to the level of their highest Science qualification. The following trends emerged:

- Occupations of respondents with a Pass or Honours BSc only tend to be spread across the range of managerial, technical and professional levels in both Science and other than Science areas. However, the largest group (20 per cent) are Science professionals. A further 20 per cent of Honours graduates are in other professions. Around 15 per cent of both Pass and Honours graduates are IT professionals.

- Respondents whose highest Science qualification is a Combined degree that includes Science are predominantly in professional positions other than Science, Medical/Health or IT but 20 per cent are IT professionals.

- 58 per cent of the PhDs are Science professionals; the next largest group is the 13 per cent who are in professions other than IT, Science or Medical/Health. Ten per cent are in other technical positions.

- Around one-quarter of respondents whose highest level of Science qualification is a Coursework Masters are Medical/Health professionals; another quarter are in other professions. Respondents with Masters by thesis were more likely than Coursework graduates to be Science professionals.

- If a graduate diploma was the highest Science qualification, respondents tended to be spread across a range of occupations and levels; however, a notable proportion, 18 per cent, were in Science Education.

Science relatedness

To date, in this analysis, we have used the researchers' assessment (using ABS occupational codes) of whether occupations are Science-based, IT-based, Medical/Health based, Science Education based or other. We were interested to explore the impact of highest level of Science qualification when we took account of the extent to which

respondents themselves saw their job as related to their Science degree. A further analysis therefore grouped respondents by whether they said their undergraduate degree was directly related, somewhat related or not related to their current occupation, as well as by their coded occupational area and level — in effect using a self assessment of science-relatedness as well as an occupational code. The following trends emerged:

- 27 per cent of respondents whose highest Science qualification is Pass or Honours BSc are in Science professional positions that the respondents see as 'directly' related to their undergraduate Science degree; a further 22-23 per cent are in Science professions that the respondents see as 'somewhat' related to their undergraduate degree. These trends are virtually identical for Pass and Honours degree holders.

- Respondents whose highest qualification is a Combined degree including Science are somewhat less likely than Pass and Honours degree holders to be in Science professions directly related to their undergraduate degree, and more likely to be in Science professions that are somewhat related, or not at all related to their undergraduate Science degree.

- Compared with other groups, a much higher percentage of respondents with a PhD in Science (57 per cent) are in Science professional positions directly related to their degree; a further 14 per cent are in Science professional positions somewhat related; very few are in positions which they assess as not related to their undergraduate Science degree.

- As in our previous analysis, there are some indications of a different pattern for respondents whose highest Science qualification is a Masters by Coursework and those who do a Masters by thesis. Around 50 per cent of the Coursework Masters are in Science professional positions closely related to their undergraduate degrees; a further 25 per cent are in Science positions somewhat related. The comparable figures for Masters by thesis respondents are 43 per cent and 17 per cent.

- Nearly 60 per cent of respondents with a Graduate Diploma are in Science professional positions directly related to their undergraduate degrees.

These findings suggest that respondents with PhDs and Masters degrees in Science are more likely to be in Science–related positions than are respondents with Pass or Honours degrees. This is hardly a surprising finding and is an endorsement of the efficacy of doing a higher degree in Science if the aim is to obtain a directly Science-related position where, presumably, Science skills are used. However, a higher degree is not a guarantee of getting a desired position or a job where Science skills are used, as the qualitative comments from both the survey and the interviews show.

Nor is a higher degree necessarily a passport to a higher income. Only 22 per cent of Science PhDs and 17 per cent of Masters Coursework respondents are in the top third of income levels for the sample, compared with 38 per cent of respondents whose highest

Science qualification is a Pass degree and 33 per cent whose higher Science qualification is an Honours degree.

Analysis also indicated that undertaking a subsequent Science qualification in addition to the undergraduate degree did not necessarily lead to greater satisfaction with job security and salary. It was, however, associated with higher mean ratings on a scale we called 'Having an interesting job using science skills', and with high prestige occupations, having autonomy in a job, and being in a job where Science skills were used and valued, but only for respondents who completed their subsequent Science qualification between four and six years after they completed their undergraduate degree. (The derivation of these scales and analysis is described in Chapter 8.)

Summary

The impact of additional qualifications varies considerably but some patterns are clear. There are notable patterns of difference in impact according to the categories of employment. Those with only an undergraduate degree or graduate diploma, are spread across the range of occupational types. Graduates with higher qualifications tend to be in the professional occupations. We noted differences in the impact of Science and non-Science additional qualifications, the most obvious pattern being that research degree graduates were more likely to be Science professionals.

The notion that graduates with higher degrees in Science are more restricted in their employment prospects is true in the sense that they are less likely to be found in employment unrelated to their study. That is, fewer of them are found in the broader range of occupations. With respect to those who complete Masters and PhDs in Science, it is true that they will not be guaranteed a higher income, but they are likely to be in the jobs they trained for, and they seem, on the whole, to be satisfied with the recognition and use of their skills.

Finally, there are indications of some changes in outlooks and motives. The reasons for undertaking a subsequent Science qualification confirm research elsewhere that most people are motivated by both intrinsic and extrinsic reasons. However, there is some indication that more recent graduates are more likely than earlier graduates to undertake an additional Science qualification because they believe it will enhance their career prospects; and to be motivated to undertake additional qualifications by the prospect of getting a better paid position.

There are also indications of a declining influence of academics on student career choices and further study. We noted that early 1990s graduates are more likely than late 1990s graduates to have undertaken additional qualifications because they were encouraged to do so by academic staff at university. We are not sure why this should be so, but it bears further investigation.

8: WORTHWHILE EMPLOYMENT IN SCIENCE AND OTHER AREAS

In this Chapter, a number of aspects of how respondents view their jobs and their Science degrees are explored, and in doing so, we address the question of whether respondents find worthwhile employment in areas other than their initial area of study or their major discipline.

Aspects of worthwhile employment

There are many ways in which worthwhile employment may be assessed. In this instance, we have focused on respondents' satisfaction with their job and their salary, their views about various characteristics of their employment, and their income level. The following scales, which we use as partial measures of 'worthwhileness', were derived from items concerning how respondents' see their job, and items concerning their reflections on their interest in Science, their Science degree and their skills.

1. Job satisfaction: The three items making up this scale are: 'I am satisfied with my salary', I am satisfied with the security of my job' and 'Generally speaking, I am satisfied with my job'.

2. Job interest and use of Science skills: The separate items on this scale are: 'My job gives me the chance to use the skills and abilities acquired in my undergraduate science training'; 'Overall, my work is interesting'; 'Overall, I like the people with whom I work'; 'Overall, I believe my job contributes to the betterment of society'; and 'It is important to me that my job contributes to the betterment of society'.

3. Job status: Items in this scale are: 'Generally speaking, my profession is well regarded by the public'; 'My current position would be regarded as having high prestige attached to it', and 'The status of my current profession is important to me'.

4. Job autonomy: The scale included the items: 'I have a lot of freedom to decide what I do at work'; 'I have a lot of freedom to decide how I do my own work', 'The amount of freedom I have in my work is important to me'.

5. The utility and value of Science skills: Our final scale relates to Science skills being used and valued in one's job, and includes the items: 'I feel that my Science skills are not being recognised in my current job' (reversed), 'I feel frustrated that my science skills are not used in my job' (reversed), and 'My employer values my scientific knowledge and skills'.

Occupational groups and worthwhile employment

Tables 8.1 and 8.2 show how respondents in each of the main occupational categories rate various aspects of their employment. The occupational categories used here are those we have used in many of the analyses already presented; they take account of the area (Science, IT, Medical/Health and Other) and the level (technical, professional and managerial) of employment. The mean ratings for occupational groups on each of the scales are shown in Table 8.1.

Most mean ratings are higher than the mid-point of 3 on a scale of 5, indicating in general, positive feelings about each of these aspects of respondents' jobs. There are only two mean ratings around the mid-point (clearly indicating neutral or unsure feelings) and they relate to the job status of Science technicians and Science education professionals. It needs to be noted, however, that these are mean ratings and some individual respondents obviously feel less positive about their employment.

Table 8.1: How respondents view their jobs: mean ratings on scales relating to aspects of employment (5=strongly agree), N=1245

Occupation group	Job satisfaction	Job interest & use of science skills	Job status	Job autonomy	Utility and value of science skills
Science technician	3.5	3.9	3.0	3.7	3.6
Science professional	3.4	4.1	3.4	3.9	4.0
Science manager	3.8	4.0	3.5	4.4	3.8
Science education professional	3.5	4.2	3.0	3.7	3.9
Other technician	3.5	4.0	3.3	3.7	3.3
Other professional	3.7	3.9	3.6	4.1	3.4
Other manager	3.9	3.8	3.5	4.3	3.4
Medical/Health professional	4.0	4.2	3.8	3.9	3.8
IT professional	4.0	3.8	3.9	4.1	3.7
IT manager	4.0	3.9	4.3	4.5	3.4

Table 8.2 summarises the key differences between occupational groups. High ratings (designated as H) indicate that mean ratings for the occupational group(s) are statistically

significant from those of (some) other occupational groups. The analysis reveals some interesting differences between the ways in which various occupation groups rate their work.

The major differences concerning satisfaction with job security and salary are between IT professionals and Medical/Health professionals who have higher mean ratings and the groups of Science professionals, Science technicians and other technicians who have lower mean ratings. The groups most likely to say they are satisfied with their job security and salary are Medical/Health professionals, IT professionals and the small group of IT managers in the sample. We have seen from other findings that Science professionals are not likely to be in the highest third income group of respondents.

Table 8.2: How respondents view their jobs: groups with *high mean ratings on five scales, N=1245

Occupation group	Job satisfaction	Job interest & use of science skills	Job status	Job autonomy	Utility and value of science skills
Science technician					
Science professional		H			H*
Science manager				H	
Science education professional		H			H
Other technician					
Other professional	H		H	H	
Other manager	H			H	
Medical/Health professional	H	H*	H		H
IT professional	H		H	H	H
IT manager	H*		H*	H*	

- * 'high' = statistically significant differences (.05) found between these occupation groups and (some) other groups (see text for which groups)
- **highest mean rating for the scale

In relation to 'Job interest and use of Science skills', Science professionals, Science Education professionals and Medical/Health professionals rate their positions higher than do Managers in areas other than Science and IT professionals. Medical/Health

professionals also rate this aspect higher than do professionals in areas other than Science. The groups of respondents who are most likely to say they have an interesting job using their Science skills had mean ratings of between 4.1 and 4.2 on a scale of 5 (Table 8.1).

The two sets of findings above tend to support a view that Science professionals rate their jobs highest on having an interesting job and having their skills used and valued, rather than on job satisfaction including job security and income. It would seem that for a good proportion of Science-trained employees, there is a trade-off between finding a job which interests them and in which they can exercise at least some of their Science skills, and finding a job that is highly paid.

As we might expect, there are differences in the job status scale between respondents in professional and managerial positions (in Science, IT, Medical/Health Sciences and Other) who have higher mean ratings that and those working in technical positions and Science Education. The mean rating of only one occupation group, IT managers, is over 4 on a scale of 5 (Table 8.1). The mean for Science professionals was 3.4, only a little higher than the mid-point of the scale.

The occupational groups with significantly higher mean ratings on job autonomy include IT and Other professionals, and Science, IT and Other managers. All have mean ratings of over 4 on a scale of 5. The small group of IT managers rate their positions highest on the employment autonomy scale, with a mean of 4.5. The mean rating for Science professionals is 3.8.

In relation to the utility and value of Science skills, Science, Science Education, Medical/Health and IT professionals had significantly higher mean ratings than those of Other professionals and technicians.

Undergraduate areas of study, desired career positions and worthwhile employment

Given previous findings showing that a high proportion of those who did Computer Sciences at the undergraduate level go into Computer Science jobs, and that those in Computer Sciences occupations are most satisfied with their job security and salary, it is not surprising that respondents whose major area of study was Computer Sciences, or Computer Sciences and Maths, have the highest mean ratings for satisfaction with job security and salary.

Respondents who said that their job was a 'desired career position' were noticeably more satisfied with their job security and salary than were those whose job was a 'stepping stone leading to a career position' or an 'interim job not leading to a career position'. This appeared to be so, irrespective of the area of initial study. In each of the major areas of undergraduate study, respondents who were in desired career positions had mean ratings of 4 and over on a 5 point scale, and noticeably higher mean ratings that those who were not in a desired career position.

68

A similar pattern was evident whatever the respondents' occupational category. For the majority of occupational categories, mean satisfaction ratings were higher for those in desired career positions, including those in Science technician and other technician positions, who had comparatively low mean ratings overall.

Respondents whose major undergraduate area of study was Medical/Health Sciences, Life and Physical Sciences, Life Sciences, Life and Medical/Health Sciences, and Computers and Maths are most likely to say that they have an interesting job where their Science skills are used. Being in a desired career position led to higher ratings on the scale, with mean ratings of over 4 on a scale of 5 for most major areas of undergraduate study.

Summary

It is clear that Science graduates find worthwhile employment in areas other than their area of initial study or major discipline. Respondents across all occupational groups are generally positive on a range of indicators of work satisfaction and the extent to which they find their work worthwhile. Science technicians and other technicians are perhaps the exception, although they rate relatively highly on the scale of job interest and use of skills.

Nevertheless, it should be said that there are few indicators on which responses could be described as especially positive, but since we do not have direct comparisons with other occupational groups it is not appropriate to make too much of this. It is important to recognise that the sources of satisfaction and sense of worth vary across the occupational groups and represent a series of tradeoffs. For example, as we have indicated, Science professionals get lower incomes but the payoff is to have a job which they find interesting, being able to use their skills, and having those skills valued. In contrast, Science managers are lower on these indicators, but have a high degree of autonomy in their work, which, presumably, they find rewarding.

9: SCIENCE DEGREES AND EMPLOYMENT SKILLS

We turn now to how respondents regard their Science degrees and whether the skills gained are related to their employment. We first discuss the skills and attributes they say they gained from their undergraduate Science degree, and the importance and value of such attributes as far as employment is concerned. We then discuss more general reflections on the undergraduate Science degree. Both the survey and the interviews also reveal respondents' perceptions of what is lacking or deficient in an undergraduate degree in regard to employment and career options.

Attributes gained in an undergraduate Science course

In examining views about skills gained in an undergraduate degree, both the percentages of people who believed they have gained such skills and the strength of their agreement is important. Table 9.1 shows the former and Table 9.2 the latter; we refer to both Tables in the following discussion.

There was a high level of agreement amongst respondents that their undergraduate degrees had provided them with analytical skills, problem-solving skills, subject-specific knowledge and understanding, an ability to use research to inform analysis and decision-making, and an awareness that knowledge is always being revised and extended. Three-quarters or more of survey respondents agreed that the degree had provided these attributes to 'an extent' or to a 'great extent' (Table 9.1). Four of the items received a mean rating of around 4 on a scale of 5, indicating relatively strong agreement with the items. They were analytical skills, an awareness that knowledge is always being revised and expanded, problem-solving skills and subject-specific knowledge and understanding (Table 9.2).

There was less agreement around other attributes. Between one-quarter and one-half of respondents agreed that courses provided oral communication skills, the ability to use information technology effectively, an understanding of other points of view, flexibility and adaptability, and an awareness of the social implications of developments in their field. Less than one-quarter agreed that they provided management skills, competence for working in an international environment and an understanding of other cultures (Table 9.1).

Table 9.1 also indicates the percentage of respondents agreeing that the same set of attributes are important in their current employment. The highest proportions of respondents agree that problem-solving skills, the ability to work independently, flexibility and adaptability, the ability to work with others, oral communication skills, and analytical skills are important in their employment. Mean ratings indicate that the extent of agreement for all but four of the items is strong, with ratings of 4 or more on a scale of 5 (Table 9.2). Skills rated most important in employment are problem-solving skills,

oral communication skills, the ability to work independently, flexibility and adaptability, and the ability to work with others.

Table 9.1: Respondents agreeing that attributes were gained in an undergraduate Science course, and that they are important in current employment, and differences between the two (% of respondents) N=958

	Attribute gained in an u/g course	Attribute important in employment	Differences in percent agreeing
Analytical skills	82	86	-4
Problem-solving skills	76	95	-19
Subject-specific knowledge and understanding	76	58	18
An ability to use research to inform analysis and decision-making	75	75	0
An awareness that knowledge is always being revised and extended	75	77	-2
The ability to work independently	67	91	-24
A capacity to deal with complexity and ambiguity	59	81	-22
Written communication skills	57	82	-25
The ability to work with others	54	90	-36
The ability to use information technology effectively	45	85	-40
Flexibility and adaptability	45	90	-45
An awareness of the social implications of developments in your discipline/field	41	52	-11
Oral communication skills	41	89	-48
An understanding of other points of view	40	76	-36
Management skills	20	79	-59
A sense of confidence and competence for working in an international environment	19	51	-32
An understanding of other cultures	14	42	-28

There are, then, some considerable gaps between respondents' perceptions of the attributes they gained from an undergraduate Science degree and their views about attributes that are

important in their current employment. There are only three — analytical skills, an ability to use research to inform analysis and decision-making and awareness that knowledge is always being revised and extended — where the match between what is gained from an undergraduate course and its importance in employment is relatively close.

Table 9.2: Mean ratings on attributes gained in an undergraduate science course and their importance in employment (5=strongly agree), N=958

	Attribute gained in an u/g science course	Attribute important in employment
Analytical skills	4.1	4.3
Problem-solving skills	4.0	4.6
Subject-specific knowledge and understanding	3.9	3.5
An ability to use research to inform analysis and decision-making	3.9	4.0
An awareness that knowledge is always being revised and extended	4.0	4.0
The ability to work independently	3.8	4.5
A capacity to deal with complexity and ambiguity	3.6	4.1
Written communication skills	3.5	4.2
The ability to work with others	3.4	4.4
The ability to use information technology effectively	3.2	4.3
Flexibility and adaptability	3.3	4.4
An awareness of the social implications of developments in your discipline/field	3.1	3.4
Oral communication skills	3.1	4.5
An understanding of other points of view	3.2	4.0
Management skills	2.4	4.2
A sense of confidence and competence for working in an international environment	2.4	3.4
An understanding of other cultures	2.1	3.1

Subject–specific knowledge and understanding is important in the jobs of almost 60 per cent of respondents. The findings indicate, however, that respondents believe their undergraduate degree provided little assistance in regard to a number of skills that are

important in their jobs, i.e. management skills, oral communication skills, flexibility and adaptability, the ability to work with others, and to use information technology effectively. Whether or not it is possible for an undergraduate degree to provide such a range of skills is another question. The findings indicate that undergraduate Science degrees are limited in significant ways in providing skills and attributes required in the jobs that the respondents have undertaken.

On the other hand, however, the majority of respondents agreed that their undergraduate Science degree was important in obtaining their employment. An overall 41 per cent of respondents said that their undergraduate degree was essential to obtaining their current or most recent job; a further 34 per cent said it contributed a great deal to obtaining it. More women than men (46 per cent compared with 28 per cent) said that it was essential.

Gender differences in perceptions of Science courses

A comparison of female and male views about attributes gained from an undergraduate Science degree revealed some interesting differences, with statistically significant differences concerning seven attributes. The extent to which these differences result from different experiences of a Science degree, different course and subject choices, differences in the working and learning styles of males and females, and other factors, including an interaction between experiences and learning styles, is not clear from our findings. However, the following are noteworthy:

- Male respondents were significantly more likely than female respondents to say that they had 'not at all' gained the ability to work independently in their undergraduate degree (although males and females were equally likely to say that they *had* gained this ability 'to a great extent');

- Female respondents were significantly more likely than male respondents to say they gained the ability to work with others to a 'great extent' and significantly less likely to say they did not gain this ability 'at all';

- Females were significantly more likely to say that they gained both written communication skills and oral communication skills from their undergraduate Science degree;

- Females were significantly more likely than males to agree that they had gained an awareness that knowledge is always being revised and expanded, an awareness of the social implications of developments in their discipline or field, and an understanding of other cultures (although as we have seen, only a small proportion of respondents overall agreed that an undergraduate Science degree provided the last of these three skills).

There were also gender differences in regard to the importance of the attributes in respondents' employment. Again, there are likely to be a number of factors contributing to such differences, although we can of course speculate that they relate to differences in the

employment patterns of female and male respondents already noted, especially the greater tendency for males to be in IT areas, and females to be in the Life Sciences. Two points of difference stand out:

- Female respondents were more likely than male respondents to agree that the following attributes were important in their employment: subject specific knowledge and understanding; the ability to work independently; an awareness that knowledge is always being revised and expanded; an awareness of the social implications of developments in their discipline or field; and an understanding of other cultures; and

- Male respondents were more likely than female respondents to say that analytical skills and ability to use information technology are important in their employment.

Perceptions of undergraduate Science degrees: filling out the picture

Qualitative comments from the interviews and the survey help to fill out a picture of respondents' views. Interviewees were able to readily identify a range of skills and attributes developed from doing a Science degree and the findings are consistent with what has already been said. Most consistently noted were analytical, problem solving and organisational skills. In addition to generic skills, interviewees spoke of laboratory skills, technical skills and Science-related knowledge; specific skills were, however, less frequently mentioned than generic skills. Other interviewees referred to note taking, report writing, information gathering and interpretation, memorising skills, and strategies for finding information.

Whether or not team work, presentation skills and confidence in speaking in front of others was an outcome of the degree, depended on whether they had been part of an individual's experience in the degree. Such skills were more frequently noted as lacking in a Science degree. More generally, some spoke of encouragement to think in different ways, having their mind expanded, learning independence and self-discipline through doing a Science degree. For example:

> *What I gained from my Science degree was the capacity to look at things in an ordered way, which may be restrictive in some ways, but it can also be liberating because it can help you to find ways out of messes. I also developed the capacity to read quickly, to know where and how to look things up and to understand scientific language, which I find can often be applied to different areas of expertise.*

Most useful skills and attributes gained

In addition to the quantitative data concerning skills gained in an undergraduate degree, we analysed responses to an open-ended question that asked survey respondents what was the most useful thing their undergraduate Science degree contributed to their ability to do their

present job. As expected, responses tended to reflect the quantitative findings. Subject-specific knowledge and understanding, analytical skills, and problem solving skills were frequently and most consistently cited; general laboratory and technical skills, and an understanding of scientific method and broad research skills were somewhat less frequently mentioned, as was the ability to gain further knowledge — how to learn and how to apply skills to new situations.

Beyond that, factors were very varied. There was a group of attributes which seemed to derive from experiences in the undergraduate course of working together with others on a task or project and presenting material to a group (i.e. team work; oral communication; presentation skills). Conversely, some referred to learning in their degree to work independently and to organisational skills and learning how to handle a fairly heavy workload. Others noted that their degree had helped them to tolerate uncertainty, develop a sceptical approach, be open-minded and think laterally. These were the capacities that had most assisted respondents in their employment.

There were other comments too that reflected individual situations and specific course experiences. A respondent who did a BSc, then went on to Medicine (which she had originally wanted to do) said: '*The BSc fulfilled the requirement to apply for postgrad medicine, and it was also a good basic science grounding on which to build practical knowledge*'. A respondent who had a Bachelor of Applied Science in diagnostic medical imaging and was working as a radiographer said: '*The knowledge I gained has given me an excellent foundation on which I can build and keep learning more. And being able to use it daily helps everything about my job. It's second nature for me now*.'

The following comment from a survey respondent, related to the importance of practical experience during a Science course, is reported partly because of the perceived deficiency in practical, work-related experiences noted later in the chapter when we discuss what respondents believed was lacking in their Science course.

> *Apart from the geophysical/geological content that provided a good background for my present job, it was the fieldwork associated with the course that was most beneficial. My current job involves working on a ship at sea with a small group of people on a five-week on/off rotating schedule. It was the field work throughout my course that provided the 'qualities' such as working with a small group of people for extended periods of time away from home. When I first started this job, it was like going on a Uni. field trip. Two years later, nothing has changed.*

Some said their general university experience rather than their Science degree was important in gaining work-related skills:

> *Except for one subsection of one subject (approximately 4 weeks) none of the tuition provided by my course was directly useful in any work I have ever done. That said, I consider my time at university absolutely essential to my career and my current position. Being exposed to so many interesting people and creating a network of peers is, without doubt, the most important and most influential part of the university (Science) education.*

Perceived deficiencies in a Science degree

Both the survey and the interviews provide information about what respondents regard as lacking or deficient in their undergraduate degree in enabling them to do their present job, or in regard to career options generally. The responses fall into a number of broad categories. They are not presented in order of importance, however, the first, second and third of these categories were consistently and frequently noted.

Lack of, or limited career advice

There were numerous comments relating to lack of broad career advice and information, and lack of information about where courses could potentially lead. Some examples from both the interviews and the survey are given below:

> *It is not the science degree that is lacking or deficient but the career advice and honesty of universities in informing people that a science degree won't necessarily lead to a job.* (male, completed PhD in the mid-1990s)

> *What's lacking is career advice regarding what jobs you can get with what major, what are the needs of industry and the science growth areas – the areas that have jobs for people with a BSc, and general career advice for students.* (female, pass degree recently completed)

> *I didn't understand that you needed a PhD to have a 'career' in science.* (female, Honours degree completed mid-1990s)

> *There was very little in the way of support and advice to help people realise there are career options outside lab-based work* (male, Honours degree completed in 1992)

> *There was no information regarding the abysmal career structure or opportunities, particularly the lack of funding at the senior post-doctoral level and above.* (Research Fellow working overseas)

Sometimes, such comments were related to a view that university study was divorced from the 'real world':

> *Universities don't prepare you for the real world. I didn't have any real career preparation and little knowledge about my prospects.* (female, Pass degree completed in early 1990s)

Limited or no employment-related skills

Many respondents noted the absence of a range of directly work-related skills — management, leadership, finance, business, oral communication and team work skills, presentation and written communication skills. We have not included many quotes here

because the responses were usually quite brief and to the point, e.g. 'a basic understanding of business principles', 'business and financial skills', 'people management', 'management and conflict resolution'.

Courses not practical enough

This group of responses referred to such factors as the 'lack of connection to real world situations', courses being 'not practical enough', 'little real workday focus — too idealistic' 'more realistic experience' being needed. One respondent commented in more detail saying that what was needed was a *'thorough understanding of practical application of scientific principles as required in work places (practical sessions at university reinforce subject theory but are generally unrelated to real work related requirements)'.*

Related to this issue were comments about a lack of practical experience during courses:

> *What was lacking were the practical aspects, that is, going into real life situations. Science is about the real world. It should be more outside and there should be more about applying the skills you learn. Also it should be more about looking at user needs.* (female, Honours degree in biology completed in the mid-1990s)

Some suggested that work experience, or more work experience, was needed during the degree. Others called for clearer links between theory and real world problems:

> *Science is about the real world. It should be more outside and there should be more about applying the skills you learn. Also it should be more about looking at user needs.*

> *Lack of a thorough understanding of the practical application of scientific principles as required in work places.*

Computer and IT skills

Some respondents said their courses lacked training in the use of computers and general information technology skills. This reflects the survey findings reported earlier in this chapter, i.e. there was a gap between the extent to which respondents' believed they gained the ability to use information technology effectively and the importance of this skill in employment.

Narrowness of courses

Another group of responses suggested that some courses were too narrow, too 'funneled', too 'specific', with limited electives.

> *I feel the degree should offer an opportunity to take on more electives from other fields. I feel most scientists lack a general knowledge of other fields.* (BSc, Biomedical Science, female)

Finally, a small number of comments expressed strong dissatisfaction with a course or with the general tenor of a faculty.

Appreciation for a Science degree

We included in the survey several questions that asked respondents to reflect on aspects of their undergraduate degree and on Science education in Australia.

This research confirms that most people do undergraduate Science degrees because they are interested in the area and 'love science'. It accords with the importance of intrinsic interest as a motivating force for undertaking undergraduate study in general (McInnis, James and Hartley 2000). Do these feelings remain some years on? We asked people about the extent to which they agreed with the item: 'Even if I never work/worked in a Science-related area, it has been worthwhile and satisfying having completed a Science degree'. The responses suggest a strong individual appreciation of Science skills and training. Almost 70 per cent of respondents agreed with this item, and only 14 per cent disagreed with it.

It is perhaps of note that only 45 per cent of respondents from a Medical/Health Sciences background and 61 per cent from a Computer Sciences background say that doing the degree has been worthwhile irrespective of the employment outcome. Our findings indicate that these undergraduate areas of study tend to lead to relatively specific employment outcomes. Conversely, three-quarters or more respondents from Life Sciences, Life and Physical Sciences, and Maths and Physical Sciences, which tended to lead to more diverse employment outcomes, agreed. So too did 77 per cent of those whose areas of undergraduate study included both Computing and Maths.

A further breakdown of major area of study into subject areas showed that respondents who studied Pharmacology, Applied Maths, Environmental Science and Biology tended to have the highest rates of agreement that their degree had been worthwhile, irrespective of the occupational outcome. Around 80 per cent and more of respondents who studied these subjects agreed with the statement. While findings concerning respondents with different subject backgrounds are interesting and perhaps suggestive, the number of respondents in some categories was not large, and further research would be needed to establish whether there is a relationship between subject background and strong appreciation of a Science degree irrespective of the employment outcome.

Although 70 per cent of respondents said their Science degree had been worthwhile even though they never work or worked in a Science-related area, somewhat fewer said that if they had their time over again, they would still have done a Science degree. Sixty-two per cent agreed, while 19 per cent disagreed and 19 per cent were unsure.

Respondents appeared to be reasonably content with their choice of focus for their undergraduate degree, with only 23 per cent saying that if they had their time over again, they would have done a degree in a different area of Science.

Despite the relatively strong appreciation of a Science degree that is evident from the findings reported above, almost half of the respondents agreed that sometimes they regretted that they did not study other things at university beside Science. This is reflected in some of the comments regarding perceived deficiencies in a Science degree noted below.

Science-based job opportunities in Australia

The commitment and general enthusiasm for Science reflected in the relatively high rate of agreement that doing a Science degree was worthwhile is not matched by views about the current status of Science in Australia. Only 21 per cent of respondents agreed that there are many Science-based opportunities in Australia today; 47 per cent disagreed and 32 per cent were unsure. Similarly, respondents were quite divided on whether it was a good time for young people to aspire to a career in Science. Almost equal proportions of respondents agreed, disagreed and were unsure about this proposition.

Summary

Respondents clearly agree that their undergraduate degrees provided them with analytical skills, problem solving skills, subject specific knowledge and understanding, an ability to use research to inform analysis and decision-making, and an awareness that knowledge is always being revised and expanded. On the whole, there is a relatively strong appreciation of the skills they have gained but certainly not by all. Some criticisms were quite trenchant.

There are large gaps in perceptions of attributes gained in an undergraduate course and the importance of those attributes in the current jobs of the respondents. Major differences on some items include management skills, quite large discrepancies in relation to written communication, the ability to work with others, flexibility and adaptability (considered very important by employers) and the ability to use information technology effectively. The need for a high level of oral communication skills stands out as an attribute needed by almost nine out of ten respondents in their current employment, while only four out of ten felt they gained such skills in their undergraduate course.

Some interesting and important gender differences emerged from the data in this chapter. They suggest possibly that females have a quite different outlook on what they gained from their undergraduate degree, which to some extent is based on the kinds of courses they take, the gender mix and so on. Nevertheless, there are lessons that might be applied from these findings, and a closer examination of the ways in which females experience the development of these crucial generic skills would be worthwhile.

One of the most positive findings is the 70 percent who said their Science degree had been worthwhile, even if they never worked in a Science or Science-related area. Similarly, 62 per cent said they would still do a Science degree if they had their time over. Nevertheless, it is also important to monitor the finding that 23 per cent concluded that they should have

chosen a different area of Science. Perhaps related is the important finding that about half of the respondents regretted they did not study other things at university besides Science.

On the basis of the qualitative investigation a number of themes stand out as deficiencies in the undergraduate experience of Science: the lack of career advice; limited opportunities to develop employment related skills; and the view that courses are not practical enough, and not related to the 'real world'.

10: FINDINGS FROM THE EMPLOYER CONSULTATIONS

Skills required by employers

It is self-evident that there are variations in what employers require for different positions. This will vary, at the very least, according to the variety of occupations science degree holders go into even within directly science-related areas, different levels of responsibility and experience, and the different mix of technical and other skills and knowledge required for different positions. Nevertheless, the employer and recruitment agency consultations revealed some consistencies.

A range of skills

The consultations confirmed that, whereas in the past, science graduates were not necessarily required to have skills other than technical and 'science' skills, employers now tended to seek people with a variety of skills, including being able to communicate well with others. Most of those consulted are looking for people who can make decisions, who have team work skills, interpersonal skills, are 'project management minded' and have good problem solving skills. They noted that while technical skills are clearly essential for many positions, for others, the type of degree matters less than a range of other skills and previous experience. The 'other' skills include the ability to communicate, adaptability, resourcefulness, and for some jobs, creativity. For higher level positions, demonstrated ability to handle a high level of responsibility is required.

Depending on the job, good communication skills may include the ability to communicate with a diverse range of people such as engineers, management, clients, researchers, and the public, and the capacity to translate scientific terms and ideas into language that all of these different groups can understand. Business acumen, coupled with technical skills is also highly regarded for some positions, as are marketing and public relations skills.

A large international firm we consulted has common criteria across the world for recruiting graduates — they are capacity, achievement and relationships. It was explained that while a credit average is necessary for a graduate to be even considered for a position, high levels of academic achievement are no guarantee of success. This company recruited on a candidate's judged potential, and past achievements were assessed more for what they said about potential performance in the future than for their own sake.

Several respondents suggested that an increasingly important factor influencing an employer's choice is the degree of compatibility between the culture of the company and the graduates' personality — whether the person is going to fit in with or complement the company's culture, a consideration that can override the best qualified person. A large employer talked of 'cultural fit' as the employee sharing the same values and mission as the organisation. Technical skills are a high priority in certain departments, but these must

be weighed against the responsibilities of the company to its stakeholders. Employee activity must be a value-adding process.

> **Box 10.1: The importance of personal qualities and skills**
> *The most successful employees from Science backgrounds are not necessarily those with the most knowledge but those that can get the work done in the most effective way. They tend to be good communicators, people with good interpersonal skills and committed to both developing themselves and the organisation. I have seen many Science graduates have very successful careers in Sales, Marketing and other business directed activities. It is important to develop good commercial acumen. 'The transferability of the persons' skills is not dependent on what they have studied but what other qualities they have that shape the way they use their knowledge. Not all people are able to move into supervisory roles easily. It is expected that once an employee moves into a higher level in the company, expectations of them do not only revolve around their technical abilities but how they manage processes and systems* (Human Resources Division of a large health-related organisation, previously government owned, now privatised).

These general requirements for a diverse range of business-related and interpersonal skills must be seen against the reality of some 'lab' jobs. More than one Science graduate interviewee spoke of the limited challenge and creativity required in some laboratory positions. Some said that the fear of getting stuck in such a job was a motivating factor for further study or a change of direction. In response to the question: 'what was the most useful thing your undergraduate science degree contributed to your ability to do your present job?' one survey respondent wrote: 'The persistence to be able to do the same test thirty or forty times each day!' (It has to be said that it was not clear whether the respondent viewed this as a positive or a negative quality.)

The importance of work experience

The reliance on past experience as a criterion for assessment and employment obviously presents barriers for those who have not been able to find a relatively skilled position in the years immediately after graduation. One recruiting agency suggested that employers are expecting people who have finished their BSc a few years ago to have a demonstrated track record and that it will be possible to assess their business acumen from their work experience. Work experience thus becomes very important to employers when assessing graduates' suitability, and it was suggested that some employers look more favourably on graduates who have other than science work experience, believing that this demonstrates a diversity of skills, to the extent that a BSc graduate who has worked in a pub while studying would be judged as having good interpersonal skills as well as Science skills.

It was suggested that some employers look similarly at the work experience of PhDs. Work experience in an area other than science is regarded as an advantage. Conversely, some employers expect that if PhD students do not have work experience in another area, this indicates that they have committed all of their time to specific areas of interest, and they will therefore have an extensive amount of experience in their area of expertise and will demonstrate passion and commitment in their field of study.

> **Box 10.2: The importance of work experience and extra curricular activities**
> *A consulting firm which employs approximately 300 people national-wide, and whose main activities are in the information technology area, was able to provide an indication of the number of science graduates they had employed in Melbourne in the past 2-3 years. In 1999, 18 of 112 graduates employed had a BSc (16 per cent) and for the year 2000 to August, 26 of 230 graduates (11 per cent).*
> *They summarised the qualities they were looking for as: good team skills; good communication skills; good problem solving skills; self control and self confidence; people who have got a bit of 'get up and go'; people who are inquisitive and like problem solving. They were quite clear that excellent results were not the main or only consideration; excellent grades but no work experience at all while studying would not get anyone an interview. Extra curricular activities were also regarded favourably, together with part-time work, they were seen as demonstrating time management skills, an ability to deal with and interact with different people and the general public and the capacity to cope with multiple tasks. Double degrees were regarded positively because they were seen as providing the person with a balance, producing a multi-skilled, multi-talented graduate.*

The influence of preconceptions

We noted earlier that some science degree holders interviewed had found that employers held stereotypes about the types of skills Science graduates had, and perhaps more importantly, what they lacked. However, the quantitative survey results did not confirm this as a general trend. Only about 15 of the respondents (slightly more males than females) agreed they had found stereotypical employer attitudes. Nevertheless, one in seven had found this to be the case, and it is when Science degree holders move into employment areas not directly related to Science that this will have an impact.

Several comments from employers related to this issue, either confirming the view or challenging it. One large employer spoke in general terms: 'Science graduates are perhaps labeled with a preconception about what approach they will take to a particular situation.' Another disputed a popular misconception:

> '*I know there is a view that Science graduates lack communication skills but I don't subscribe to that. Our experience has been that if any particular type of graduate could be seen as having poor communication skills, it is information technology graduates.*'

However, this employer conceded that, as their organisation was chiefly concerned with IT:

> '*You have to think a bit more about where BSc's fit in, how their skills relate to the four main areas of the organisation. If a person with a BSc applies for a non-science job we do question them as to why they want to move away from science-related work. On the other hand, you don't have to think about where ITs fit because there is a specific IT section of the organisation.*'

Conversely, the representative from the large health-related organisation, in which there are many more opportunities for people with science backgrounds than IT backgrounds, said that a Science graduate has ample opportunity to move around the organisation, gain exposure to various departments and develop well rounded knowledge, skills and experiences. The same is harder to do with IT graduates, although IT graduates have often studied within a business discipline and completed studies in business related subjects, so have some business skills.

Employer training

Perhaps not surprisingly, the consultations revealed diverse attitudes towards employers' role in the training of new employees. Some large organisations accept that it will take some time to inculcate graduates into their business and they have structured and well developed programs of initiation and staff development. Others seem less happy about having to spend time training recent graduates in a range of business and work-related skills. A food industry employer suggested that the graduates they get, especially BSc's, do not have project management and business protocol knowledge, knowledge of financial systems and, in some cases, interpersonal skills. When these are not present, it often takes up to two years to train people.

'Value-adding' to a science degree

We consulted with a number of companies engaged in other than Science-related activities. It is difficult to obtain any quantitative information about the employment of Science degree holders in such companies. Records of staff qualifications are frequently not routinely kept in a form that is readily available. If someone is employed on the basis of a subsequent qualification or relevant experience, details of the first qualification may not be known.

The Melbourne office of a large international business consultancy firm recruits across disciplines, usually from business and economics. In a recent survey, they found that only one science graduate had been employed over the past couple of years, although they do employ some Law/Science graduates who go into accounting. Similarly, an international business strategy consulting firm, said that they employed only a handful of science graduates, predominantly PhDs, although they do recruit across disciplines from university campuses. Their main criteria are exceptional achievement academically; strong analytical skills; a high level of skill with numbers; people skills and demonstrated appropriate extra curricula activities. Again, the importance of other than academic work and experience is important, and employees have to be team-oriented.

Science graduates and IT graduates

One of the issues this project was concerned to explore is the extent to which the employment of natural and Physical Sciences graduates in their profession, in management and other areas, increases to levels comparable with technology professionals by about ten

years after graduation. While the employers' consultations do not offer answers to this question, some comments relevant to the issue were offered.

For one company employing approximately 850 people in the sales, marketing and computer networking area in Australia, experience and what people have done is more important than the particular qualifications they hold, so a science degree would have no more or no less influence than any other qualification — relevant experience, demonstrated ability, the capacity to self-start and manage a project are the important factors.

Research scientists

Representatives from three CSIRO Divisions were consulted regarding trends in the employment of a group of Science degree holders who can clearly be designated as research scientists. Some consistent trends were noted, although one respondent pointed out that comments are anecdotal to some extent as there is not always a lot of hard data to back them up.

Overall, it was suggested that the emphasis is on employing well trained, flexible, creative scientists who have the ability to work cooperatively and in teams. Noticeable trends in the employment environment are the effect of technology in all areas of science, leading to new and rapidly expanding areas of Science; the undoubted importance of IT skills in any area of science, specific modeling experience in some areas, and computational skills ('You don't get a lot of jobs without some maths, or computational ability'); and the importance of communicating with a range of people including funders, clients, and 'ordinary' people. There is an imperative to be able to explain and persuade people about the value-added nature of the research.

Limited tenure (externally funded) post-doctoral positions, generally of three years, are increasingly part of the career pathway of a research scientist. There is an expectation that the first three to six years after the PhD is a developmental and training period, with one respondent noting that the career pathway was becoming more like that in medicine. At least one, but usually two or more, post-doctoral appointments are expected, with one giving overseas experience. Training and development during this period includes how to conduct research ('in the real world'), how to manage funds and people, and how to communicate with a range of people. Technical brilliance, while very important, is no longer the only requirement of a research scientist. It is much more difficult now than in the past to be a research scientist without being a manager.

A further trend identified is the tendency for research to involve less extensive fieldwork ('marine scientists don't go off to collect buckets of water' much any more), fewer data collections and greater use of modeling of probabilities in areas where these techniques were previously not used.

Summary

The consultations give some indication of how a small number of enterprises and employment agencies view graduate employees. They reinforce the importance of generic skills yet, importantly, reveal some diversity. We are of the view that the expectations of large employers can be markedly different from those running small businesses and so it is vital that a balanced assessment of employer perceptions drives consideration of course change. However, there are some common themes. The sheer range of skills now expected of Science graduates is a challenge, for them and for faculties of Science. The responses of employers reinforce the importance of work experience during the undergraduate degree, not necessarily directly related to the actual position. This suggests that employers generally are concerned that graduates have successfully acquired a diversity of skills in different work environments.

11:CONCLUSIONS

The critical role of universities in preparing a workforce capable of meeting the demands of the knowledge economy is now becoming more widely understood. Science faculties must be at the forefront of the national effort to provide research and innovative solutions to lead and support the changing national priorities. Much of this effort will depend on the quality of undergraduate programs in Science and the effective use of graduate skills in the workforce. However, there are some major gaps in our knowledge of what graduates do with their Science degrees and how faculties of Science might best address their needs, and the emerging national priorities.

On the question of whether Australian universities are producing too many Science graduates, the present research can offer only a partial answer. The findings presented in the report suggest there is no evidence that there are 'too many' graduates, if employment and unemployment rates are any measure. We point to the reasonably high employment levels of the group surveyed and the generally high levels of use of their skills across a broad range of work environments.

The simple answer to the question, 'Is there a career structure for Science graduates?' is 'no', certainly not in the conventional sense as understood by Science academics or researchers. Rather, there are multiple career patterns, varying according to areas of undergraduate study and any subsequent qualifications, to labour market factors, and to a range of personal and circumstantial factors. We have a considerable amount of information about respondents' qualifications and their employment-related activities since they completed their first undergraduate science degree. We do not have information about the range of personal and circumstantial factors, such as family and other responsibilities, relationship ties, health, housing options, temperament, personal preferences and attitudes, that may well be as important in determining the jobs people look for and undertake as are area of study, level of qualifications and the state of the labour market.

The notion of under-employment from the project brief was examined and not found to be of great concern in terms of proportions, although there are gender differences to be considered. It is predictable enough that graduates early in their careers might be in part-time employment looking for full-time employment, and closer investigation of this might be worthwhile. We do caution that responding to the finding that fewer graduates from more focused courses are under-employed by tightening course structures, or limiting options, needs to be set against the broader goals of Science education.

We have noted the relatively low levels of unemployment. The findings suggest two important aspects of unemployment related to course structures and choices. Graduates from courses where there was just one major area of focus were more likely to have jobs. This applied across all ages and stages. Again, as with under-employment, this should not be taken to mean that reducing choice in course structures will make an impact on

employment rates. There was no difference in unemployment rates with respect to perceptions of the extent to which respondents saw their course as 'tightly structured with few choices'.

The great majority of respondents (around 80 per cent) said that their undergraduate Science degree was 'directly' or 'somewhat' related to their current or most recent job. A significant minority of the Science graduates in the survey have found employment in areas other than their initial area of study, and for many this is likely to follow further study after the undergraduate degree. Consistent with other findings already discussed, graduates from a Computer Sciences or Medical/Health Sciences area of study are most likely to say their degree is directly related to their job.

It is clear that, in a narrow sense, higher degree graduates are restricted in their opportunities and rewards. Certainly, academic careers are not particularly promising. More generally, the results suggest that an additional qualification in Science was not necessarily a passport to higher income. Even when the higher paid people who did Computer Sciences at the undergraduate level were excluded from analysis, more respondents with a basic (Pass or Honours) Science degree were in the top third income group than were respondents with a postgraduate qualification in Science. This says little for the salaries available to some highly qualified Science-trained people.

Overall, our findings suggest that for many, a Science degree is what you make of it. Respondents have followed some quite diverse employment pathways by variously building on the skills gained in their undergraduate degrees; discovering the limitations and restrictions of their initial training and branching out into other areas; following their interests; retraining in a new area; and returning to areas of study they wanted to do but initially could not get into. Nevertheless, there are some identifiable patterns. Perhaps the clearest of these relates to the minority of Science degree holders who pursue a career as a research scientist. However, even here, there are variations within a broad pattern.

It may be that the general pattern of career diversity for Science degree holders, and some of the patterns themselves, are similar to those of degree holders in other areas of university study. It is not easy to make such comparisons because our dataset is in many respects unique. No comparable Australian research is available on any graduates for the number of respondents and with the level of detail included in this survey. There are, however, a number of less detailed and less extensive studies, including Waugh (2000) which examines what happens to Liberal Arts graduates, and the studies of graduates five to ten years out conducted by a number of Australian universities.

The career patterns and job choices of Science degree holders also need to be seen in the context of two other factors — the limited relevance of linear career structures in current work environments, and the age range of our respondents. The great majority of survey respondents are aged between 25 and 35 years. Some are in the relatively early stages of their employment career; a few may be relatively well advanced; all, potentially, have many years ahead of them in the workforce, and their careers will continue to be 'in

process' for some years. To some extent, then, employment patterns we identify are conditional and incomplete.

Our data reveal a picture at a certain point in time, and while we can make statements about what has gone before, we cannot predict with certainty what respondents will be doing in the future. There may well be changes for a significant proportion of them. Decisions to have children, for example, will, intervene for some and it is overwhelmingly females who will feel the greatest career impact of such decisions. We described how respondents have undertaken a range of Science and other qualifications, chiefly in order to enhance their career prospects or to retain their present employment. The trend to undertake additional training and further qualifications is likely to continue, given the rate of change in Science and other jobs, and this too will have an impact on what respondents do in the future.

It is important to highlight again the positive outcomes of this study. Most Science graduates are happy with their jobs and with the undergraduate degree as a foundation. Most feel their employers value the skills they gained from their undergraduate degree. While it is true that around one in five respondents said that their current employment was not at all related to their undergraduate Science degree, further analysis revealed an interesting finding. When we looked at whether current jobs were related to people's most recent qualification, as few as 16 per cent of respondents said they were not at all related, irrespective of whether they had an undergraduate degree only, a postgraduate Science qualification, a postgraduate qualification in other than Science, or a postgraduate qualification in both Science and other than Science. This does not strike us as a negative or unexpected result, although the variations across the categories and fields needs closer examination. It seems unrealistic, and undesirable, to expect a direct fit between most Science courses and occupations.

The findings confirm that most people do undergraduate Science degrees because they are interested in the area and 'love Science'. Across all occupational groups, the Science graduates surveyed are generally positive on a range of indicators of work satisfaction, and the extent to which they find their work worthwhile. Science technicians and other technicians are perhaps the exception, although they rate relatively highly on the scale of job interest and use of skills. It is noteworthy that only 45 per cent of respondents from a Medical/Health Sciences background and 61 per cent from a Computer Sciences background say that doing the degree has been worthwhile irrespective of the employment outcome, in contrast to the three-quarters or more respondents from Life Sciences, Life and Physical Sciences, and Maths and Physical Sciences—courses which tended to lead to more diverse employment outcomes. Some qualification to this relatively positive picture needs to be made however. Science degree holders who have never worked in a Science area, or who are disgruntled, highly dissatisfied with, or alienated from, their undergraduate experience may well be under-represented in the survey population. We do not know the type of employment they have found, if any, or their income levels.

There is much more to be analysed in the data set now available to the Australian Council of Deans of Science and it will be possible to develop further papers on specific issues

from time to time. This study also provides a set of benchmarks and an opportunity to monitor changes in the employment outcomes of Science graduates, and will also be available to measure the impact of policy and contextual changes.

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Appendix 1

(a): Methodology

1. Selection of the sample for the mailed survey

Dobson and Calderon (1999) suggested that longitudinal data in which individual careers were followed over an extended period of time would be the best way of exploring the impact of labour market demand on employment of science graduates. They added that such an approach is expensive and time consuming. It is interesting to note that in the US, databases maintained by the National Research Council of Scientific and Engineering Personnel provide information about the educational course and employment status of scientists educated to the PhD level in the US. Records are collected when the degrees are awarded and are updated biennially through surveys of a sample of doctorate holders (National Academy of Sciences 1998).

Australia has no such databases, although there have been calls for much better information concerning graduate pathways over the past decade or so. However, more accurate information about PhD pathways is only part of what is required. For a fuller picture, we also need to know what happens to those with a Pass or Honours Science degree over time.

We sought from each of the universities a sample of those who had graduated with a Pass or Honours degree in Science over the past ten years, and explored with them the best means of obtaining the most accurate list of records available. In general, this proved to be a combination of student records and Alumni or graduate roll records. Lists from four of the institutions were validated against White Pages information, i.e. the names and addresses supplied by universities were matched against telephone directory information and only those records that matched certain criteria of accuracy were used. We were informed that details from the other two institutions had already been through a checking process, although there proved to be inaccuracies in these lists, and significant inaccuracies in one of them. Contact details of students who graduated earlier than 1995 were not able to be obtained in another institution as it was undergoing a major change in its student records system. Although it was initially thought that this would be completed in time for a comprehensive list to be available, this proved not to be the case.

The six institutions included a considerable variety of science courses, and the areas of study included in the Faculties of Science varied. We were guided by the Deans of each as to what courses should be included in selecting the sample of graduates. Those courses that did not include a significant emphasis on the basic sciences were excluded, as were degrees that were vocationally specific, such as optometry. We also over-sampled for

93

people who graduated in the early 1990s in order to ensure some longer out respondents. The profile of respondents shows that this was largely successful.

While the research team carried out some selection from the lists provided, we were reliant on the universities to provide initial lists within the requested categories of graduates. In the majority of cases, it appears that the lists did match the parameters requested; however, in a minority of cases, especially from one university, a postgraduate qualification had been done at that university and the undergraduate science qualification at another institution. As explained below, these surveys were put aside.

It is clearly the case that Alumni records are likely to be selective in a variety of ways, and are unlikely to include science degree holders across the whole range of potential and actual employment outcomes. It is also probable that those who are in general more satisfied with what they are doing are more likely to respond to a mailed questionnaire, and that the disaffected will not respond. On the other hand, they may welcome an opportunity to put a negative or disaffected view.

International students and science graduates working overseas
International students now make up approximately 10 percent of total enrolments in Australian universities. Between 1988 and 1998, award course completions for overseas students in science increased by 17.2 per cent, however, this was not as large as increases in other broad fields of study, and the total number of course completions represents a little less than a quarter of the number in business, administration and economics (DETYA 1999, p. 160).

Our experience in other research projects with mailing surveys to overseas addresses has been that response rates are very low; the cost benefit of such an approach suggests that other strategies should be tried. We therefore sought means other than mailing to contact potential respondents. They included seeking out email addresses where possible, checking addresses provided by universities against internet directories, publicising the study through at least one Alumni electronic newsletter, and, where telephone numbers were available, selective telephoning of overseas graduates to encourage them to fill in the survey online.

In the event, we had limited success in obtaining responses from international graduates who had returned to their home country. A sprinkling of other science graduates working outside of Australia is included in the sample, contacted through our general publicity of the study, through snowballing of contacts and sometimes from mailed survey respondents advising us of friends and colleagues working in other countries.

2. Mailed survey returns

Table A1.1 summarises information regarding mailed and emailed survey returns.

Table A1.1: Mailed and emailed survey returns

Institution	*Estimate of surveys delivered	No. of valid returns	% valid returns
Established University	1451	339	23
International University	1440	364	25
Rural University	494	118	24
Innovative University	466	80	17
New University	1476	297	20
Regional University	497	131	26
All other		165	
Total	5826	1494	26

*Number mailed less return to senders from the institution, except for International University where an estimate of invalid addresses based on a MacroMatch report has also been factored in. The original number of surveys sent out to each institution was 1500 each to Established, International and New Universities, and 500 each to Rural, Innovative and Regional Universities.

3. Selection of sample for analysis

For certain parts of the analysis, it was appropriate to use the whole sample of valid returns. This included the principal components analysis and the written responses which formed the basis of qualitative inference (eg. most useful aspects and pereceived deficiencies of an undergraduate degree as regards employment; and community/voluntary organisations which have benefited from the respondent's science training). However, it was decided that no chances could be taken with this sample group for the greater part of the quantitative analysis, given that the responses were solicited from target organisations and channels other than university administration or alumni lists.

Consequently, the sample was pared further to include only those graduates who completed their undergraduate Science degree from one of the six target universities, within the time frame of the final year of study being between 1990 and 1999 (inclusive). Some respondents, for example, were found to be included on university lists because they had completed a postgraduate qualification at one of the target institutions. They were excluded if they had either earned their undergraduate degree from a university other than one of the six target institutions, or if they had completed their final undergraduate year outside the decade-long time frame we specified. This 'main' sample is shown in Table A1.2.

Table A1.2: Main survey returns

Institution	*Estimate of surveys delivered	No. of valid returns	% valid returns
Established University	1451	300	21
International University	1440	342	24
Rural University	494	106	21
Innovative University	466	76	16
New University	1476	287	19
Regional University	497	125	25
Total	**5826**	**1235**	**21**

4. Questionnaire design

An extensive review of research studies and survey questions likely to be relevant to the focus of the study was carried out. The following research instruments and data sources were examined:
- the Graduate Destination Surveys carried out by the Graduate Careers Council of Australia
- the 1996 Census,
- a customised data matrix from the 1996 Census,
- the 'extra' questions about transition from university to work included in the Melbourne University MIAESR Graduate Destination Survey
- the CSHE Graduate Feedback Survey
- 'The PhDs Ten Years Later' study carried out by Nerad and Cerny in the United States, which surveyed 6000 PhDs in 1996, and
- the Melbourne University MIAESR Employer Feedback Survey

While offering a valuable guide in some regards, the review revealed the limitations of the data sources for answering the specific questions to which the ACDS was seeking answers. The surveys and existing data sources have however provided a basis for the development of the present questionnaire, and where relevant, we sought to include questions used in previous surveys, so that comparisons could be made with other groups or with a wider population.

1(b) Associations through which the project was publicised

SEEK Communications
Australian Association of Graduate Employers
Australian Quarantine Services
CSIRO Staff Association
CSIRO Plant Industry and Land and Water Divisions
Lions Club of Victoria
Science Teachers Association of Victoria
Federation of Australian Scientific and Technological Societies
Association of Professional Engineers, Scientists and Managers, Australia (APESMA)
University of Melbourne Alumni
Australian Institute of Physicists
Deakin University (Faculty of Business and Law, Graduate School of Management)
Macquarie Bank
Hartley Poyntons
Licensing Executives Society
Homesglen TAFE (Small Business Course)
Commonwealth Bank
Colesmyer
Australian Conservation Foundation
Pacific Access (White Pages)
Centre for the Public Awareness of Science, ANU

*Personal networks where also used for establishing contacts, sometimes snowballing into several contacts.

1(c) Employer and recruitment agencies consulted

Andersen Consulting
CSL
Coles Myer
Deloitte Touche Tomatsu
Bain International
Ernst Young Pty Ltd
CISCO, Sydney
CSIRO Divisions
  Land and Water
  Plant Industry
  Marine Research
The Australian Institute of Food Science Technologists
National Foods
Simplot (Food)

Sinewave
Tanner and Menzies Recruitment Agency
Mills Harding Recruitment Agency
SEEK Communications
Tanner Menzies

Appendix 2

Profile of respondents

A total of 1494 Science degree holders completed the survey, 1388 in response to a mailed survey and 101 online. A small number in each group proved to be out of scope in that they graduated more than ten years ago. As noted above, some of the mailed survey group were in scope but had done their undergraduate degree at an institution other than the six universities we focused on. While the email group and the mailed survey group were similar in a number of respects, the former were more likely to have done Honours and more likely to be employed in a Science-based organisation.

Where appropriate and legitimate, we have used the total sample in analysis of findings — for example, in regression analyses, factor analysis and reporting of comments. However, in order to keep the reporting as 'clean' as possible, and to focus directly on the questions of interest to the ACDS, in most of the analyses it was decided to use only those 1245 respondents from the mailed survey who did their undergraduate Science degree at one of the six universities.

Table A2.1: Respondents' secondary schooling location (urban/metropolitan, regional, rural) by gender (%), N=1245

Location of last two years of secondary schooling	Males	Females	Total
Urban/ metropolitan	77	73	74
Large regional town	14	18	17
Rural/ township area	9	9	9

Table A2.2: Respondents going directly from secondary school to university by gender (%), N=1245

Males	Females	Total
81	83	82

Table A2.3: Type of undergraduate Science course by gender (%), N=1245

Type of course	Males	Females
Bachelor Pass	60	56
Bachelor Honours	34	40
Combined degree	6	4

Table A2.4: Time of completion of undergraduate Science degree (%) N=1245

	Males	Females	Total
Early 1990s (1990-1993)	38	36	37
Mid 1990s (1994-1996)	36	35	35
Late 1990s (1997-1999)	26	30	28

Table A2.5: Respondents' undergraduate Science degrees: number of areas of study (respondent-defined) (%), N=1494

	Males	Females
One major area of study	33	28
Two or three major areas of study	52	56
Generalist	16	16

Appendix 3

Tables referred to in Chapters 3-9

Table A3.1: Employment rates for areas of study in the undergraduate degree, males and females (%), N=1154

Area of u/g science degree	Males	Females	All respondents
Computer Sciences	100	96	99
Life Sciences	94	90	92
Mathematical Sciences	95	91	93
Physical Sciences	91	91	91
Medical/Health Sciences	100	87	91
Computing and Maths	91	100	94
Life and Physical	86	91	88
Maths and Physical	87	90	88
Life and Medical/Health	89	83	86
Other Science Combinations	86	91	88
General Science	91	91	91

Table A3.2: Current employment status of male and female main survey respondents, N=1245

	Males	Females
Full-time paid employment	67	62
In full-time employment, seeking a change of job	17	13
In part-time employment, seeking full-time	3	3
In part-time employment, content with part-time	7	13
Unemployed	3	3
Not in the labour force	4	7

Table A3.3: Males and females falling into the bottom, middle and top third income quantiles for full-time employment income (%), N=958

	Bottom third income quantile	Middle third income quantile	Top third income quantile
Males	31	31	38
Females	42	32	25