ATTRACTING & RETAINING STAFF ENGAGED IN SCIENCE, ENGINEERING & TECHNOLOGY: A REVIEW OF NATIONAL AND INTERNATIONAL BEST PRACTICE

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Abstract

Australian and international literature is reviewed with the aim of informing government, industry and employers of ways to better attract and retain science, engineering and technology (SET) staff. Challenges and solutions are discussed including the need for greater job availability and stability within SET careers, implementing more sophisticated recruitment and selection processes, building greater flexibility in pay structures, sufficiently rewarding high performing SET workers, providing ongoing training and development of existing staff, greater involvement of employers in the education of future staff, greater attention being given to meet the unique needs of older workers and women, and actively competing in overseas markets to attract SET workers to Australia. Recommendations are given for future research that would overcome existing knowledge gaps and uncertainties, and which would provide Australian employers with best practice case studies.

Key Messages

- Much of the national and global focus on the shortage of SET staff has explored what needs to be changed in the educational systems and early career experiences to “push” prospects into an ongoing SET career. This review explores a “pull” strategy involving employers improving the workplace experience of mid and late-career workers to retain existing staff and develop an attractive long-term career for prospective SET workers.

- In comparison to economically similar countries, Australian private industry employs a relatively small number of highly qualified SET workers. Greater spend and stability is required in SET jobs by government and, in particular, industry if SET is to be seen as a viable long-term career for prospective workers.

- To better compete in a tight labour market, many SET firms now have to more heavily resource their recruitment efforts and develop a more strategic and tactical approach to recruitment.

- The cost:benefit ratio of an SET career has been steadily worsening. Education costs in Australia have increased, and this heavy early investment is paired with a large gap between the high financial aspirations of students and the lower financial rewards and lack of prestige experienced by many SET staff. Employers need to explore ways to increase flexibility in pay structures and sufficiently reward high performing SET workers.

- The nature of SET work is constantly changing and hence ongoing training and development is crucial for skills and knowledge to remain current. With the reduction in the number of early-career training opportunities in the public sector, and concerns being expressed about the appropriateness of current educational content, employers need to play a larger role in training and developing their existing staff and contributing to the education of future SET staff.

- While the current hype around generational differences is unproven, older workers do have some unique needs owing to their life stage. In particular, if employers are to attract and retain older workers, potentially beyond traditional retirement age, then attention should be given to ongoing training opportunities, flexibility of hours, and developing explicit equal employment polices for older workers.

- In a competitive labour market employers must explore ways to better meet the needs of women and other under-represented groups. Attention should be given to initiatives such as targeted recruitment, mentoring and development opportunities, accommodating caring responsibilities, and setting goals for overcoming the imbalance in numbers of women and other minorities.

- While much focus has been given to the “brain drain” of local workers moving to overseas markets, much greater benefit can perhaps be achieved by better attracting SET workers to Australia. Employers, industry associations and government may benefit from actively sourcing fully skilled workers as well as under-skilled workers who can then be trained to meet Australian standards.

- Further Australian-based research would overcome gaps and uncertainties in existing literature, provide Australian employers with greater confidence in conclusions from existing research, and provide case studies of best practice from the Australian workforce.

Executive Summary

The Audit of Science, Engineering and Technology Skills (Department of Education, Science and Training [DEST], 2006) identified that the adequacy of science, engineering and technology (SET) skill supply is an ongoing concern for Australian industry, governments and the scientific research community. The concern is shared by many Organisation for Economic Cooperation and Development (OECD) countries. A range of challenges and initiatives were proposed by the Audit including raising awareness of SET career paths, developing methods to accelerate SET skill acquisition, exploring ways to increase the attractiveness of early-to-mid career researchers, and ensuring adequate infrastructure is in place to support SET training and research.

One particular question, addressed by the current literature review, that arose from the Audit related to the capacity of existing SET industries and employers to attract and retain SET workers. Much of the global focus on the shortage of SET staff has adopted a "push" approach to the problem – that is, it has explored what needs to be changed in educational systems and early career experiences to "push" prospects into an ongoing SET career. This current literature review is somewhat unique in exploring a "pull" strategy for responding to the skills shortage – that is, the review explores how employers can change the workplace experience of mid and late-career workers to retain existing staff and develop an attractive long-term career for future workers. The review focused on national and international literature that could inform private sector employers, public sector employers (in particular, public sector research institutions) and, to a limited extent, universities.

Drawing upon existing career development models, the review develops an integrated model of career attraction and retention. The model highlights that career attraction is determined both by (1) early learning experiences, as well as (2) the perception that a career will provide long-term satisfaction. The previously mentioned "push" approaches to increasing SET career attraction focus predominantly on enhancing the quality of early learning experiences. Such approaches, however, may only have a short-term impact if the mid-term and long-term career prospects are poor. The integrated career development model presented here suggests that "pull" approaches, focused on improving long-term working experiences and person-job fit may have greater effect. Improving the work environment and fit should increase retention of existing staff, and satisfied medium and long-term SET workers will in turn attract newcomers to SET careers.

Using the model as a base, this review is structured around the following nine employer initiatives proposed to be important for attracting and retaining SET staff:

1. Job availability and security. In comparison to many economically similar countries, Australia has a low total spend on SET, and research and development is confined largely to universities. Further, industry and government spend on SET is in flux. These factors all contribute to low availability and security of SET jobs, clearly creating an immediate disincentive to anyone considering an SET career. Greater spend and stability is required in SET jobs by government and, in particular, industry if SET is to be seen as a viable long-term career.

2. Meeting the values and preferences of SET workers. If an organisation is going to maximise its attractiveness to existing and new staff, it needs to understand and meet the unique needs of the type of staff it wants to attract. In comparison to the average worker, SET staff tend to have stronger "realistic" preferences (valuing practicality and using tools and equipment) and "investigative" preferences (valuing exploring, autonomy and learning). Further, the typical SET worker tends to have weaker interest and skill in "social" activities (involving cooperation and teaching) and "enterprising" activities (involving risk-taking, influencing and managing). SET work,

however, is become less investigative (reduced autonomy and opportunities for learning) and more social (with a high emphasis on working in teams) and enterprising (requiring strong managing and influencing skills). Employers need to consider ways to increase autonomy and learning opportunities, while also giving SET workers the training and development needed to adjust to the growing social and enterprising demands of the work.

3. Recruitment and selection. Employers that have only recently started experiencing labour shortages may not have developed the extensive and thorough recruitment and selection processes necessary to compete in a tight labour market. Many SET firms are now having to more heavily resource their recruitment efforts and develop a more strategic and tactical approach to recruitment. Initiatives that SET employers should consider include more extensive marketing efforts to attract candidates, use of recruitment agencies and executive search firms, better targeting under-represented groups of potential employees, graduate recruitment programs, and using outsourced resources such as temporary staff, contract staff and outsourcing work to other firms.

4. Rewards and recognition. The cost:benefit ratio of an SET career has been steadily worsening. Education costs in Australia, in particular with the introduction and expansion of fees for university study, have substantially increased the investment required for a degree-based career. Moreover, education in SET is often more expensive than alternatives because of the heavy cost of equipment and a low student-to-teacher ratio often required for practical training. This heavy early investment, however, is paired with a large gap between the high financial aspirations of students and the lower financial rewards and lack of prestige experienced by SET staff. Part of the reason for the low pay and prestige is that Australia has, comparatively, a small proportion of its SET workforce in industry – many research and development jobs have been in universities and the public sector which, aside from smaller governments resulting in fewer jobs, also often impose inflexible pay structures which minimise the relationship between pay and performance. There are few financially successful role models towards which young, financially motivated workers can aspire.

5. Learning and development. The nature of SET is constantly changing and hence ongoing training and development is crucial for skills and knowledge to remain current. Also, SET workers typically have a higher personal desire to learn than in other professions. However, reduced job opportunities and cadetships within the public sector have resulted in fewer early-career training opportunities for SET workers. Unfortunately, this role of early-career trainer has not yet been picked up by private industry. Further, employers are increasingly expressing concerns that tertiary and vocational training institutions are delivering course content that is outdated. Hence, effective early training is increasingly unavailable from universities, government or industry. An additional problem is that promotional opportunities and career progression is becoming increasingly restricted within SET careers, with senior management positions being more frequently filled with professional managers rather than experienced SET workers.

6. Meeting the needs of older workers and different generations. With a high proportion of the Australian population nearing retirement, combined with a slowing growth in the labour market, many employers are looking for ways to entice older workers to remain at work longer than they may have originally planned. At the other end of the age spectrum employers are interested in knowing if younger generations have different needs than earlier generations. Despite the interest generated by consultancies and media, there is an absence of research investigating age-related differences in work motivators. The research that exists is mixed in its findings and

perhaps the best conclusion at present is that there are many more similarities than differences across age groups. The differences that exist appear to be more related to life stages, career stages or societal changes that affect all generations equally, rather than differences between generations. For example, many retired or near-retirement workers have steady sources of non-work incomes and hence are only moderately interested in pay. Also, given they have been exposed to change and technology less during their careers they tend to have less confidence (but not necessarily less ability) in their capacity to change and learn new technologies. Overall, older workers are more satisfied with most aspects of their work environment than are younger workers. All generations appear to be most motivated by contribution, sense of purpose in their work, participation, recognition, learning and development, and organisations that are handling change well and improving from year to year.

7. Meeting the needs of women. Women are under-represented in SET careers. The integrated model of career attraction and retention presented in this paper suggests that this under-representation has resulted from early environmental and learning experiences as well as workplaces that often do not have the features and flexibility desired by women. In a highly competitive labour market many employers are benefiting from better catering to the needs of women by providing mentoring and networking programs for women, ensuring training opportunities and career paths for women, accommodating family caring responsibilities, and setting goals to achieve an appropriate proportion of women at senior management levels.

8. Attracting and managing immigrants. In comparison to other countries, Australia has a high proportion of its tertiary qualified residents that are migrants, and has the highest proportion of expatriates within its workforce in the OECD. Given Australia's net immigration it is gaining in quantity of skills but there is concern that there is a net drain in quality of skills. However, the number of SET workers lost through emigration is quite small in comparison to the absolute level of SET workers in Australia, and hence employers and government may need a heavier focus on attracting immigrants than the current preoccupation with preventing the loss of SET workers to overseas markets. As well as attracting fully skilled migrants, employers should also explore options for attracting under-skilled migrants who can be trained to meet Australian standards.

9. Employer involvement in pre-employment education. While employers have expressed concerns about the deteriorating quality of education and reduced early-career training opportunities in the public sector, employers themselves have been reluctant to play a larger role in pre-employment and early-career training. Nevertheless, substantial international research and case studies highlight the importance of early, practical, work-related learning experiences, and the benefits for both workers and employers of industry developing a much closer relationship with educational providers. Based on overseas experience it would seem that employers in Australia can take a much larger role in the design of educational content, provision of practitioners to help schools deliver training, and the availability of internships and scholarships.

The report concludes that, to the extent that industry and employers are experiencing labour shortages, existing literature suggests there is much that industry and employers can do to help overcome the shortage. While the government and educational system can certainly take steps to enhance the "push" of workers into SET careers, responsibility and action is also required from industry and employers to "pull" workers into SET careers and then retain them in those careers.

The report highlights, however, that there are many gaps in the literature and that our existing knowledge about work motivators for SET workers is heavily based on overseas research and case studies. Hence, further Australian research on this topic would (1) help overcome any uncertainties which the existing literature cannot confidently resolve, and (2) provide Australian employers with greater confidence given they could then inform Australian management practices with sound Australian research and case studies that are directly relevant to them. Further research should focus on both employees and employers and address issues such as:

1. What are the work opinions and motivators of existing SET workers within Australia? Do these opinions and motivators differ to non-SET workers? Do these opinions and motivators differ between SET industries and occupations? Do older and younger SET workers have different opinions and work motivators? Do women, migrants and other under-represented groups within SET professions have different work opinions and motivators than the typical SET worker? What are the biggest gaps between what SET workers want and what SET employers are providing?

2. To what extent are SET employers willing and able to modify their work practices to better attract and retain SET workers? What obstacles exist to changing work practices? What successful case studies exist that could inform other employers of how to better attract and retain SET workers?

Australia's social and economic future is heavily dependent upon the capacity of its workforce to innovate and implement. SET workers provide the backbone to this capacity. Any threat to the future supply of SET workers must be addressed energetically. Other reports recently commissioned by DEST have proposed ways to modify government policy and Australia's educational systems. In contrast, however, this review emphasises that much of Australia's future economic success rests on the shoulders of current industry associations and employers and their attempts to modify workplaces to better attract and retain SET workers throughout their careers.

1 Introduction

What has prompted this review?

This review is a response to concerns expressed by industry and science research organisations suggesting that the current and future supply of skills in science, engineering and technology (SET) may not be adequate to meet current and future demand.

A key finding of the Audit on Science, Engineering and Technology Skills (Department of Science, Education and Training, 2006) was that demand for engineers at all levels and scientists in specific disciplines (e.g., geoscientists, taxonomists and spatial modellers) was greater than supply as indicated by significant recruitment difficulties. Regional and remote areas also showed patterns of difficulties in recruiting and retaining staff.

Demand from industry for employees is comprised of two basic components – the first being demand that arises from staff turnover, movements and retirement (replacement demand), and the second being demand that arises due to growth in industry and the creation of new positions that did not previously exists (new demand). This demand in SET industries, however, is not being matched by supply – along with a reduction in the growth of labour supply across all industries, Australia is also experiencing a decreasing proportion of graduates choosing SET careers. The results of the Audit indicate that, while attraction of new workers will always be important, retention of existing staff will become increasingly important, with an emphasis on employers providing incentives and conditions for employees to discourage them from leaving for better employment conditions elsewhere and to encourage older workers to remain at work. One of the purposes of this project was to gain a better understanding of the incentives and conditions that attract and retain employees in SET professions.

The capacity of the Australian educational system (at primary, secondary and tertiary levels) to meet the needs of emerging industries has been the subject of much discussion as the skill needs in SET are argued to be quite different to the mix of skills that schools, universities and vocational training institutions are producing. There has also been a wide ranging debate on “brain gain/drain” issues. Many Australians now live and work overseas and some commentators have suggested that Australia is losing its “best and brightest” to overseas labour markets.

The issue of skills shortages in SET has raised concerns globally. Reflecting the importance of the SET skills to innovation and economic growth, the Organisation for Economic Co-operation and Development (OECD) has recently undertaken work on the issue.

This specific review is one of several stemming from an audit of SET skills conducted by the Department of Education, Science and Training (DEST, 2006). This specific review will inform the Department, employers, industry associations and other stakeholders about factors that motivate SET employees to seek out and stay in SET careers. Essentially, the review contributes to an understanding of why SET jobs are perhaps becoming increasingly unattractive relative to alternative occupations and relative to economic need. This review provides a systematic analysis of national and international literature regarding what employers can do to attract and retain SET staff.

Why is SET important?

Australia's SET capacity supports our ability to undertake research and innovation, to ensure that Australia can find new economic opportunities and continue our growth in standard of living. Our SET capacity makes a vital contribution to ongoing production across a variety of industries. Further, people with SET skills do not only contribute to economic growth in a narrow sense - as expressed in a recent OECD report on SET skills, they also expand the frontiers of knowledge and help address some of humanity's most pressing economic, social and environmental problems. Not least, they act as the temporary custodians of accumulated knowledge and ensure its transmission to future generations (Cervantes, 2006).

In a very practical way, SET occupations represent around 14% of national employment, with around 1.3 million SET staff employed by the private and public sectors within Australia. Using slightly different means of categorisation, the OECD reports that the share of the workforce working in SET within OECD countries is 25 to 35% with Australia at the upper end of this range.

A two-year study on the declining interest and enrolments in scientific studies by the OECD Global Science Forum (reported in Cervantes, 2006) shows that between 1993 and 2003 there has been an overall increase in enrolments in science and engineering studies as well as in the number of graduates and PhD completions. However, the study also found that the relative share of graduates in science and technology disciplines had actually declined over the period in 10 out of 16 countries studied and that the trends were even more negative at the doctorate levels in all except three countries. While the proportion of Australia's higher education degree entrants and graduates in SET has increased by 1 to 2% per year from 1993 to 2003, the proportion of PhD completions has declined by about 3% per year over the same period, indicating that SET graduates are, on average, becoming less educated each year.

Who is the audience for this review?

Many groups within the Australian economy and society are likely to have an interest in this review and other reviews currently being developed by DEST. Nevertheless, this specific review has two primary audiences:

1. Employers wanting to improve their people management practices to ensure the retention of existing SET staff and a sufficient future supply of suitably skilled staff, and

2. Employer associations, industry groups, and policy makers wanting to educate, encourage and support employers to better manage the imbalance of supply and demand for SET staff.

Focusing on "pull" rather than "push"

This review is one of several currently commissioned by DEST. Other projects are exploring ways the education system can increase the supply of SET staff, the career paths of researchers within higher education, and community attitudes towards science, engineering and technology as career choices.

Such projects mirror those of the OECD which has recently undertaken a review of policies and practices such as the place of SET in primary through to tertiary education, better monitoring and matching the supply and demand for SET university graduates, increasing

the participation of women choosing to pursue an SET career, and better understanding and facilitating international mobility of SET researchers (Cervantes, 2006; Cervantes & Kergroach, 2006).

Indeed, the majority of work conducted in Australia and overseas has tended to focus on a "push" approach to overcoming the SET problem. That is, much attention has been given to the educational system and improving the training of students. While commendable and critical, this typical approach to the SET problem is limited to the pre-career experience of potential SET staff. In this sense, most approaches to the SET problem have looked at ways to establish conditions that will "push" people into working in SET.

The focus for this specific review is somewhat different. This review explores the characteristics of workplace culture and human resource practices that most effectively ensure a sufficient supply of skilled SET staff. Instead of focusing primarily on the "push" of people into SET careers, this review explores SET work itself and the experience of a career in SET. In so doing, the focus here is primarily on the "pull" – rather than focusing on educational experiences and encouraging people to choose to pursue the goal of an SET career, this review focuses on the goal itself with an eye to making that goal more attractive.

A consequence of this focus is that the recommendations are aimed at employers' management practices rather than primarily being focused on government policy and funding decisions. Specifically, the review focuses on ways that employers can achieve two broad goals:

1. Better attract new SET workers (i.e., increase the recruitment of SET staff from other organisations, from other occupations and careers, from overseas, and by becoming more actively involved in the transition from study to work), and

2. Better retain existing SET staff (i.e., decrease the turnover of SET staff in their own organisations, as well as decrease the loss of SET staff to other occupations and careers).

While directly helping government and industry better understand ways to attract and retain SET staff, this literature review is also intended to inform future research examining the opinions and work motivators of SET workers.

2 Methodology

Scope of occupations in SET

The Australian Standard Classification of Occupations (ASCO) grouping for SET is shown in Appendix A. The list covers managerial, professional, para-professional and trade occupations associated within SET.

The combination of SET occupations into a single category is common practice internationally. In Australia the group is commonly labelled SET, as is used throughout this review. Elsewhere the grouping is sometimes known as “science and engineering” (S&E), “science and technology” (S&T), “science, mathematics, engineering and technology” (SMET), and “science, engineering, medicine and technology” (SEMT).

Range of “employers” addressed

There are three main classes of employers discussed in this review, with a primary focus on the first two groups and a lesser focus on the last of these groups:

1. Private sector industry employers,

2. Public sector employers (excluding universities), and

3. Universities.

The importance of separating universities from other public sector employers for the current review is twofold. First, as will be discussed in more detail later in this report, a large majority of the people involved in research and development within Australia are employed by universities. In comparison with other OECD countries, Australia has a high proportion of its total workforce of researchers employed doing research and teaching within universities and, in contrast, we have a smaller than average proportion of practicing researchers in private industry or working in non-university public sector organisations.

The second reason for separating universities from other public sector employers is to draw a clearer distinction between this current review and other research currently being undertaken by DEST examining career paths for researchers within universities. The current review will include discussion of universities as employers but will not extensively discuss career paths for researchers; rather, the review will explore broader aspects of the working environment and human resource practices for SET staff working within universities.

Literature review and summary

The focus of this current project was to conduct a review of national and international literature that could inform Australian employers of best practice in attracting and retaining SET staff.

Regarding international sources, direction was specifically given to explore material from Europe, United Kingdom, United States, and Canada.

The project lead for the literature review and summary was Dr Peter Langford from Voice Project, Department of Psychology, Macquarie University. He was supported by three research assistants: Leanne Fear, Jennifer Keen and Anna Shcherbak.

A wide range of databases were searched and material accessed. Literature was gathered from academic journals, government publications, industry papers, special interest groups, magazines, newspapers and internet publications.

Literature searches were conducted through academic databases available through Macquarie University and through more general web searches using search engines such as Google and Yahoo. The most common search terms that were used included “science, “engineering”, “technology”, “SET”, “trade”, “apprentice”, “attraction”, “retention”, “turnover”, “career”, “human resource”, “commitment”, “satisfaction”, “tenure” (and derivatives of these words such as “scientist”, “SMET”, “retain”, etc).

3 Findings

3.1 The Role of Employers in Career Attraction and Retention

Existing models informing attraction and retention

Researchers have adopted a number of approaches to examining what attracts people to a job and the factors that influence their likelihood of remaining in those roles. Before focusing specifically on the role that employers can play in attraction and retention it is worthwhile examining how employers fit into a broader model of career choice.

One of the most widely discussed empirically supported models of career choice is the Social Cognitive Career Development model (Lent, Brown & Hackett, 1994). The essential elements of this model are as follows:

1. Personal characteristics (ability, interests, gender, etc.) and environmental characteristics (socio-economic class, opportunities, social network, etc.) contribute to a finite range of learning experiences of which only some will be successful experiences (e.g., coming from a wealthy family and attending a school with high quality scientific teaching and equipment will increase the likelihood of successful learning experiences in science). As demonstrated by Bright, Pryor, Wilkenfeld and Earl (2005), some of the major influences upon career choice come from one's social network (in particular, parents, friends and teachers) and many environmental influences on career choice are chance events.

2. Choice of career goals will be determined by the occurrence of successful early learning experiences (e.g., a successful early learning experience in science will increase likelihood of choosing a career in science), as well as by the awareness and understanding of career options (e.g., if a student is unaware of options for a career in science then the student is likely to choose an option more commonly discussed by parents, peers, teachers and the media).

3. Successful early experiences pursuing a career will further enhance the interest and likelihood of continuing along that career path (e.g., an engaging early work experience, perhaps as a placement while at school in a research and development department, will increase the likelihood of the student continuing that career path).

While the first component of the Social Cognitive model above cannot easily be influenced by employers, there are opportunities for employers to apply the second and third components of this model to increase the attraction and retention of SET staff, as will be discussed later in this review.

A second widely cited empirically supported model, relevant to the needs of the current review, is the Person-Job Fit model (Dawis & Lofquist, 1984; Edwards, 1991). Whereas the Social Cognitive model described above focuses more heavily upon the mechanisms that determine whether someone will enter a career, the Person-Job Fit model attempts to explain employee stress, satisfaction and performance by examining the "fit" between an individual and the work environment.

The two primary components of the Person-Job Fit model are as follows:

1. Different jobs require different knowledge, skills and abilities for successful completion of tasks. Successful and satisfactory job performance will result from a good fit between the job's need for knowledge, skills and abilities, and those possessed or developed by employees. Employee stress and loss of confidence will result from a prolonged gap between the needs of the job and the knowledge, skills and abilities possessed by the employee. For example, if a successful career in civil engineering requires both good knowledge of construction and also good project management and people management skills, an individual without good project management and people management skills may be unsuccessful and unsatisfied in an engineering career.

2. Based on their personality and historical experiences, different employees have different work-related interests and values. Greater employee commitment will result from a strong match between the values of an employee and workplace culture. Higher employee turnover will result from a mismatch between one's own personal values and the enacted values in a chosen workplace. For example, a researcher having a high need for autonomy and self-direction may, despite having appropriate knowledge and skills, be unsatisfied in an environment that places severe constraints on the amount and direction of research activities.

Highly similar to the Person Job-Fit model is the often-cited Attraction-Selection-Attrition (ASA) model (Schneider, Smith & Paul, 2001). Specifically, because individuals fundamentally differ as to their values, personality and talents, they feel attracted to and actively search for situations that fit their make-up. This attraction process is systematically reinforced because those whose characteristics fit the demands of the situation at hand are selected in while others are selected out.

The implication of the Person-Job Fit model and the Attraction-Selection-Attrition model for attracting and retaining SET staff is that employers need to (1) better match the required skills of the job with those recruited and trained in their organisations, and (2) understand the values and preferences of SET staff and ensure their jobs and work environments meet those needs. Both of these implications will be discussed in more detail later in this review.

The final model to be presented here is a more recent "7 P's" model developed by the current author within Voice Project at Macquarie University (Langford, Parkes & Metcalf, 2006). Using data from over 10,000 employees from over 700 organisations, the author examined the impact of a wide range of human resource practices on turnover and employee "passion" (equivalent to the currently popular term "engagement" and representing an aggregate of the frequently studied outcomes of job satisfaction, organisational commitment and intention to stay). Analysing results across all industries, the following three broad clusters of management practices proved to be the strongest predictors of employee passion:

1. Purpose – staff understanding and believing in the overall direction and ethics of the organisation,

2. Participation – staff feeling recognised, involved and growing in the organisation, and

3. Progress – staff believing that the organisation's goals are being achieved, that the organisation is improving and the future is positive.

These three broad groupings of important management characteristics closely match a recent study by Jordan (2005) examining 36 different workplace characteristics within three

major research and development centres in the US. Surveying over 2,200 scientists and engineers, the above model can neatly categorise those practices that Jordan found to be most strongly linked with job satisfaction: the vision and strategy of the organisation and identification of research opportunities (Purpose), decisive and informed management, a sense of challenge, rewarding and recognising merit (Participation), and investment in future capabilities and the overall success of research projects (Progress).

The model also highlights those aspects of the work environment that are least important. In particular, passion showed noticeably weaker relationships with property (the amount and quality of resources and facilities available), people (the teamwork and talent of non-managerial staff) and peace (the level of wellbeing and work/life balance experienced by staff).

A clear implication for employers from the 7 P's model is that, in order to attract and retain staff, investment should be directed towards building purpose, participation and progress, with priority given to these human resource practices over those associated with property, people and peace. Like all general models, of course, the 7 P's model has been developed across a broad range of industries and occupations and is yet to be thoroughly tested specifically with SET workers.

Integrated model of career attraction and retention

To serve the needs of the current review, the above three models are integrated and simplified to create the model of career attraction and retention in Figure 1. The essence of the Social Cognitive model is shown in the left half of Figure 1, with an individual's environment and personal characteristics shaping his or her early learning experiences which in turn contribute to awareness, skills and interests in particular careers.

To use terminology introduced earlier in this review, interventions aimed at influencing these early, pre-career learning experiences can be regarded as "push" interventions. To use a colloquial example, such interventions can be equated to giving someone a fishing rod if you want to encourage them to fish.

On the right side of the diagram, the top half represents the Person-Job Fit model described earlier, and the bottom half represents the 7 P's model. It is the right side of Figure 1 that has more direct relevance to employers and hence better serves the focus of this review. As suggested by the model, employers can improve attraction and retention of SET staff using human resource practices to improve the work environment (such as building purpose, participation and a sense of progress) and managing the fit between workers and the work environment (in regards to both skill and values).

To continue the fishing analogy, such "pull" interventions can be equated with selling the taste of the fish and the challenge of fishing. Instead of "pushing" people towards a career goal by giving them early support and encouragement, employer interventions can be regarded as primarily "pulling" people towards a goal by making the goal more desirable.

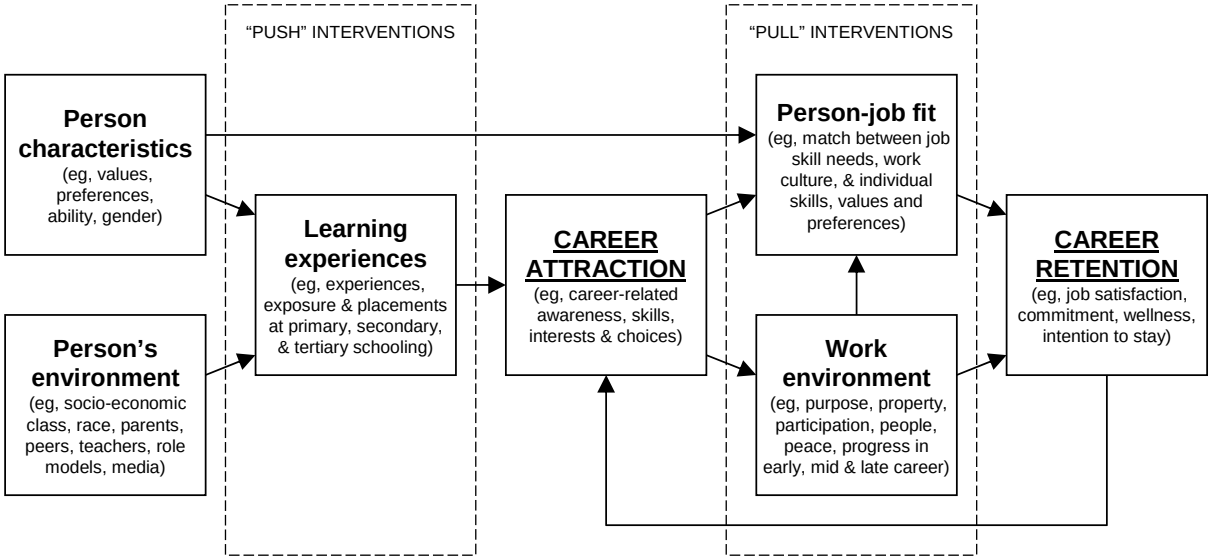

Figure 1. Integrated model of career attraction and retention.

Implications for employer interventions

Figure 1 drives the structure and content for the rest of this review. First, and perhaps one of the simplest conclusions from Figure 1, there can be no attraction and retention for SET jobs if the work environment does not exist or if the security provided within the work environment does not fit the security desires of potential and existing staff. Hence, the first area for employer intervention is to ensure adequate **job availability and security**.

A key premise in the Person-Job Fit model is that attraction and retention will be poor if employee values and preferences are not met by the work environment and the job itself. Hence, the next intervention examined in this review is to better understand and meet the **values and preferences** of SET staff.

As suggested by the 7 P's model, certain perceptions of the work environment (especially the experience of purpose, participation and progress) appear to be near-universally important for attraction and retention. This review explores three human resource management practices that appear to be particularly important for SET staff. Specifically, the review examines ways employers can improve **recruitment and selection**, **rewards and recognition**, and **learning and development**.

The review then returns again to the Person-Job Fit component of the model and explores what employers can do to better meet the needs of the following three specific groups of SET employees: **women**, **older workers** and **immigrants**. Finally, the review discusses ways that employers can become more actively involved in **pre-employment education**.

3.2 Job Availability and Security

Australian has a low total spend on SET

To attract new SET workers, and by definition to retain existing SET staff, a sufficiently large number of jobs need to be created and maintained. To achieve this end there needs to be a significant, continuing and increasing spend on SET activities.

Australia, however, lags behind many other comparison countries. For example, according to the OECD's science and technology indicators (OECD, 2004, reported in Campaign for Science and Engineering, 2005a), Australia ranks 18th out of 30 countries for investment in research and development as a percentage of gross national product. We are substantially behind investment levels of Sweden, Finland, Japan, Iceland, Korea, United States, Switzerland, Germany and Denmark. Those we exceed (including Mexico, Slovak Republic, Poland, Turkey, Greece, Portugal, Hungary and Spain) we typically do not regard as being appropriate comparators in terms of economic development and quality of life.

Since the 1980s, the growth in SET occupations in the United States has grown more than four times the growth rate of all other occupations (National Science Foundation, 2006). In comparison, Australia's gross domestic expenditure on research and development has only doubled between 1986-87 and 2002-03, demonstrating a weak 4.5% per annum growth that is only marginally above inflation.

With regards to trades, alongside a consistent concern about skill shortages is a somewhat paradoxical decline in employment opportunities in many trades. For example, according to a report by the National Centre for Vocational Education Research (NCVER; Borthwick, John & Werner, 2000), employment in automotive trades (predominantly motor mechanics, auto electricians and panel beaters) has declined by approximately 1% a year since 1990 and is predicted to continue to decline by 0.7% a year in the foreseeable future. Indeed, the report showed that 21% of trades-qualified people who left the automotive trade did so because of lack of work or because they were laid off by their employer. Against this background, however, there has been substantial demand and shortage for specialist skills in areas such as transmission, electronic fuel injection and liquid petroleum gas. The report suggests that training of automotive trades has not kept pace with the changing skills and specialists required by the industry, a conclusion supported by the more recent Automotive Industry Skills Report (Automotive Training Australia, 2006).

Research and development is confined largely to universities

Not only does Australia have a low total spend on research and development, but Australia also has a disproportionately low proportion of researchers in active practice in industry and non-university public sector research institutions.

Of the top 20 nations in the OECD against whom we like to compare ourselves economically, Australia ranks 8th in number of researchers as a proportion of total employment. However, along with New Zealand, Australia has the lowest proportion of researchers in private industry (approximately 30% of Australia's researchers are employed by private industry; Cervantes, 2006). Of those countries examined, Australia is lower than the United States (with over 80% of researchers in industry), Finland, Sweden, Japan, Denmark, Norway, Belgium, France, Canada, Germany, Korea, Luxembourg, Switzerland, Ireland, Austria, UK, Netherlands, Czech Republic and Italy. We have a similar proportion of researchers in business as New Zealand, Spain, Hungary and Greece, and only exceed the Slovak Republic, Poland, Portugal, Turkey and Mexico.

Further, not only does Australia have a relatively high proportion of researchers in the public sector, but more than 80% of these researchers are found in universities. Of the 14 OECD countries with 50% or more of their researchers in the public sector, only Turkey has an equivalently high proportion of researchers in universities.

SET occupations are not limited to researchers, of course, but this distribution of researchers throughout the Australian economy can be regarded as a reasonable proxy of how we compare to other countries in our distribution of SET staff throughout industry and the public sector.

The consequences of such a distribution are substantial. First, regarding researchers, our very high proportion of researchers in universities means that there are few applied researchers solving practical problems and developing commercially-viable solutions in private industry or public sector research institutes. Second, with the continuing rationalisation and slimming of the public sector workforce, many of the public sector SET jobs are threatened.

The immediate conclusion from this analysis is that, if we wish to benchmark ourselves against many comparable countries, private and public sector employers may benefit from lifting their employment of SET staff. Australian industry could double the number of researchers in private industry and would then only be equivalent to the 10th ranked country in the OECD.

Industry and government spend on SET is in flux

The shift in public research funding towards a more complex funding system involving competitive and project-based funding as well as funding from business exerts more pressure on public research to adopt more flexible employment arrangements. Given that much scientific research is now project based, with only short-to-medium term funding guarantees, job security has decreased for SET researchers.

Australia is not unique in this regard. The Campaign for Science and Engineering in the United Kingdom (CaSE) has consistently argued that employing individuals on a continuing series of very short-term contracts, with the constant threat of redundancy yields unstable and unpleasant work conditions (CaSE, 2005a). Indeed, research by Jalajas and Bommer (1999) has empirically demonstrated that both past and threatened downsizings of engineering firms are significantly associated with lower staff satisfaction and commitment and higher voluntary staff turnover.

Finegold, Mohrman and Spreitzer (2002) have shown that poor job security might have different effects with different groups of researchers. Studying scientists and engineers in the United States, they found that staff aged 30 or younger showed little concern with lower job security. For staff over the age of 30, however, job security was significantly associated with loyalty towards an organisation and willingness to put in extra effort for an organisation.

ICT gives employers increased potential to compete in R&D

Despite Australia's low relative spend on research and development, in particular within industry and in the public sector outside of universities, there are good reasons to believe that Australia could compete internationally in research and development.

Historically, research and development has been dependent upon centralisation of funding and activities in large research centres. In the past there have been substantial economies of

scale and efficiencies with sharing of information when research and development activities have been geographically co-located. With the need for centralisation, Australia has been at a disadvantage because of its physical distance from Europe and the United States, and internally because of the expanse of the continent and distances between capital cities.

With the development of new information and communication technologies (ICT), however, Australia's ability to compete internationally in research and development has increased. Scientific collaboration no longer needs neighbouring offices given ICT enables almost instant access to any person anywhere in the world via written word, voice or visual image. Similarly, the provision of SET services, and the development and delivery of SET-related knowledge and products, can occur remotely.

3.3 Values and Preferences

Values of SET workers: Autonomy, application and contribution

The model in Figure 1 highlights the need for person-job fit. That is, in addition to selecting staff who meet the skills need of the organisation, the organisation also needs to modify its practices to meet the values and personal needs of its workers. Without a match on both skills and values long-term productivity and commitment are unlikely.

One of the most cited and applied models of occupational interests is that of Holland (1959, 1996) and the associated Strong Interest Inventory (Harmon, Hansen, Borgen & Hammer, 1994). Holland's model divides work interests into six broad categories which can be represented by the acronym of RIASEC:

1. Realistic – Valuing tradition, practicality, and common sense, and preferring occupations that involve operating equipment, building, using tools, and delivering practical, hands-on services.

2. Investigative – Valuing exploring, autonomy and learning, and preferring occupations that involve solving problems, conducting experiments, and searching for understanding.

3. Artistic – Valuing beauty, originality and imagination, and preferring occupations involving art, music, writing and performing.

4. Social – Valuing cooperation, generosity and altruism, and preferring occupations involving caring, counselling, training and teaching.

5. Enterprising – Valuing risk-taking, competition and influence, and preferring occupations involving selling, managing and persuading.

6. Conventional – Valuing accuracy, stability and efficiency, and preferring occupations that involve organizing, procedures, systems, and recording.

SET occupations quite neatly fit into the first two categories and to a lesser extent the final category, with SET trades falling very strongly in the Realistic domain and SET professions being closely associated with the Investigative domain. While neatly consolidating what SET staff hold closely as values and preferences, the model also highlights what SET staff do not hold closely. Perhaps of greatest relevance to the current review, most SET professionals do not naturally gravitate to roles which have heavy Social or Enterprising characteristics. SET staff do not typically want jobs that involve providing to others a high level of caring and

training, nor do they naturally want to be put into positions involving a heavy need for managing and persuading.

A more recent but similar model of career interests, the Business Career Interest Inventory (BCII), has been developed by Butler and Waldroop (2004). The list below shows the eight broad categories of interests and the correlations with satisfaction in various SET occupations (a positive correlation shows higher satisfaction whereas a negative correlation suggests lower satisfaction; the larger the correlation the stronger the relationship).

1. Applied technology – significant correlation with satisfaction in a career as a scientist (.68), medical technologist (.68), systems analyst (.66), engineer (.63), research and development manager (.58), computer programmer (.56), and chemist (.56). This scale also correlates strongly (.68) with the Realistic domain within Holland's model described above.

2. Quantitative analysis – significant correlation with satisfaction in a career as a mathematician (.50), systems analyst (.43), medical technologist (.36), scientist (.35), maths teacher (.33) and engineer (.33). This scale also correlates strongly (.50) with the Conventional domain within Holland's model described above.

3. Theory development – significant correlation with satisfaction in a career as a scientist (.57), science teacher (.44) and chemist (.40). This scale also correlates strongly (.60) with the Investigative domain within Holland's model described above.

4. Creative production – significant negative correlation with satisfaction in a career as an agribusiness manager (-.51) and pharmacist (-.27). This scale also correlates strongly (.74) with the Artistic domain within Holland's model described above.

5. Counselling and mentoring – significant negative correlation with satisfaction in a career as a geologist (-.45), mathematician (-.39), physicist (-.33), research and development manager (-.30), systems analyst (-.27) and computer programmer (-.26). This scale also correlates strongly (.63) with the Social domain within Holland's model described above.

6. Managing people – no substantial correlations with SET occupations. This scale correlates strongly (.53) with the Enterprising domain within Holland's model described above.

7. Enterprise control – no substantial correlations with SET occupations.

8. Influence through language and ideas – significant negative correlation with satisfaction in a career as a mathematician (-.38), computer programmer (-.35) and radiological technician (-.30).

As with Holland's model described above, the message is fairly clear for SET occupations. According to the BCII, SET staff like the application of technology, using equipment and tools, developing theory, solving problems, working with procedures and systems, conducting analyses, working autonomously, and being self-directed. There is also evidence for a natural aversion among SET staff to activities involving counselling, caring, mentoring, managing people, influencing, and marketing – activities which are being increasingly demanded of SET professionals.

Supporting the claims made above, Jones (1996) investigated the impact of organisational culture on the job satisfaction of research and development professionals. His research confirmed that establishing a work environment which encourages freedom and autonomy is

important to establishing a positive reputation among research and development scientists. Further, satisfaction was higher in workplaces seen to be innovative, in which scientists could work creatively, and develop and pursue ideas. The implication of this finding for employers is that to attract and retain research and development scientists it is important to create a working environment that promotes freedom, autonomy and innovation.

In further support of the above claims, at a recent conference on postgraduate careers, the Campaign for Science and Engineering in the United Kingdom presented a paper (CaSE, 2005b) outlining characteristics of a work environment that make science careers attractive. The three broad factors they discussed were as follows:

1. Academic freedom to pursue their own research interests – CaSE argued, however, that this has been restricted by governments dictating specific directions for research,

2. Lifestyle and the autonomy to manage one's own time and the capacity to work from home – Again, CaSE argued that increased bureaucracy has increased workload with few compensating benefits; whereas scientists had historically shown a willingness to sacrifice a salary for lifestyle benefits and autonomy, this willingness has been eroded by increasingly bureaucratic demands; further, increasing student debt levels upon entry to the workforce has further diminished the attraction of a low-paid and increasingly bureaucratic job, and

3. The possibility of making a constructive difference to the world by achieving scientific breakthroughs – Once more, CaSE argued that this drive has been slowed by the lack of recognition for, and the undervaluing of, scientific achievement.

3.4 Recruitment and Selection

Options for obtaining skills

Spinks, Silburn and Birchall (2006) recently produced a report for The Royal Academy of Engineering titled "Educating engineers for the 21st century: The industry view". In discussing evidence for skill shortages in the United Kingdom, the authors explained three broad channels through which engineering firms have sourced the skills they needed:

1. Upskilling – increasing training and development of current or newly recruited staff,

2. Inskilling – intensifying recruitment efforts and better targeting specific groups of potential employees, and

3. Outskilling – using outsourced resources such as temporary staff, contract staff and outsourcing work to other firms.

The issue of training and development will be addressed in a later section of this review. Of interest here in particular is the preferred option of recruiting appropriately skilled staff, as well as the potential, although often less desirable, option of a temporary workforce or outsourcing work.

Graduate recruitment

SET employers may be able to better emulate some of the graduate recruitment programs of other professional service firms. The United Kingdom Department of Trade and Industry (DTI) recently produced a report titled "Investing in Innovation" (DTI, 2002). In that report

they highlighted the need for much clearer career paths from graduate and postgraduate study into industry (and also into academia although that is not the primary focus of this review). They compared SET-related occupations with other prominent professions including law, accounting and medicine. Each of these other professions have a tight structure, path and timeline for progressing from their studies to early career positions in the profession, and to being fully qualified and recognised practicing professionals. The authors of the report suggested that SET professional and industry associations or even individual organisations could benefit from emulating some characteristics of these approaches.

In 2006 Raison and Etheridge concluded a study at Macquarie University examining student awareness of, and attitudes towards, SET careers. While student attitudes is not a focus of the current review, the study helps inform employers in improving their recruitment activities. A survey was conducted of 1790 SET "stakeholders" (including high school students, Macquarie University students, as well as science professionals and employers of SET staff). Focus groups were also held with 215 of the high school students.

While students agreed that SET careers sounded exciting and challenging, they were also strongly career-focused in their choice of a degree, wanting their studies to be as short as possible and lead to a specific job. The majority of students saw no clear career path after studying a Bachelor of Science at university, and the high school students had little awareness of science disciplines other than medicine.

The Macquarie University study also provides information about the gap between what high school and university students are looking for in their careers, and how SET professionals described their careers. Specifically, SET careers met student desires for challenge, contribution to the community, and working with different and interesting people. There was a clear gap, however, between a strong desire from students for financial reward, career advancement and travel, and much lower scores from existing SET professional on these factors.

Recruitment agencies

In a trade magazine article, Clegg (2005) discusses how engineering firms can better use outside recruitment consultancies to head-hunt engineers. While commonly used for managerial positions and in professional services, use of recruitment agencies for science and engineering positions is much less common. Clegg argues that, given engineering candidates are extremely marketable and difficult to attract, recruitment agencies can play an important role for sourcing engineers because of the following:

1. They have better knowledge of the labour market for engineers, and have inside knowledge of candidates looking for work and employers looking to downsize their workforce,

2. They have many existing candidates in their staff databases,

3. While demanding a sometimes significant fee for sourcing a candidate, the overall cost effectiveness of recruitment agencies can be high because less time is taken away from existing staff and managers within the hiring firm,

4. They filter potential candidates and hence provide an additional component of an overall selection process for new staff, and

5. They are able to recruit for confidential roles much more easily than can staff and managers within a hiring firm (for example, they can carry out some of the early

stages of recruitment without candidates knowing the firm that is hiring),

Networking

In contrast to the above advice, however, one particular Sydney-based engineering firm has had little success using recruitment agencies. In a recent interview for The Weekend Australian newspaper (2006), a representative of Itech Corporation explained his lack of success using advertising and third party agencies to recruit tradespeople. Instead, greater effect was achieved by leveraging the networks of existing staff (that is, by asking existing staff to refer candidates to their employer) and by directly contacting companies that had announced closures and consolidations and offering to take some of their staff. One additional approach taken by Itech was to do all they could to retain staff during economically less successful periods – even though the employees' skills may not be fully utilised during such times substantial time and costs are saved when the firm does not need to undertake extensive recruiting during more prosperous times.

3.5 Reward and Recognition

High costs

Investing in an SET career can be expensive and for some fields within SET the private returns may be too low to offset the opportunity costs. It should, of course, be acknowledged that many people engage in an SET career because they see it as a calling, because they have a passion for the pursuit of science, and love the intellectual challenges of a research career. Many of these less tangible benefits may outweigh the material rewards. However, for a larger majority of students, the time required and costs associated with pursuing advanced studies in science may force them to consider more lucrative fields.

The high cost of a university education is seen as restricting the supply of SET graduates both in the United Kingdom and Australia (CaSE, 2005; Engineers Australia, 2005). A user pays approach to fees results in higher fees for science students because science courses are more expensive to run given the equipment needed and low teacher-to-student ratio required for practical sessions. The impact of this is compounded by relatively poor wages for science graduates. Engineers Australia also suggested that many university students work lengthy hours in paid jobs to financially support their studies which in turn prevents students from undertaking industry placements.

An argument against the Engineers Australia position, however, would be that Government education loans such as the Higher Education Contribution Scheme (HECS) reduce the pressure for students to pay off their education debts while studying. Further, if industry were willing to increase paid scholarships and internships the students would have little need to work in non-engineering roles while studying.

Low pay and prestige

As mentioned earlier in this review, the study at Macquarie University by Raison showed several gaps between the career desires of university students and the career experiences of SET staff. One of the most notable gaps was that between financial aspirations of students and the financial rewards reported by SET staff.

An examination of comparative purchasing power of academics across 10 developed countries, reported by the Save British Science Society (2002), suggested that Australian academics out-earned academics in the United Kingdom, Germany, Spain, Norway and France, but under-earned counterparts in Finland, United States, Italy and Canada. It should be noted that these calculations were based on several assumptions of living expenses and as such should only be taken as a general guide. Nevertheless, it suggests that Australia is at roughly market average when competing against other countries, may have a competitive advantage against the United Kingdom (a culturally similar competitor) and may be at competitive disadvantage in comparison to both the USA and Canada (two other countries culturally similar to Australia).

Further, academic salaries on their own (i.e., without considering outside contractual work) are rarely competitive with comparative positions in industry. Hence, for academics in particular, there are substantial incentives for top performers to look to other industries nationally or to look for academic positions internationally.

Examining trades, the previously discussed report on automotive trades by NCVER (Borthwick et al., 2000) presented a survey of qualified staff who left the automotive trade. The most commonly cited reason for leave was poor pay, career and promotion opportunities.

Poor flexibility in pay structures

The high proportion of research jobs in Australia in the public sector, and in particular in higher education, means that such jobs face the rigidities of the public sector labour market. Such structural inflexibilities include restrictive guidelines around workplace policies and little flexibility in design of workplace conditions and financial reward programs. The Australian Government is attempting to overcome some of these restrictions with the Higher Education Workplace Reforms. However, further flexibility in pay could be achieved with greater attention given to the management of patents, intellectual property, commercialization, and income from outside the university.

As reported in the “Investing in Innovation” report (DTI, 2002), the Roberts Review of higher education in the United Kingdom concluded that insufficiently competitive remuneration packages were a significant factor in the failure of the higher education system to attract the most talented scientists and engineers. Attempts are currently being made in the United Kingdom to better differentiate senior academic salaries to reflect market forces. Pay at middle and junior levels, however, remains restricted and differentiation between good and poor performers is by promotion and the provision of other benefits such as reduced teaching and administrative hours. It was suggested in the report, however, that such strategies may be more effective in retaining existing staff rather than attracting new staff given that such benefits are less visible to people exploring career options.

A Government-University-Industry Research Roundtable in the United States (Jackson, 2003) conducted a similar review of science and engineering positions in public and private sectors. Similar conclusions to those of the “Investing in Innovation” report were drawn. It was recommended that pay and promotions be based more heavily upon performance rather than years in service, that competitive incentive schemes be explored and that pay, promotions and development be influenced in part by peer evaluation. It was further recommended that governments work to ensure that science and engineering positions within the public sector maintain a similar level of challenge and variety as those in industry.

Further emphasising the need for higher base pays, and stronger pay-for-performance practice in SET jobs, the National Science Foundation (1999) explored the reasons why

graduates in the United States remained in SET careers or changed careers. The author found that the two primary reasons for a change in career were: 1) lack of pay or promotion (stated by approximately 25% of participants), and 2) lack of jobs in the desired field (stated by approximately 30% of participants, although those with higher grade point averages (GPAs) were less likely to report lack of jobs as a reason for switching). Lesser reasons for switching were a change in career interest, job locations and working conditions. Interestingly, the author also found that students' GPA predicted their likelihood of remaining in their job, perhaps highlighting the importance of intelligence and academic ability for successful performance on the job, and hence the need to appropriately reward and recognise staff with high intelligence and ability.

Zenger (1992) examined the structure and consequences of pay scales for engineering firms in the United States. The most common reward and recognition systems involved correcting the behaviour of very poor performances and recognising and financially rewarding a small group of very high performers. That is, only a small percentage of employees in the extremely low or extremely high performance categories received reward and recognition levels noticeably lower or higher than the vast majority of employees. For most employees there was no clear link between rewards and performance. A natural consequence of such a reward system is that employers are systematically under-rewarding their above-average employees and over-rewarding (or under-correcting) their below-average employees. This reward system is likely to lead to the retention of a small percentage of extremely high performers (because they are being rewarded for their outstanding performance) and moderately low performers (because they are contributing less but receiving rewards similar to above-average performers). Conversely, such a pay system will lead to the attrition of the small percentage of extremely low performers (because they are being corrected, and potentially managed out of the organisation, for their low performance) and the moderately high performers (because they are contributing more than most other employees but are being rewarded at a similar level to below-average employees). To avoid these problems employers need to achieve greater differentiation in their pay and reward structures and establish a pay gradient that is less level across the majority of employees and more linearly related to performance.

Differentiation in pay for entry versus senior level jobs

Governments across the globe have examined reward, recognition and support structures for SET occupations and in particular for university and public sector positions. It is a common assumption and focus for much government policy that greater support and funding needs to be directed to increasing the salary levels, stipends and fellowships for people early in their career. To reiterate an earlier analogy, such a "push" approach is akin to giving someone a good quality fishing rod if you want them to fish. Such an approach, though, is unlikely to work if the fish they are likely to catch are scrawny.

The logic and evidence for such a heavy focus on entry level jobs is unclear and unproven. It is equally logical that increasing the attractiveness of the end goal (the experience in mid-to-late career) could prove more attractive than boosting the attractiveness of the means to achieving the goal. That is, we might do a better job of encouraging someone to fish by getting them excited about the quality of fish and the challenge of fishing. As argued earlier, such a "pull" approach to attracting and retaining SET staff has been under-investigated. Such an approach is common, though, among other high profile careers. Medicine, law, accounting, consulting, and architecture are all renowned for relatively poor early career salaries and working conditions. Nevertheless, the early career pain is treated as a rite-of-passage by many young professionals who keep their eye on the prize of a significant increase in pay later in their careers. It may be worthwhile for SET employers and policy

makers to give greater attention to the end game and not the opening of SET careers.

3.6 Learning and Development

Training

SET staff are faced with a career that is perhaps the most in need of continual education. The knowledge base and tools used within this occupational category have changed dramatically over the past few decades and show no sign of slowing. SET workers can soon become obsolete if they do not keep pace with such change and continuously update their knowledge and skills. There is some evidence, however, that this need is not being sufficiently met by some employees and employers.

In 2005 Engineers Australia submitted a response to the Discussion Paper associated with the Australian Government's current Audit of Science, Engineering and Technology Skills. In the submission Engineers Australia argued that the training opportunities, especially for early career workers, have disappeared as a result of public sector rationalisation and funding reductions. Cadetships that were available to trainee engineers in the public sector are no longer available as many engineering activities of the Government have been privatised or outsourced.

It is possible that the Australian economy has reached an impasse between the government, private industry and employees regarding who will fund early career training and ongoing career education. To reduce costs the public sector has released its role in being a primary early-career educator. Private industry, however, has yet to take over this role. Employees are, to some extent, paying for their own further education, but such efforts are heavily directed towards management training, with little opportunity or action in the direction of ongoing self-funded SET education.

An argument can, however, be made for private industry playing a larger role in early and ongoing education. As one example of industry-driven education, Byrnes and Barrett (2005) describe the development initiatives of Schlumberger Oil, an oil-field services giant. For early career engineers the company has devised an extensive three-year education program that combines in-class learning with on-the-job projects. After two-to-four months of starting the job, field engineers return for a 12-week training program which meets the primary goals of ensuring consistency of skills across all employees, and serves as a very effective induction program in which employees better understand the scope and values of the company. After 30-36 months on the job engineers are required to return for a two-to-three day workshop where they present and discuss projects they have completed. The standards of this training program are very high and many staff do not succeed – approximately 40% of new engineers and 10% of research and development staff do not finish the program.

Career development

One problem raised within the above case study of Schlumberger Oil is that only one in four entry level engineers progresses to a managerial career within the company. An interview in the case study with an ex-employee suggests that many managerial positions are increasingly being filled not by engineers but rather by professional managers with MBAs.

As discussed earlier in this review, SET staff do not typically show a natural affinity with managerial roles. Nevertheless, for their careers to advance most are faced with the need to development more advanced management skills. Indeed, as highlighted in the previously discussed "Investing in Innovation" report (DTI, 2002), there are often few alternative career

paths for SET staff. The risk, however, with such a move into management is that it will take SET staff away from the rapidly growing knowledge base within their original profession. With evidence to suggest that SET career changes tend to be one way (that is, many people move out of SET careers but few people move in), many SET staff are faced with having to abandon their original profession in order to advance their careers.

This sometimes unpalatable choice between career or profession was raised earlier by the Macquarie University study by Raison and Etheridge that found that career advancement was one of the largest gaps between graduate desires and job characteristics for SET jobs. The point is further emphasised by findings of Cramer (1993) who examined tenure, commitment and satisfaction of college graduates in an engineering firm. The three primary characteristics of the work environment that predicted low commitment were dissatisfaction with salary, the lack of a career structure, and poor quality supervision.

Employers are naturally constrained in the career paths they are able to offer staff. It is likely that efficiencies drive the predominance of professional managers rather than career professionals (that is, people who stay focused on their original careers) at higher ranks in private industry. Nevertheless, there may be ways employers can help SET professionals manage the choice and transition. One obvious possibility is to give SET professionals the opportunity and funding to pursue management studies. Sponsorship of an SET staff member to do an MBA, for example, could enable SET staff to rise through an organisation's hierarchy and reduce the reliance upon having to hire professional managers from outside the organisation. Some high performing staff may also warrant ongoing SET education as well as management education. For staff who wish to remain focused on their profession, employers may be able to develop a career structure and ongoing education that enables them to become experts in a particular sub-discipline of their profession.

3.7 Older Workers and Generational Differences

Motivators for older workers

Due to Australia's ageing population, there is an increased need to keep SET professionals working beyond the official retirement age. It should be noted that the retirement age of 65 was set in Australia in 1909 when average life expectancy was 58 (that is, on average people died seven years before the official retirement age). Life expectancy is now around 75 years and is steadily growing. With a growing labour shortage there is certainly some room for a reassessment of how we think about retirement.

Employers can start by surveying the retirement intentions of their staff and can begin discussing ways to retain workers beyond the official retirement age. Recent Government changes to superannuation in Australia remove financial disincentives that previously existed for working beyond 65. What is left then is to understand what would motivate older workers to remain in the workforce.

Lord (2002) surveyed 29 engineers over the age of 55 to determine what keeps them motivated and prevents from leaving their current employer. While using a very small sample, the study is suggestive of potential obstacles and desires for older workers. Older engineers are a unique category of workers because they typically do not depend on salary to meet their basic needs. Although the sample was small, and cannot be considered representative of all engineers, 24 of the 29 participants indicated they had sources of income from outside of their current job and were hence only moderately interested in the pay they currently received from their job.

The results of Lord's survey showed that positive job attitudes were associated with having a sense of achievement and accomplishment in their work, the variety and challenge in the work itself, having responsibility, good teamwork with colleagues, and feeling recognised, valued and respected. Factors that appeared to be less associated with likelihood of staying or leaving were communication, job security, pay, company policies, working conditions, advancement and supervision.

Lord interpreted the qualitative responses from participants using the structure of Maslow's Hierarchy of Needs (Maslow, 1987). Only a few of the workers described being motivated by the first "survival" level or second "safety" level of Maslow's hierarchy ("I work because I must" and "to provide benefits for my family"). Most participants described motivators that better matched the third "social" level and fourth "self-esteem" level of the hierarchy ("to maintain contact with people" and "to be needed by customers/my employer"). Although Lord concluded that no comments represented the fifth "self-actualisation" level of Maslow's hierarchy, the results demonstrate the importance of achievement, variety and challenge and hence suggest that this fifth level of the hierarchy is also useful for understanding the motivators of older workers.

Rau and Adams (2005) investigated workplace practices that would entice near-retirees to maintain their employment beyond their previously planned retirement age. The authors found that both flexible work hours and explicit age-related equal employment opportunities policies increase the attraction of an organisation to older workers. Morris and Venkatesh (2000) examined generational differences in relation to technology and concluded that older workers are slower at adopting and learning new technologies, and hence the specific needs of older workers must be considered and supported during change initiatives involving the introduction of new technologies. Similarly, Armstrong-Stassen and Templer (2005) found that while older workers may not differ from younger workers in their capacity to learn new work practices, older workers have lower confidence in their ability to learn resulting potentially from having to live through a lower rate of workplace change during their careers.

The problem of an ageing workforce also impacts trades. Trades are heavily dependent upon apprenticeships, and apprenticeships have historically been focused on the 15-19 year old age bracket (Automotive Training Australia, 2006; Borthwick et al., 2000). With the ageing of the Australian workforce, however, this demographic is expected to remain stable in absolute numbers and decreasing as a proportion of the total population. Hence, any growth in trade employment may need to be associated with sourcing employees from older age groups, although "older" in this context refers to people aged 20 and over who are already skilled or who may be interested in developing the appropriate skills.

Older versus younger workers

Consultancies, the popular press and practitioners have shown a great deal of interest in possible differences in work motivators for different generations of workers. Of particular interest has been the potential differences between "baby boomers" (often described as being born 1946 to 1964), "generation X" (born approximately 1965 to 1979), and the emerging "generation Y" or (born approximately 1980 to 1994).

Despite the assumption among practitioners that practically important differences exist between generations, there is very little scientific evidence to support the claim. The research that exists has shown very mixed results, but tends to suggest that the similarities across generations far outweigh the differences. Further, those differences that exist can largely be explained through life stages, career stages, or society changes, which affect all generations equally, rather than differences between generations. Given the paucity of information

available, the review on older versus younger workers that is reported here explored all industries and occupations rather than limiting the search to only SET workers.

Smola and Sutton (2002) explored generational differences across a contemporary sample (collected in 1999) of MBA students containing both baby boomers and generation X'ers. The authors were also able to compare results against a similar study exploring age differences conducted 25 years earlier (collected in 1974 and reported in Cherrington, 1980 and Cherrington, Condie & England, 1979). Despite the authors highlighting some statistically significant differences in their analyses, the results did not demonstrate a clear pattern, with many findings being contradicted by others. On a range of questions exploring the desirability of work outcomes (such as promotions, pay, recognition), no practically important differences were found across age groups in either the 1974 or 1999 samples. Examining questions associated with pride in craftsmanship (e.g., "a worker should feel a sense of pride in his work"), contradictory results were found across the two samples, with the 1974 sample suggesting older workers showed marginally greater pride than younger workers, whereas the opposite effect was found for the 1999 sample. Finally, examining questions associated with the moral importance of work (e.g., "working hard makes one a better person"), the 1974 sample showed consistent, but again very small, trends towards older workers believing more strongly in the moral importance of work, whereas the 1999 sample showed no clear pattern of results across generations.

Jurkiewicz (2000) provided a good review of the literature of age-related differences in work motivation, and empirically explored the differences between baby boomers and generation X'ers in the US public sector. Jurkeiwicz's review of the literature concluded that generation X'ers demonstrated higher rates of avoidable absence, higher turnover, higher illness and higher accident rates than do baby boomers. The author concluded, however, that evidence for differences in work motivations is mixed, citing contradictory findings regarding the importance of money across age groups. Further, Jerkeiwicz suggests that if any differences exist on desire for promotion and entrepreneurialism (a common perception is that generation X'ers are less interested in rising through a hierarchy and are more entrepreneurial) such differences may simply be the result of structural changes in the workplace – with lower economic growth and a large number of baby boomers occupying upper echelons of hierarchies, generation X'ers have fewer options of advancing within an organisation and hence many are forced to seek different forms of careers.

In her own study, Jurkiewicz (2000) asked baby boomers and generation X'ers to rank order 15 different workplace values covering issues such as "a stable and secure future", "chance to benefit society", "freedom from supervision", and "high salary". She concluded that the two generations were more alike than different. Of the 15 factors studied only three were significantly different across the generations. Baby boomers ranked "chance to learn new things" and "freedom from pressures to conform" as more important than did generation X'ers. On the other hand, generation X'ers ranked "freedom from supervision" as more important than baby boomers. No differences were found for all other issues including pay, contribution to society, prestige, advancement, variety of work, working as part of a team, leisure activities, and security.

Data collected within the Voice Project at Macquarie University by the current author supports the contention that the similarities are far greater than the differences. Based on data from 5935 employees from over 400 different organisations, the author has explored employee perceptions of 28 different workplace characteristics, as well as how strongly those workplace characteristics are associated with overall employee engagement. The main difference that was observed across age groups was that older workers were generally more satisfied than younger workers with most workplace characteristics. The pattern of satisfaction was, however, consistent across ages, with all age groups generally liking the people they work with, being generally satisfied with their levels of wellness and work/life

balance, and believing in the purpose of their work and their organisation. Likewise, all age groups were least satisfied with leadership in their organisations, their level of participation in decision-making, the level of communication throughout their organisation, career opportunities, and how change is handled. Examining which workplace characteristics showed the strongest relationship with employee engagement, again the age groups showed strongly similar patterns. For all age groups, the most important work motivators appeared to be how well their organisation was performing, how well change was handled, how satisfied customers were, the amount of reward and recognition they received, the level of participation they experienced, career opportunities and confidence in leadership. The least important workplace characteristics, again similar across all age groups, were work/life balance, teamwork, and quality of facilities. Referring back to the 7 P's model discussed earlier in this review, all age groups showed a clear preference for experiencing purpose, participation and progress in their workplace, and likewise all age groups were less motivated by property, people and peace. In contrast to much popular press, work/life balance appeared to be of slightly greater importance for middle and older workers and of less importance for younger workers, although as stated above, of the 28 workplace characteristics work/life balance showed the weakest relationship with employee engagement for all age groups.

3.8 Meeting the Needs Of Women

Women are under-represented in SET

Women obtain more than half of all university degrees in many countries including Australia, but only around 30% of the university degrees awarded in science and technology (Cervantes, 2006), with a higher proportion within science than in engineering. Within science, women graduates are more common within life sciences than in computing and physical sciences.

As suggested by the model in Figure 1 earlier in this review, career attraction is influenced by learning experiences which in turn are influenced by personal characteristics and one's pre-career environment. Cultural values and norms influence people at an early age to see different occupations as being more masculine or feminine. These values and norms become self-reinforcing given they shape early learning experiences ("Maths is for boys so I won't enter that maths competition") which in turn shape the range of abilities and level of self-confidence developed by children as they grow.

This cycle results in the imbalance in career attractiveness and the differing graduate profiles described in the previous chapter. The cycle is further strengthened in the workplace because organisations that have a higher inflow of males will develop and reinforce a masculine work environment. This environment further decreases career attractiveness for prospective women and it reduces the career retention of incumbent women employees. Finally, the absence of women in particular fields reduces the presence of female role models for daughters and female students. In this way the cycle becomes self-perpetuating.

Special needs for women

The forces described in the previous section are very strong and not easily turned around. Nevertheless, women may represent the greatest untapped source of potential employees for SET jobs, thus even small efforts to slowly turn the tide may produce significant benefits for employers. Applying the logic of Figure 1, employers can intervene by developing a work environment that is more attractive to women and that better fits the specific needs of women.

Morgan, Isaac and Sansone (2001) examined differing job interests of men and women undergraduates studying science. The authors found that women cited people orientation more than men did for career choices, whereas men cited pay and status reasons for career choices more than women did. The authors found, as suggested by the earlier discussed Social Cognitive Career Development model, that career attractiveness was heavily determined by self-perceptions of competence in different skill domains. Such a finding mirrors that of Jacobs, Finken, Griffin and Wright (1998) who found that competence-related factors were a distinct predictor of girls' consideration of math and science as a career.

Tilleczek and Lewko (2001) explored the transition from education to work in science. The results suggest that young women are not under-represented in their interest in scientific careers. Women, however, aspire more frequently to the medical and health sciences, while men aspire more frequently to natural sciences, engineering and mathematics.

In a Canadian study of men's and women's careers in engineering Ranson (2003) discovered that many women were at a disadvantage compared to many men when it came to balancing paid work with family responsibilities. Ranson examined Brown's (1982) three career types:

1. Organizational – built by advancement within one employer,

2. Occupational – advancement characterized by movement from employer to employer, and

3. Entrepreneurial – characterized by self-employment.

In terms of career type, men and women differed greatest in the occupational path (67% of men and 52% of women pursued occupational careers). The genders also differed in the reasons given for choosing a particular type of career. Men pursed organizational careers for the financial security, whereas women pursued organizational careers because they provided greater flexibility to meet family commitments. In occupational careers, men and women both noted career advancement and the search for the right job as factors for their career type. In entrepreneurial career types, men were self-employed in businesses which earned high incomes and in which they typically worked 50 or more hours a week. Women's self-employment, on the other hand, was divided between full-time self-employment for some of the sample, whereas for other women self-employment enabled them to work part-time and care for children while staying in touch with their profession. In all career paths, the presence of children seemed to lead to a reduction of working hours for women, but not for men. One of the conclusions was that women worked fewer hours than men due to family commitments, and women interested in a career had to delay family commitments whereas men did not.

Although the research into women's career preferences is far more extensive than that presented above, four special needs of women are quite clear and have direct implications for how employers can better attract and retain women:

1. Women show a preference for higher levels of interpersonal interaction than men. A common approach to meeting this need is to provide mentoring, buddying and networking programs for women in the workplace.

2. Women on average have less confidence in their abilities in male-dominated occupations. To address this potential obstacle, employers can emphasise the availability of training opportunities and provide a structured development and career

path through which women can progress.

3. Childrearing falls heavily on the shoulders of women. Employers need to explore more flexible work schedules in order to accommodate family caring responsibilities and time taken off during and after childbirth. Employers also need to ensure that use of these more flexible work schedules by women does not reduce opportunities for development and advancement.

4. Finally, the earlier discussion of Figure 1 and its implications for women highlights the structural and self-perpetuating obstacles women face. Employers may need to go beyond equal opportunity policies and instead adopt affirmative action policies by setting goals and perhaps quotas for the proportion of women in senior positions.

3.9 Immigration and Emigration

International mobility

Migrant workers make up a substantial proportion of the international research and development workforce. In 2003 there were about 33,700 doctorates in United States' academic institutions, an increase of 6% from the previous year with predictions that the trend will continue for many years. Of this number, the majority (60%) were foreigners on temporary visas and it is the foreign students who account for the predicted growth in the number of doctoral students (Cervantes, 2006).

Within the OECD, Australia is only lower than Luxembourg on the proportion of tertiary qualified residents that are migrants (approximately 28% of Australia's tertiary educated workforce are migrants; Cervantes, 2006). Moreover, Australia lags only the United States and Canada in its share of all international expatriates within the OECD (the Australian workforce has 8% of all international expatriates, Canada has 11% and the United States has 45%). When adjusted for population size, Australia has the highest percentage of expatriates within its workforce in the OECD.

Attracting migrants

Given Australia's positive net immigration, Australia is gaining in quantity of skills from migrants. The concern, however, expressed by many sectors is that the quality of immigrant skills is poor and that, although the number of people leaving the country is smaller than the number arriving, those who are leaving are taking with them highly desired knowledge and skills, hence resulting in a net loss of SET skills.

The University of Queensland recently held a workshop titled "Beyond Brain Drain – Mobility, Competitiveness and Scientific Excellence". In that workshop, Andrews (2004) discussed issues impacting the availability of SET professionals in the "hard" sciences of chemistry, physics and mathematics. While acknowledging that greater job availability and salaries draw Australians overseas, Andrews comments that the number of scientists lost by international migration is quite small in comparison to the absolute level of such scientists in Australia. Andrews reported that, to match the OECD average as a percentage of population, Australia needs an extra 75,000 scientists by 2010. Such numbers suggest that employers and the Government may need a heavier focus on attracting migrants than the current preoccupation with preventing the loss of SET workers to overseas markets.

Engineers Australia (2005) has suggested that the skills of many permanent migrant engineers are being underutilized. It is, or course, critical to maintain high professional

standards, and many migrants trained overseas may not meet exacting Australian standards in engineering or other SET professions. Nevertheless, it may be possible to develop bridging courses to bring migrants up to Australian standards. Such an approach may be necessary across all SET professions and trades. Industry and Government may need to engage in heavy overseas recruiting drives to attract migrants who, although not immediately employable, could be trained to acceptable standards.

3.10 Employer Involvement in Pre-Employment Education

The importance of SET experience in education

Researchers have consistently demonstrated that self-confidence in science, maths and technology significantly increases students' interest in careers involving these skills (e.g., Betz & Schifano, 2000; Ferry, Fouad & Smith, 2000; Kerr & Kurpius, 2004).

Gibson and Chase (2002) reported a two-year longitudinal study of an inquiry-based learning program (the Summer Science Exploration Program), the goal of which was to increase students' interest in science and a scientific career by engaging them in the practice of scientific investigation. Students participated in a two-week inquiry-based science camp during which they were encouraged to develop their own questions in the areas of biology and health. They then designed their own experiments and practiced laboratory and field techniques to investigate their questions. Two years following the camp those students who had successfully applied to attend the camp showed significantly higher interest in science as a career than a matched group of students who applied but who were not selected to attend.

There are two main obstacles, however, to the implementation of such teaching methods in schools. First, such highly practical teaching is costly, requiring time and equipment. Second, to deliver practical training in science and technology, teachers skilled in these areas are required. As reported by both the Australian Science Teachers Association (2005) and the Save British Science Society (2002), insufficient primary and high school teachers have a relevant science degree.

The role for industry in reinjecting SET skills and experience into education

Industry may be able to fill some of the gap in SET skills and experience that exists in primary and secondary education.

In putting together their Science Agenda For 2005-2010, the British Campaign for Science and Engineering (CaSE, 2005a) suggested industry could play a larger role in SET education through:

1. The provision of support materials to teachers,

2. Hosting sabbaticals and internships for teachers to update their knowledge by carrying out a project with an external organisation, and

3. Provide schools with industry practitioners to help teach students.

The US Institute of Food Technologists have adopted such an approach (see the Taste for Science program: www.ift.org/pdfs/TasteForScienceFlyer.pdf) to overcome their prediction of a labour shortfall to meet the growing food technology industry. They have attempted to overcome this shortfall by distributing multimedia kits to school teaching staff and careers

counsellors. These kits include science experiments using food, salary guides, and interviews with food scientists and graduate and undergraduate students in food science programs. The Institution has also undertaken road shows to schools, promoted scholarships and internships, and held colloquia with the aim of strengthening the relationships between industry practitioners, academia, existing students and prospective students. This later approach has also been recommended by Andrews (2004) who encouraged visits to schools from industry practitioners and science committees involving parents, staff and scientists to encourage linkages between schools and industry and to increase the visibility and perceived importance of science careers.

Craft (2000) describes the successful South Carolina Advanced Technological Education Centre of Excellence which has actively sought to build undergraduate student interest in engineering. The program has involved designing classrooms that model the workplace, teaching using real-world workplace problems, and interdisciplinary teaching teams. A feature of the program is the close connection between industry and the educational institution – 45 companies and more than 80 industry practitioners are involved in prioritising course content, making instruction more reality-based, and bringing industry problems, techniques and solutions into the classroom. A key outcome of the program has been 76-100% retention rate in comparison to a more typical 50% retention rate. Further, the participation of under-represented students, such as women and minorities, has increased considerably.

In their review of ways to increase the attractiveness of SET careers, the European Research Advisory Board (2002) recommended all SET teaching through primary and secondary schools should be heavily influenced by all SET stakeholders including universities, government and industry. The Board further recommended that SET undergraduate courses by opened up to include far greater input from industry in the design and delivery of courses and the provision of work placements, scholarships and internships.

Parker (1997) reviewed the benefits and outcomes of the US Engineering Research Centre (ERC) program. The ERC program was established in 1985 as a government-industry-university partnership aimed at developing industry-relevant knowledge and preparing engineering leaders who were more capable of successfully engaging in team-based, cross-disciplinary engineering practice. Benefits were reported for both companies and individuals. The longer a firm participated in the program the more benefits it reported such as access to new ideas and technology, access to technical assistance, access to equipment and facilities, hiring of ERC graduates, and improved products and processes. Supervisors and other industry representatives judged ERC-trained graduates to be superior to non-ERC graduates, demonstrating a better understanding of the workplace and client needs and being more able to engage in interdisciplinary teams.

Byrnes and Barrett (2005), in their article in Business Week, describe the approach of Schlumberger Ltd (an oil-field services giant) to talent management of its engineers. To ensure the company receives information on the best talent available and also to ensure university courses are aligned with highest technical and quality industry standards, Schlumberger has assigned high-level executives as “ambassadors” to 44 important engineering programs around the world. These ambassadors are usually high-ranking executives that have control of substantial budgets that can be used to fund university research. These executives stay in close contact with their universities, influencing course development and providing resources where appropriate to maintain industry relevance of the course content.

4 Conclusions and Recommendations

Summary of challenges and solutions

The national and international literature review discussed here has highlighted many of the challenges and potential solutions associated with the current and predicted future SET skills shortage. There is in Australia and overseas a dominant focus on “push” interventions focused on changing early learning experiences. The current review suggests, however, there is merit in simultaneously pursuing a “pull” approach of building a more attractive work environment and stronger person-job fit to maintain medium and long-term work motivation.

There is much that Australian industries and employers can do to better attract and retain SET workers. The primary challenges appear to be the following:

1. A large contributor to the lack of attractiveness of SET careers is that, in comparison to economically similar countries, Australia has comparatively few SET jobs available in private industry. Further, with governments reducing expenditure, the number of SET jobs in the public sector is also decreasing. With a comparatively small number of SET jobs available it is unsurprising that many prospective and existing SET workers choose to pursue careers elsewhere. To a large extent the lack of interest in SET from students is simply reflecting a lack of interest in SET from employers. Students and workers will naturally move to where the jobs are.

2. There is some evidence to suggest SET workers tend to prefer a particular style of working that poses some natural obstacles to long and successful careers in modern organisations. In particular, many SET workers may not naturally seek positions requiring close collaboration with others, being entrepreneurial, or managing work and projects with a close eye to cost and speed. In which case, employers may need to invest in training and development initiatives to build these skills among SET workers. Similarly, SET workers appear to prefer work involving exploration, autonomy, continuous learning, and the use of leading edge tools and techniques. To attract and retain SET workers employers should explore ways of designing jobs and workplaces that have these characteristics.

3. Employers unaccustomed to competing in a tight labour market will need to strengthen their recruitment and selection activities. Initiatives that SET employers should consider include more extensive marketing efforts to attract candidates, use of recruitment agencies and executive search firms, better targeting of under-represented groups of potential employees, graduate recruitment programs, and using outsourced resources such as temporary staff, contract staff and outsourcing work to other firms.

4. The cost:benefit ratio of an SET career has worsened. The costs of an education in SET are increasing. However, there appears to be a large gap between the high financial aspirations of students and the lower financial rewards and lack of prestige reported by SET staff. In comparison to many other countries, Australia has a relatively large proportion of SET workers in the public sector rather than the private sector, and hence many SET positions experience poor flexibility of pay structures limiting the potential to heavily reward high performers. Further, private sector employers have tended to follow public sector pay scales for their SET workers. To better attract and retain high performing SET workers, employers need to ensure flexibility of pay structures, link pay to performance more effectively, and be willing to pay more for a valuable and currently scarce resource. Financially successful role

models are required for financially motivated students and workers.

5. Many SET workers have a strong preference for ongoing learning, in part because SET tools and techniques are constantly evolving. Further, many employers have expressed concern that the content of SET education is out-dated, and the public sector opportunities for early-career cadetships and scholarships are decreasing in numbers. All these factors are shifting much of the responsibility for training and development of SET workers to the private sector. To attract and retain SET workers, employers must be willing to provide ongoing job-related and career-related training and development of their staff. Employers and industry associations should also seek to establish a stronger link with educational institutions and play a greater role in the design and delivery of SET education.

6. Employers may be able to slow the loss of some of their SET staff by better understanding and accommodating the needs of older workers. While the current hype around generational differences is unproven, older workers have some unique needs owing to the stage of their lives and careers. Many older workers are already financially secure and hence are only moderately interested in pay. However, older workers typically have lower confidence (although not necessarily lower ability) in their capacity to change and learn new technologies – hence, the availability of training becomes important. Further, some research suggests older workers are more attracted to workplaces that have flexible work hours and explicit policies supporting equal employment opportunity for older workers.

7. Women are an underrepresented group within SET. While this outcome is partly a consequence of early learning experiences, employers must also take some of the responsibility for not better meeting the preferences of women workers. In a highly competitive labour market many employers are benefiting from better catering to the needs of women by providing mentoring and networking programs for women, ensuring training opportunities and career paths for women, accommodating family caring responsibilities, and setting goals to achieve an appropriate proportion of women at senior management levels.

8. Many worries have been expressed about the “brain drain” of SET workers being lost to overseas markets. Nevertheless, the number of workers lost is very small as a proportion of the entire SET workforce, and hence greater benefit may come from finding ways to better attract overseas workers to Australia. Achieving this end would require Australian employers to meet the challenges discussed above such as stronger recruitment and selection efforts, more effective reward and recognition, and a heavier emphasis on learning and development. While fully skilled immigrants may be an employer’s first choice, employers may also benefit from recruiting under-skilled immigrants with the aim of training them up to Australian standards.

Questions to address in further research

While the current literature review presented here is informative, there are still many gaps and uncertainties, and Australian employers are currently required to inform management decisions based on overseas research. Employers may be more willing to take actions proposed in this report if Australian research was undertaken that filled existing knowledge gaps and drew conclusions based on Australian data.

Apart from confirming findings from overseas research, the research should also address the following questions:

1. What are the work opinions and motivators of existing SET workers within Australia? Do these opinions and motivators differ to non-SET workers? Do these opinions and motivators differ between SET industries and occupations? What are the biggest gaps between what SET workers want and what SET employers are providing?

2. Do older and younger SET workers have different opinions and work motivators? Can evidence be found to support the current interest among practitioners and the popular press regarding generation differences in work motivators for SET employees? If so, how can employers better meet the needs of older and younger workers.

3. Do women, migrants and other under-represented groups within SET occupations have different work opinions, motivators and needs than the typical SET worker?

4. To what extent are SET employers willing and able to modify their work practices to better attract and retain SET workers? What obstacles exist to changing work practices? What successful case studies exist that could inform other employers of how to better attract and retain SET workers?

Survey recommendations

The research could involve, initially, a large-scale survey of SET employees and employers. The survey would be both quantitative (involving collection of numerical data with respondents providing scores on a rating scale such as an agree/disagree rating scale) and qualitative (involving collection and analysis of written or typed responses to open-ended questions). To ease distribution and collation, an online survey would probably be the most efficient way of delivering the survey. Such an approach would be appropriate for professional and managerial SET workers. Paper surveys may need to be considered for trade workers if they have less frequent access to a computer and the internet.

To be most informative, robust results will be desired across major subgroups within the broad classification of SET workers and employers. To answer the questions posed above, results should be broken down across different professions (engineering, information technology, etc.), status (trade, professional, etc.), gender, age, and whether or not an employee is an immigrant. To provide a margin of error of approximately plus or minus five percent in accuracy of results, a representative sample of at least 300 respondents within each of the above categories would be needed. As such, a sample of approximately 3,000 responses should suffice if it adequately represents the above demographic groups. A much larger number of surveys would need to be distributed, however, to achieve 3,000 responses. With the nature of such a survey (driven by government or industry associations) the response rate will be lower than could be expected from a typical employee opinion survey conducted by an employer. Perhaps a response rate of 20% would be a reasonable expectation, suggesting the need to target 15,000 SET workers. A larger number of responses and hence a larger target population would be needed if accurate results were desired across a finer categorisation of SET workers (e.g., if robust results were desired for all or many of the occupations listed in Appendix A).

There would be many methods for distributing the survey, but one option would be to seek the participation of industry associations and employers, explaining the purpose and benefits of the survey, and asking them to complete an employer survey and encouraging some or all of their SET workers to participate in the employee survey. To encourage participation of employers, individualised reports for employers could be prepared providing feedback about

the responses of their employees and perhaps benchmarking their results against those of other participating organisations.

The content of the employee survey would address employees' opinions of a broad range of management practices discussed in this report. The survey should explore opinions about leadership, recruitment and selection, rewards and recognition, learning and development, career opportunities, levels of autonomy, participation and involvement, sense of contribution to the organisation and society, and how well change and innovation are handled. The survey should not just explore employees' opinions about whether these practices are good or bad in their workplace, but also how important these practices are for determining employees engagement with their job, satisfaction with their career, and their intention to stay with their employer and continue with an SET career. A simple method of determining importance is to ask employees what they believe is important; however a more sophisticated method would be to determine importance using statistical techniques such as correlations and regressions – perhaps a combination of these two methods could be used.

While not critical for addressing the above research questions, it could be useful if results collected from this proposed survey research could be benchmarked against non-SET data in order to understand if SET workers have work motivators that are different to workers in other occupations and industries.

The employer survey should also include both quantitative and qualitative content, exploring issues such as the extent to which employers are suffering from a short supply of SET workers, what they have done to overcome this problem, how successful those attempts have been, and what obstacles employers face in attempting to overcome the problem. The employer survey could perhaps also explore what employers believe are important work motivators for SET employees – this data could then be compared against the data collected from SET employees to see if there is a gap between employers perceptions and workers actual needs.

The survey could then be followed up with in-depth interviews with a much smaller number of selected employees and employers. Such an approach could provide the richness and real-life examples necessary to fully understand any problems and provide employers with practical case studies of solutions to SET skill shortages.

The final result of such a research approach would provide both statistical accuracy and confidence in conclusions, as well as providing employers with examples of Australian best practice in managing SET workers. Australia's social and economic future is heavily dependent upon the capacity of its workforce to innovate and implement, and SET workers provide the backbone to this capacity. Any threat to the future supply of SET workers must be addressed energetically. Other reports recently commissioned by DEST have proposed ways to modify government policy and Australia's educational systems. In contrast, however, this review emphasises that much of Australia's future economic success rests on the shoulders of current industry associations and employers and their attempts to modify workplaces to better attract and retain SET workers. The literature reviewed here provides some insights into solutions that should be attempted by SET employers. When paired with results from the proposed future research, Australian industry will be well informed about how to best attract and retain SET workers.

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Attachment A: Science, Engineering and Technology (SET) Occupations

Table 1: Science, engineering and technology occupations

Occupation Level/Occupation	ASCO*
Managerial Level	
Engineering managers	1221
Professional Level	
Chemists	2111
Geologists and geophysicists	2112
Life scientists	2113
Environmental and agricultural science professionals	2114
Medical scientists	2115
Other natural and physical science professionals	2119
Architects and landscape architects	2121
Quantity surveyors	2122
Cartographers and surveyors	2123
Civil engineers	2124
Electrical and electronics engineers	2125
Mechanical, production and plant engineers	2126
Mining and materials engineers	2127
Engineering technologists	2128
Other building and engineering professionals	2129
Mathematicians, statisticians and actuaries	2293
Business analysts	2294
Pharmacists	2382
Secondary school SET teachers	2413
University SET lecturers and tutors	2421
Associate Professional Level	
Science technical officers	3112
Building, architecture and surveying associate professionals	3121
Civil engineering associate professionals	3122
Electrical engineering associate professionals	3123
Associate Professional Level cont.	
Electronic engineering associate professionals	3124
Mechanical engineering associate professionals	3125
Other building and engineering associate professionals	3129
Trade Level	
General mechanical engineering tradespersons	4111
Metal fitters and machinists	4112
Tool makers	4113
Aircraft maintenance engineers	4114
Precision metal tradespersons	4115
General fabrication engineering tradespersons	4121
Structural steel and welding tradespersons	4122
Forging tradespersons	4123
Sheet metal tradespersons	4124
Metal casting tradespersons	4125
Metal finishing tradespersons	4126
Motor mechanics	4211
Automotive electricians	4212
Panel beaters	4213
Vehicle painters	4214
Vehicle body makers	4215
Vehicle trimmers	4216
Electricians	4311
Refrigeration and air-conditioning mechanics	4312
Electrical distribution tradespersons	4313
Electronic instruments tradespersons	4314
Electronic and office equipment tradespersons	4315
Communications tradespersons	4316

* Source: ASCO - Australian Standard Classification of Occupation, Second Edition, 1997 (Australian Bureau of Statistics Catalogue Number 1220.0)