Statistical Society of Australia Inc.

Statistics at Australian Universities

An SSAI-sponsored Review

December 2005

Statistical Society of Australia Inc.

PO Box 5111
Braddon ACT 2612
Australia

Phone: (02) 6249 8266
Fax: (02) 6249 6558

Email: admin@statsoc.org.au
Society Web Page: http://www.statsoc.org.au

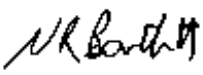
Foreword

Over the last 100 years the discipline of Statistics has grown from humble beginnings into a well developed part of the mathematical sciences that is concerned with the extraction of useful information from data that contains variation. The advent of computing technology led to a vast increase in the data available for analysis and the development of more sophisticated and appropriate methodologies for conducting statistical analyses. Consequently, the demand for statistical skills has grown consistently over many decades and the areas of application have increased markedly. More recently the development of genome related technologies has also generated additional demand for statistical skills.

Australia has always ranked relatively high with regard to participation in international research and application of statistical methodologies and Australian Universities have played a major role in achieving this standing. With a fundamental underlying increase in demand for statistical skills, one would expect growth in the supply of suitably trained graduates coming through our universities but this has not been the case. Over the last five years or so there has been growing signs of angst coming from within the university sector of the profession as well as concerns being expressed by a variety of employers about the quantity and quality of suitably trained graduates available. Universities are also major employers of people with statistical skills and many positions within universities have been difficult to fill. There was a lack of agreement about the fundamental causes of this and equally diverse views about what could and should be done to improve the situation.

These fundamentals have been the main stimuli that led the Statistical Society of Australia Inc. (SSAI) to conduct this review. By this means a complex situation could be tackled by allowing a wide range of employers, researchers and practitioners to contribute evidence, ideas and experiences in an environment without bias or pre-determined agendas. Support from sponsors was readily supplied and also an indication that some clear direction and associated actions were needed. It is particularly pleasing to see the range of response from employers (including universities), academics, practitioners, students and other interested parties. While this review is not an exhaustive analysis of the profession it certainly provides a comprehensive and authoritative view.

What we have ended up with is a report that proposes a broad range of actions that can be taken and there are opportunities for anyone with an interest in the profession to find ways of making a worthwhile contribution to the future. The statistical profession in Australia has been issued with a challenge to be more proactive regarding our future and we should collectively and as individuals step up to that challenge.



Neville R. Bartlett
Vice-president, Statistical Society of Australia Incorporated
December 2005

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Executive Summary

In summarizing the material and in developing its recommendations, the Review Team has found it convenient, at least conceptually, to group the issues raised under three broad headings: issues relating to the school programme; issues relating to organization and funding within and among universities; issues relating to the image and profile of statistics, including issues of employer/university interactions.

Issues relating to Statistics in Schools

We believe that there are two serious current problems with the teaching of statistics in schools, which are having a negative effect on many students' perception of the interest and importance of the subject.

The first relates to issues in curriculum design and implementation, including possibly inappropriate content and level of material and missed opportunities to provide close linkage with relevant data handling and display information and communications technologies.

The second relates to the absence of specific and sustained initial teacher training and subsequent continuing professional development to ensure that teachers of mathematics and statistics in schools have the background and resources to be able to convey statistical concepts and tools effectively and with competence and confidence to the students in their classroom.

Recommendation 1

- **Given the vital national importance of statistical education and the widespread concern about the current position of statistics taught in schools, and recognising states' autonomy and the diversity of approaches among different states, we recommend that the Federal Government fund a project aimed at identifying and disseminating good practice in the design and delivery of statistical education in Australian schools. In relation to this we recommend that the Federal Government give priority to funding the development of the National Curriculum Framework proposals put forward by the SSAI and the ABS in 2003 and supported by the Curriculum Corporation.**
- **In the context of such a project, the SSAI should be funded to co-ordinate a debate among stakeholders about the role and content of statistics taught in schools. In particular, the SSAI should facilitate debate about whether a distinction should be drawn between statistical education for the citizen and statistical education for pupils with a strong mathematical interest. The SSAI should also explore ways in which its members could contribute to improving problems of transition from school to university.**
- **We also recommend that the Federal Minister for Education, Science and Training encourage state authorities to involve formally the full range of**

stakeholders (including universities) in any future developments/changes in statistical education, the latter always to be considered against the background of ensuring a supply of appropriately trained and supported teachers to deliver the statistics curriculum.

Issues relating to the Management and Organisation of Universities

We believe that there are both funding and organisational issues that need to be addressed, some as a matter of urgency, to develop and sustain the appropriate level, mix and quality of statistics research and training in Australian universities. In particular, we believe there to be real threats to the sustainability of the core academic discipline itself. Insufficient numbers of PhD students are being trained to meet the needs of academe and research-based industries.

Overall funding of the discipline is a matter for the Federal Minister for Education, Science and Training, who also should have a role to play in initiating national strategies to ensure the long-term health of the discipline. Within universities, senior management have a role to play in ensuring that local organisational and funding models support and sustain quality statistics research and teaching throughout the institution. Academic statisticians themselves need to develop collaborative models, both within institutions and in local networks, which ensure most effective use of resources to promote and sustain the discipline. There is also a need for better systematic collection of data regarding manpower trends and student choices to guide future policy-making.

Recommendation 2

To the Federal Minister for Education, Science and Training:

As a matter of urgency, to reconsider the Relative Funding Model to ensure a more equitable funding arrangement for statistics in universities, bringing funding for statistics courses into line with the current funding levels for computer science courses.

To initiate strategies with the universities, employers and the SSAI to encourage, where appropriate, regional or national collaborative arrangements that will help sustain and enhance local capacity for the delivery of quality statistical education and training within universities.

To university managements:

- **To recognise the importance of statistics as a discipline in its own right, as well as an essential support for other disciplines. This is vital for the long-term sustainability of all disciplines underpinned by statistics. Within this context to support, where appropriate, the development and maintenance of quality on-campus statistical consulting services.**
- **To accept institutional responsibility for ensuring that internal structures and decisions encourage - and do not have unintended negative consequences for - the continuing existence of the discipline of statistics and the delivery of quality statistical education and training across the university in all disciplines.**

- **To be proactive in the short-term in support of the discipline in local circumstances where there is currently an absence of senior leadership and/or critical mass among the academic leaders of the discipline.**

To academic statisticians:

- **Within institutions, to accept the inevitability of changing structures and, in the changing context, proactively to seek and pursue opportunities to best position the discipline of statistics within the institution, organisationally and in terms of collaborative working with other disciplines. In particular, to emphasise the key role of statistics in many other disciplines, we encourage statisticians within universities that do not currently have a statistical consulting centre to consider establishing such a centre.**
- **Regionally and nationally, proactively to seek, where appropriate, collaborative arrangements across institutions that will serve to sustain critical mass in the discipline and develop and sustain the capacity to deliver quality statistical education and training, institutionally, regionally and nationally.**

To the SSAI:

- **To develop, through an extension of its current activities in the accreditation of staff and courses, the SSAI's capacity to influence the quality of statistics service courses, even when these are under the auspices of a substantive discipline other than statistics.**
- **In conjunction with AustMS, AMSI and the upcoming ARC sponsored Review of the Mathematical Sciences, to undertake comprehensive data collection and maintenance at sufficient detail to allow assessment of trends in university level mathematical sciences as a whole and of the component subdisciplines. Where possible such data should allow assessment of:**
  - **staff numbers and age profiles in mathematics and statistics and also in closely related areas such as econometrics, actuarial science, financial mathematics and biostatistics;**
  - **student participation in mainstream mathematical sciences programs at all levels as well as service units;**
  - **changes in breadth of unit offerings as a result of staffing and resource changes;**
  - **graduations at all levels in quantitative disciplines; and**
  - **job demand and graduate uptake in the mathematical sciences.**

Issues relating to the University/Employer interface

We have noted that there seems to be overall employer satisfaction with the technical quality of graduates employed for their generic quantitative skills, but clearly more needs to be done within the universities in relation to the communication, team-working and data-base management skills regarded as essential by many employers.

Recommendation 3

- **We recommend that the SSAI, in conjunction with organizations and activities such as AMSI and the Mathematics in Industry Study Group, continue to broker closer links between universities and employers by publicising existing good practice.**
- **We recommend that those within universities empowered to do so (Deans, Heads of Schools) involve employers in the education process via appointment to appropriate advisory boards.**
    - **We recommend that the SSAI seek to encourage the development and enhancement of graduate skills by:**
    - **including in the accreditation process a need for evidence of formal development of communication skills (encouraging the use of university provision as part of all UG/PG education/training);**
    - **setting up local mentoring/networking schemes for recent graduates; and**
    - **further encouraging the development of Young Statistician networks.**

Issues relating to Marketing, Communication and Lobbying

Statistics has a poor image and profile among students, parents and the general public. In particular, there is widespread ignorance among students, parents, teachers and careers advisers about the employment opportunities opened up by the acquisition of statistical skills. We believe that there should be a serious attempt to reverse this perception and the accompanying decline in interest in statistics.

Recommendation 4

- **We recommend that the Federal Government through DEST provide support to the SSAI to work with a wide range of employers to develop a professional communication strategy aimed at producing a significant change in the perception/awareness/esteem of statistics in schools among pupils, parents, teachers and careers counsellors – in particular in relation to the career/life opportunities opened up by the continued study of a significant component of statistics at schools and universities and its importance to the national interest.**
- **We also recommend that the SSAI work with universities to develop a variant of this strategy aimed at a wide range of students (including trainee teachers in mathematics and statistics) during their second and third years at university.**

Main Report

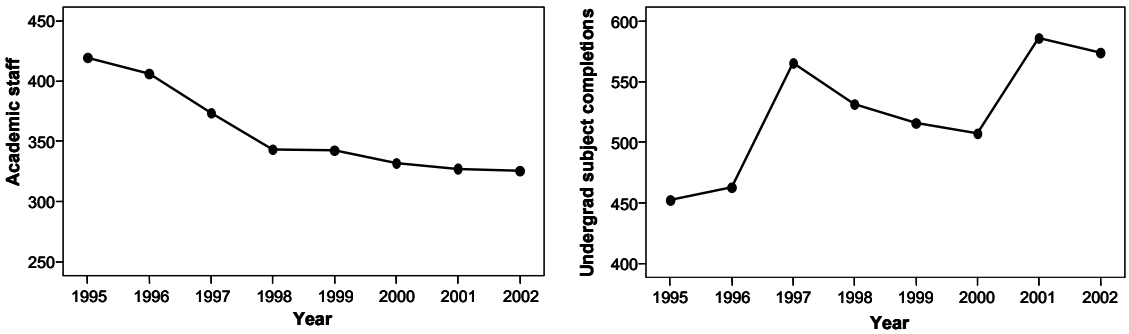
1. The Review Team received a number of insightful submissions, both in writing and in the subsequent series of formal and group interviews conducted around Australia (see Appendix for list of submissions and meetings). However, we were concerned to find that detailed data supporting many aspects of the review have been limited, unavailable or difficult to obtain during the review period, with a consequent need to rely a great deal on anecdotal evidence. Data from consolidated reports such as those from the Australian Vice Chancellors' Committee, Committee of Deans of Science and TIMSS, while providing useful overall trends, do not allow sufficient disaggregation to fully assess the situation pertaining to the discipline of statistics. Data at the levels of honours through postgraduate as collected and collated in conjunction with the Australian Mathematical Society do allow subdiscipline splits and have provided a useful resource. Even these data, however, typically do not fully embrace key related numerical disciplines such as econometrics, biostatistics and actuarial science. We believe it to be vitally important that good data are available to guide policy makers and we have therefore included, in Recommendation 2 of the report, a specific steer to the SSAI regarding future data collection.

2. In summarizing the material and in developing its recommendations, the Review Team has found it convenient, at least conceptually, to group the issues raised under three broad headings:

   (a) Issues relating to the school programme;
   (b) Issues relating to organizational and funding structures within and among universities; and
   (c) Issues relating to the image and profile of statistics, including issues of employer/university interactions.

3. A recurring concern expressed to the Review – linked to all three of these issues - has been the dwindling number of staff and declining or relatively static numbers of undergraduate students within traditional (mathematical) statistics programmes in universities (Fig. 1.) Ian R. Dobson (*Science at the Crossroads?*, for the Australian Council of Deans of Science 2003) reports a decline in mathematical sciences enrolments overall in Australian universities from 4045 in 1989 to 2787 in 2002. At the University of Western Australia, statistics majors have remained relatively static, averaging about 9.4 per year (range 3-16) from 1989 to 2003 (data from A. Baddeley). At the same time, this concern was linked to an acknowledgement of the increasing penetration of statistical ideas into other disciplines, and indeed the growth of related, but increasingly separate, disciplines – such as econometrics, actuarial science, financial mathematics, data mining and biostatistics - which are substantially founded on the application of statistical models and techniques.

Fig. 1: Mathematics and statistics academic staff levels (non research-only) and undergraduate completions, 16 universities 1995 – 2002. Data from AustMS courtesy R. Bartnik.

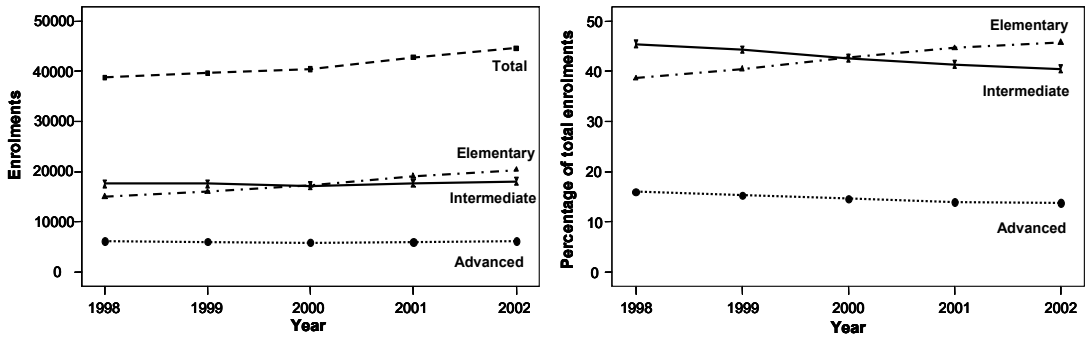


4. Whilst celebrating these extensions as a success for statistics – and of clear relevance to the employability of quantitatively skilled graduates across many different sectors of the Australian economy - many of those participating in the Review clearly also feel that this has led to a longer-term threat to the core discipline of statistics. This is partly as a consequence of many fewer students being attracted to the core discipline itself, and its impact on subject offerings; partly because the increasingly dispersed locations of statistics (and its spin-off disciplines) within universities has led to fragmentation and "turf wars", often as a consequence of differing funding regimes in different faculties.

5. The key long-term concern that emerges is the perceived increasing inability of the university system to continue to supply sufficient numbers of high quality PhD graduates to provide the next generation key leadership capability to maintain and develop innovative research within the Universities and other key Australian research organizations and agencies.

6. All the issues referred to in paragraph 2 above contribute to the situation. The overall output of students from the secondary schools with a high level of mathematical skills appears to be declining or is at best static (see eg. Fig. 2 for Victorian data. Data from other states is likely to be similar). There is considerable (at least anecdotal) evidence that, in their current form, some statistics courses in the schools have a significant negative effect on the image and profile of statistics.

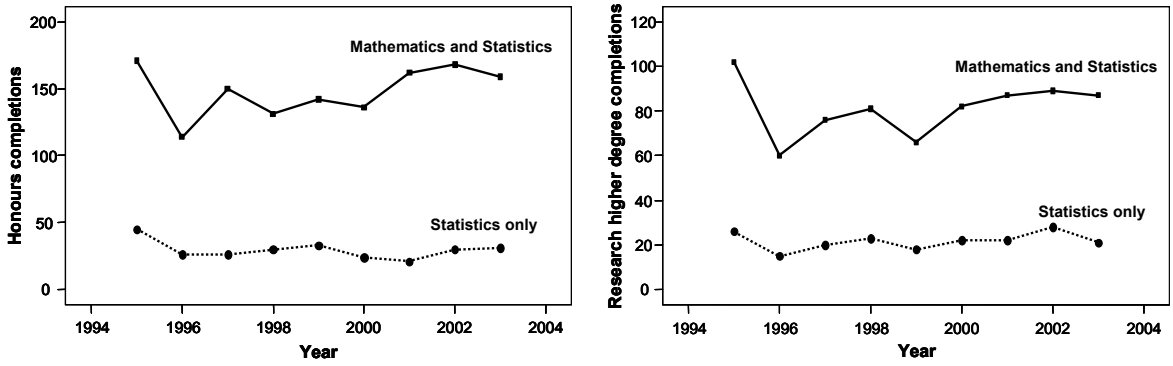
Fig. 2 Year 12 mathematics enrolments and percentages of total year 12 mathematics enrolments by level of course, Victoria 1998-2002. Data courtesy D. Finlay



7. For the most part, students leave school not appreciating the interest, importance and usefulness of statistics, and not at all seeing it as relevant to obtaining satisfying well-paid employment. Given the apparently almost universal ignorance among pupils, parents, mathematics teachers and career advisers about the employment opportunities opened up by the acquisition of mathematical/statistical skills, the proliferation of well-paid jobs in finance-related areas, among others, has clearly influenced students' choices of university courses away from the straight mathematical sciences.

8. Reduced or static intakes into mainstream mathematics and statistics courses in turn lead to reduced or static numbers of specialists taking honours and graduate courses (Fig. 3) and therefore reduced output of the very best graduates, who go on to be the leaders of the next academic generation. Reduced intakes also lead directly to reduced staffing levels in university mathematics and statistics departments (Fig. 1) with consequences for breadth of unit offerings. University funding and internal finances make it difficult to consolidate statistics staff and other resources scattered across the university into cohesive groups of sufficient critical mass to be able to sustain honours and graduate programmes.

Fig. 3: Honours and research higher degree completions 1995 – 2003. Data from AustMS courtesy R. Bartnik.



9. The resulting lack of status and visibility damages the image and profile of the discipline, both to prospective students and to other colleagues within universities, including senior management. It also undermines the collaborations and partnerships that statistics groups in the universities ought otherwise to be able to form with a range of employers and with government departments.

10. These difficulties are now deep-seated and the Review Team does not believe that there is any single short, sharp remedy. It is also clear that some difficulties can only be overcome in the longer term, whereas others require immediate attention. In drawing up its recommendations, the Review Team has therefore attempted to identify a variety of concrete practical steps that can be taken in the short term, and to outline for the relevant stakeholders and decision-makers more broadly scoped options for approaching the longer-term issues.

Issues relating to Statistics in Schools

11. One persistent theme articulated very clearly by many (though not all) of the students and recent graduates that we spoke to was the failure of current statistics programmes in the schools to excite students' interest in statistics. Indeed, it was put to us that current programmes frequently have the effect of driving good quality students away from the subject.

12. The Review Team does not believe that this is an inevitable consequence of including statistics courses at school level - we also came across examples of both students and teachers who were enthusiastic about their experience of statistics at school level. However, we do believe that there are two serious current problems with the teaching of statistics in schools.

13. The first relates to issues in curriculum design and implementation, including possibly inappropriate content and level of material and missed opportunities to provide close linkage with relevant data handling and display information and communications technologies.

14. The second relates to the absence of specific and sustained initial teacher training and subsequent continuing professional development to ensure that teachers of mathematics in schools have the background and resources to be able to convey statistical concepts and tools effectively and with competence and confidence to the students in their classroom.

15. This is, of course, related to a wider concern referred to us anecdotally in Australia about the supply of suitably qualified mathematics teachers. The Review Team noted with interest the considerable concerns expressed by university academics in this regard; we also noted that not all universities had significant, active local mentoring or support schemes in place to try to remedy the perceived problems.

16. Many respondents to the Review clearly have the impression that problems may start as far back as primary school. There is considerable general concern about what is seen as the inadequate supply of properly qualified teachers of mathematics in high schools and this is seen as implying an even more acute shortage of teachers with the competence to teach statistics, informed by a proper awareness of modern applications of quantitative methods and the resulting employment opportunities.

17. This leads into another persistent theme, reinforced many times by students and recent graduates: the lack of understanding they encountered while at school – from teachers, parents and school careers advisors – of the incredibly broad and exciting range of applications of mathematics and statistics in the "real world" and the plethora of employment opportunities that this offered. Many careers advisers both in schools and in universities have little mathematics (or general scientific) background, and are liable to convey outdated and inaccurate information about

the opportunities open to mathematics and statistics graduates in the broad sense (we received a good deal of anecdotal evidence that "becoming a mathematics teacher" was the most common response to the question of what careers are open to you if you study mathematics at university).

18. Many of the recent graduates we met with felt that the problem of lack of information about career opportunities continued in at least the early parts of their university careers. Many teachers of mathematics in schools and universities clearly have had little experience of, knowledge of, or direct contact with, the vast range of applications of quantitative methods that have opened up in recent years in government and industry and in other academic disciplines. Students are therefore emerging from school – and in many cases the early years of university - for the most part blissfully unaware of the variety of challenging careers open to good graduates with quantitative skills.

19 This sits uneasily with the fact that many young people today seem to be more vocationally motivated and are researching career options earlier than previous generations. The Review Team was informed that many would-be students – though by no means all – make use of a publication called the 'Good Universities Guide' to inform their choices. The low profile of mathematics and statistics in this publication provides a telling indictment of the damaging and inaccurate picture of these disciplines available to young people at an important decision point in their lives.

Recommendation 1

- **Given the vital national importance of statistical education and the widespread concern about the current position of statistics taught in schools, and recognising states' autonomy and the diversity of approaches among different states, we recommend that the Federal Government fund a project aimed at identifying and disseminating good practice in the design and delivery of statistical education in Australian schools. In relation to this we recommend that the Federal Government give priority to funding the development of the National Curriculum Framework proposals put forward by the SSAI and the ABS in 2003 and supported by the Curriculum Corporation.**
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- **We also recommend that the Federal Minister for Education, Science and Training encourage state authorities to involve formally the full range of stakeholders (including universities) in any future developments/changes in statistical education, the latter always to be considered against the background of ensuring a supply of appropriately trained and supported teachers to deliver the statistics curriculum.**

Issues relating to the Management and Organisation of Universities

20. The Review Team recognizes that Australia has historically punched way above its weight in terms of international profile and distinction in all branches of statistics. In the 1970s and 80s there were a number of flourishing university departments of statistics in Australia.

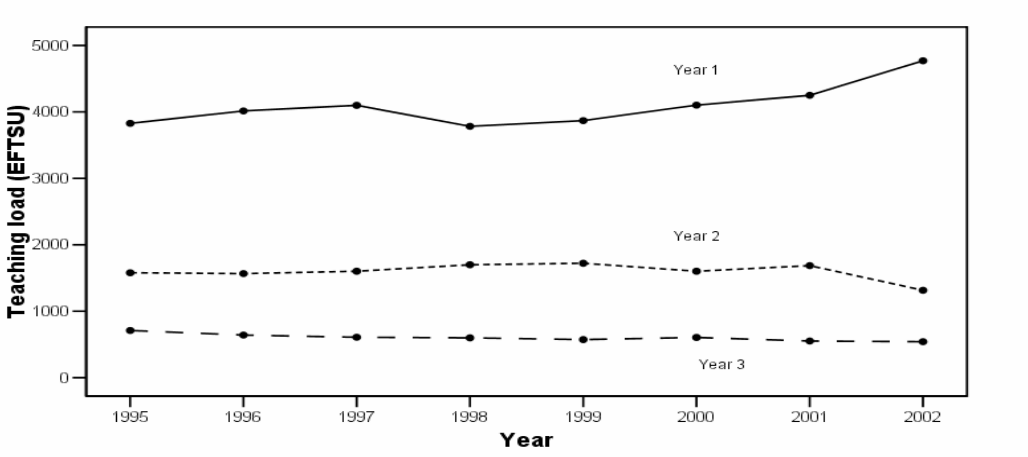
21. Much of the concern expressed to the Review Team has been about the considerable decline in critical mass of traditional mathematics/statistics groupings that has taken place in many Australian universities over the past two decades - and, anecdotally, within that overall decline, a disproportionate decline in the statistics component. Given this very real decline in the critical mass and international profile of statistics in Australia, the Review Team can well understand the sense of angst conveyed in many of the submissions made by respondents to the Review.

22. However, the Review Team is very conscious that the wider government policy environment within which Australian universities now operate sets great store by markets and competition. Inevitably, those running universities must today necessarily pay close attention to changing patterns of student and employer demand and respond, on the supply side, by making appropriate internal changes to the structure and balance of course offerings.

23. Viewed from this perspective, some respondents to the Review have argued that the decline of traditional mathematics/statistics departments and the corresponding growth of actuarial science, econometrics, financial mathematics, etc, should simply be seen as a natural adjustment within universities to changes in student demand, itself reflecting an evolving and expanding spectrum of employer demand.

24. Change in student demand does not necessarily manifest itself in initial entry to university. Many institutions still attract relatively large numbers into units with a mathematics/statistics designation in first year/second year, but then most experience a large drop-off in third and honours years. (Figs. 2, 3, 4) This is in large part related to the drop-off in service teaching load in later years but may also reflect students' increased concern with employability issues as they move into later stages of their university careers.

Fig. 4: Mathematics and statistics teaching loads (EFTSU), twelve universities 1995-2002. Data courtesy R. Bartnik.



25. From the employers' perspective, evidence to the Review Team made it clear that many employers seeking graduates with relevant quantitative skills do not perceive this shift of course take-up within universities in response to student demand as a problem. Indeed, many employers went so far as to say that graduates acquiring their quantitative skills in traditional mathematics/ statistics courses were less attractive in terms of their communication, team-working and problem-solving skills than, for example, students with significant exposure to economics and business course components.

26. So is there a problem with the shift away from demand for traditional mathematics/statistics courses and the knock-on decline in critical mass of these departments in Australian universities?

27. A number of respondents to the Review have pointed out that many of the key academic staff who are now leaders in the related disciplines that have emerged from statistics were themselves trained to a high-level in the core mathematics/statistics tradition. These respondents have argued that it is precisely this original immersion in depth in the rigorous generalities of the core discipline that has enabled the brightest and best brought up with the core to innovate and to forge the new disciplines and areas of application that are currently overshadowing the core discipline. They also point out that many of the best PhD students in emerging new statistics related disciplines and applications areas are likely to have come from a core discipline background.

28. The Review Team takes these arguments very seriously indeed. The significant decline in the number of students proceeding to the higher levels of traditional mathematics/ statistics programmes has a knock-on effect on the numbers of students proceeding to PhD studies in the core discipline and more generally to statistics related fields. Without sufficient numbers of students proceeding to PhD studies, all the related academic disciplines are in danger of not being able to develop and nurture the next generation of the brightest and best students to form the next generation of internationally competitive academics. The Review Team regards this as the most serious problem facing Australian statistics.

29. The problem is already with us. Respondents to the Review from the academic sector report that universities are currently having great difficulty in filling senior positions. Recently there have been several long-term unfilled chairs of statistics, and there is concern that, in the last decade, an increasing number of high profile Australian academic statisticians have left to take up posts overseas. [J. Thomas (2000) "Mathematical Sciences in Australia: Looking for a Future"; J. Thomas (2002) "Mathematical Sciences in Australia: Still Looking for a Future" FASTS Occasional Paper Series.] A related concern is the ageing of the remaining staff. At the end of 2003 the median ages of levels E (professor), B-D (lecturer - associate professor) and A (associate lecturer) mathematics and statistics staff were in the ranges 55-59, 50-54 and 45-49 years, respectively [Data from AustMS surveys courtesy of R. Bartnik].

30. The problem is not, of course, simply one of declining numbers of students proceeding to higher- level courses. More generally, there has been a substantial decline in the perceived attractiveness of academic positions in Australia (and elsewhere), not only in terms of comparative salaries, but also in terms of working conditions. For many who would be capable of taking up such positions, academic jobs no longer necessarily appear attractive by comparison with research or consulting jobs in industry and government agencies. This, of course, has a knock-on effect on the choices made by potential graduate students, who more and more weigh up the costs and benefits of PhD training versus immediate (and often well paid) employment.

31. Over and above the general decline in student demand and the attractiveness of academic jobs, a number of respondents have argued that the university environment for core mathematics/statistics departments has been further comparatively adversely affected by external and internal university funding mechanisms.

32. The representation most frequently made to the Review Team in this regard is that the relative funding models introduced to Australian universities around 1987 had a rapid and deleterious effect on student and staff numbers in the universities, and remain a major barrier to the reinstatement of more successful statistics programmes. The funding regime which resulted put statistics and mathematics into the second lowest funding band – at a lower band than computer science and informatics. Practically all respondents to the review regard this as objectively indefensible in that it fails to acknowledge the very significant, and often specialized, computational and IT resources required for modern statistics research and teaching (including industry standard software packages, data base technology and supercomputers).

33. Respondents are clear that significant underfunding for statistics relative to many other subjects has further contributed to the downward spiral in the fortunes of departments. Not only does this result in lower direct funding, but the funding differential is seen as having encouraged other departments and faculties to carry out their own statistics service teaching, rather than contracting it out to mathematics/statistics departments. Instead, there is a direct incentive for disciplines with higher banding funding to themselves deliver statistics "re-labeled" within a course attracting higher band funding. Since, in most universities, the financial sustainability of the statistics department was predicated

on significant amounts of income from service teaching (80-90% in some institutions) this has had a serious impact on many statistics departments. It has led to a decline in staff numbers (Fig. 1) and core course offerings, a decline in the status and profile of the discipline and a serious decline in staff morale. It is vital that the Minister for Education, Science and Training addresses the issue of the relative under-funding of the discipline of statistics.

34. Is there anything that should or could be done within universities? In principle it is within the power of individual university administrations to direct their income as they see fit. The fact that universities accept the situation that has developed with regard to statistics service teaching presumably reflects the fact that internal university decision makers do not see the threat to statistics departments as an individual institutional problem. While perhaps recognizing the national long-term dangers of the decline of the discipline, it is easy to see why an individual university would argue that it is more logical to have the service teaching resource stay within, and help to grow and strengthen, the areas of buoyant student demand.

35. Given the autonomy of individual universities, and their need for financial viability in a market framework, it would seem hard to mount an argument for statistics based on an altruistic appeal to Vice-Chancellors. If there is to be leverage on this issue beyond the intervention of the Minister for Education, Science and Training in reviewing funding levels, it seems to the Review Team that this will have to be a combination of two approaches: first, more creative thinking and leadership from the statistics community itself to better exploit opportunities within the current context; and secondly, influencing national policy making in directions that will provide incentives for individual universities to rethink their support for statistics.

36. Let us first consider steps that could be taken by statisticians within and across universities.

37. Within many universities, the Review Team has been surprised to discover how rarely the body of statisticians spread across departments and faculties has formed itself into some kind of “collective” to provide an institutional voice for statistics and to lead on a strategy for internal collaboration that would strengthen the overall position of statistics. This requires collaboration between departments to reach understanding of the relative purposes and merits of their respective offerings. It seems to us clear that combining all the expertise within an institution must lead to a richer set of offerings for students and teaching efficiencies. In some institutions, such collaboration underpins a university-wide statistics consulting service, producing both added value for other disciplines and raising the profile of statistics.

38. In addition, within many universities we have observed the trend towards double degrees and majors, which are seen both as desirable in themselves for the range of skills they give students and as highly marketable for precisely that reason. We see considerable scope for statisticians to participate wholeheartedly in collaboratively working with other disciplines to develop a range of such degrees with a substantial statistics component.

39. Longer term, one might hope that such bottom-up collaborative working would lead to a breaking down of interdepartmental barriers. What seems to us to be missing here currently in many cases is local leadership and energy.

40. Across universities within the same locality, it seems to the Review Team prima facie irrational to have small groups of statisticians in many different universities each trying to maintain a wide range of courses attracting only a handful of students. We believe that in many states/cities more energetic consideration should be given to exploring the possibility of state/city based honours and postgraduate statistics centers, to which all the local institutions contribute their own teaching and supervision strengths. Again, this would lead to a richer and more robust set of offerings to students and give them a sense of belonging to a greater critical mass than is present in any one institution. This seems to us particularly important given the small and fluctuating honours and postgraduate numbers in any one institution. We believe that such collaboration would also enhance inter-institution staff interaction, stimulate joint research and potentially increase the possibility of industrial funding.

41. We are aware from our discussions with local groups of statisticians that there are concerns about how to get this to work geographically in many cases. To some extent, we again sense a lack of creative leadership and energy. After all, it is these same respondents who have urged on us the seriousness of the current situation: we think it appropriate to expect that they themselves explore every possible avenue for improving the situation. Indeed, we were surprised to discover that many of those we talked to were completely unaware of government funding schemes such as the Collaboration and Structural Reform Fund which are precisely designed to support such collaborative initiatives. We were also concerned that, in many instances, there seemed to have been little serious exploration of the potential of on-line and distance learning provision to overcome geographic difficulties in implementing such collaborative schemes.

42. In this connection, the Review Team was very interested to learn about the history and workings of the Biostatistics Collaboration of Australia (BCA) programme, which is now taking about 20-30 students per year into a 3-year part-time Masters degree, many for retraining after original qualifications in medicine or in mathematics and science disciplines. The model is that of a national programme with teaching and supervision inputs from a number of far-flung institutions, the whole thing co-ordinated from a single administrative center, and employing a significant component of distance learning delivery. The programme is certainly very successful in providing a national training resource that could not be delivered by any individual institution, or even a small group of institutions. Could this provide a model for other aspects of targeted statistics education and training?

43. The Review Team believes that this is a model that should be carefully looked at as a possible way of generating co-ordinated critical mass from otherwise scattered small groups. However, we are aware that there are special features and problems with the model that would need careful consideration. One special feature is that the scheme has strong backing not only from the sponsoring universities but also, and crucially, from the employer groups concerned, including pharmaceutical companies and the health service. Even then, BCA still

requires Government financial underwriting. Maintaining the centre of administration and developing and supporting distance education provision are both expensive. That said, its great interest is that it is a model that has allowed a programme to be developed which could not be developed otherwise, with considerable national benefit.

44. Let us now return to possible steps to be taken to influence national policy making which impacts on the problem of statistics in universities.

45. The first "external leverage" issue is financial. We have been told many times that it is unlikely that changes would be made to the national funding (banding) model solely on the basis of a case made for statistics. Nevertheless, the Review Team wishes to record its view that placing statistics in a lower funding band than computer science and informatics is quite simply based on an outdated, incorrect view of the resource needs of modern statistics teaching and research. It is also unclear to us why the HECS for statistics is science based but the Relative Funding Model is not. Recognition via HECS that costs for teaching statistics are in the upper bands is inconsistent with funding at the severely lower levels for carrying out that teaching. These funding issues have already been the subject of representations to government by chairmen of the Committee of Deans of Science of Australian Universities. However, we believe that there is a need not only to continue such representations but also to secure support and backing of industry groups.

46. The second "external leverage" issue we would wish to bring to the fore in the context of statistics teaching in general and service teaching in particular is that of quality of provision. We have already indicated that we accept that individual universities must manage their resources in the way they best see fit. However, in addition to efficient management of resources, universities need to be concerned with the quality of service delivery. It is not clear to us that, in all cases, the shift of responsibility for statistics service courses away from the core discipline to other disciplines has necessarily maintained appropriate quality of provision. This is an important issue for employers because many of the students they take on for their quantitative skills will have acquired these in statistics service courses. It seems to us that the ideal is a situation where both the statistics group and the substantive discipline group collaborate in designing and teaching the statistics service courses, with the common aim of ensuring top quality teaching.

47. However, as far as we can see, there is currently no mechanism for checking on quality. We suggest that there is scope here for the SSAI to explore whether an extension of its current accreditation activities to cover statistics service courses, even where the main control remains within the hands of the substantive discipline, might be an effective lever on good practice. Professional accreditation processes in the substantive disciplines may provide such leverage.

Recommendation 2

To the Federal Minister for Education, Science and Training:

- **As a matter of urgency, to re-consider the Relative Funding Model to ensure a more equitable funding arrangement for statistics in universities, bringing funding for statistics courses into line with the current funding levels for computer science courses.**
- **To initiate strategies with the universities, employers and the SSAI to encourage, where appropriate, regional or national collaborative arrangements that will help sustain and enhance local capacity for the delivery of quality statistical education and training within universities.**

To university managements:

- **To recognise the importance of statistics as a discipline in its own right, as well as an essential support for other disciplines. This is vital for the long-term sustainability of all disciplines underpinned by statistics. Within this context to support, where appropriate, the development and maintenance of quality on-campus statistical consulting services.**
- **To accept institutional responsibility for ensuring that internal structures and decisions encourage - and do not have unintended negative consequences for - the continuing existence of the discipline of statistics and the delivery of quality statistical education and training across the university in all disciplines.**
- **To be proactive in the short-term in support of the discipline in local circumstances where there is currently an absence of senior leadership and/or critical mass among the academic leaders of the discipline.**

To academic statisticians:

- **Within institutions, to accept the inevitability of changing structures and, in the changing context, proactively to seek and pursue opportunities to best position the discipline of statistics within the institution, organisationally and in terms of collaborative working with other disciplines. In particular, to emphasise the key role of statistics in many other disciplines, we encourage statisticians within universities that do not currently have a statistical consulting centre to consider establishing such a centre.**
- **Regionally and nationally, proactively to seek, where appropriate, collaborative arrangements across institutions that will serve to sustain critical mass in the discipline and develop and sustain the capacity to deliver quality statistical education and training, institutionally, regionally and nationally.**

To the SSAI:

- **To develop, through an extension of its current activities in the accreditation of staff and courses, the SSAI's capacity to influence the quality of statistics service courses, even when these are under the auspices of a substantive discipline other than statistics.**

- **In conjunction with AustMS, AMSI and the upcoming ARC sponsored Review of the Mathematical Sciences, to undertake comprehensive data collection and maintenance at sufficient detail to allow assessment of trends in university level mathematical sciences as a whole and of the component subdisciplines. Where possible such data should allow assessment of:**
  - **staff numbers and age profiles in mathematics and statistics and also in closely related areas such as econometrics, actuarial science, financial mathematics and biostatistics;**
  - **student participation in mainstream mathematical sciences programs at all levels as well as service units;**
  - **changes in breadth of unit offerings as a result of staffing and resource changes;**
  - **graduations at all levels in quantitative disciplines;**
  - **job demand and graduate uptake in the mathematical sciences.**

Issues relating to the University/Employer interface

48. Over the past decade, there has been a very significant increase in both the variety and volume of job opportunities for graduates who have acquired a significant element of quantitative skills in their university courses. The Review Team has tried to form an overall picture of what employers are looking for in graduates, whether they feel that the current supply of such graduates – both in terms of numbers and quality – is meeting their needs and, if not, what they perceive to be the problems.

49. We begin with a (non-exhaustive) review of the broad groups of employers we met with during the course of the review. These include: the Australian Bureau of Statistics; other national and state government agencies (eg. the Tax Office, and state agricultural bureaus); the pharmaceutical industry; banks and finance companies; market research companies; the health services; CSIRO and other scientific research organizations and companies; and the universities themselves. We would summarise the position for each of these as follows.

50. The ABS seeks to recruit mainly good honours students in statistics and has in place a cadet scheme, which is widely acknowledged as an excellent training opportunity for the brightest young statistics graduates. It also recruits at PhD level, particularly to its methodology branch. The main problems identified by the ABS are a declining pool of good honours graduates from whom to recruit at that level, together with a shortage of PhD level applicants. Overall it has a number of unfilled positions. In addition, the ABS suffers from a significant leakage of staff to other government organisations and to industry. ABS has sought to underpin its recruitment by entering into collaborative arrangements with a small number of universities, notably Wollongong and ANU.

51 Other national and state government agencies are more varied in their requirements, with less focus overall on honours statistics graduates and PhDs. In some cases, the need was for graduates with good quantitative skills of some kind; in others there were more specific needs – eg. possession of a biometric background. In general, there was a concern that it is getting progressively harder to recruit simply because of the shortage of supply of appropriate statistics graduates.

52 The pharmaceutical industry in Australia entered the picture less than a decade ago, but is already a significant employer of statisticians. There are essentially three companies, each recruiting specialist statisticians both at good honours and at PhD level. In addition, there is a need for recruiting larger numbers of graduates with good overall quantitative skills. There have been significant difficulties with local recruitment, but these have been largely overcome through overseas recruitment. The companies have also adopted the strategy of recruiting appropriate non-statistics graduates who can proceed to acquire the necessary bio-statistical skills through the BCA. The very serious remaining

difficulty seems to be that of recruiting high quality PhDs to provide high level project leadership.

53. Over the past decade, banks and finance companies have very significantly increased their recruitment of graduates with high levels of quantitative skills. These include graduate statisticians, but the Review Team was interested to learn that statistics graduates are not necessarily preferred to graduates from more broadly based degree courses, including actuarial science and business and management studies. The requirement of these employers is less for graduates with specific technical statistical skills than for students with a reasonable level of all round quantitative reasoning skills combined with a flexible approach to problem solving, the ability to handle basic computing and data management packages and, above all, team working and communication skills. In general, this employment sector seemed satisfied with both the volume and quality of available graduates. There are also examples of industry/education linkage (e.g. Westpac's links with UNSW and its sponsored mathematics competitions).

54. The work of market research companies seemed to fall into two categories: routine surveys, for which the target graduate recruitment market was very much the same as that for the banks and finance companies; and non-standard projects, where specific technical statistical skills were very much sought after. It was felt that there were few recruitment problems in the first category, but significant problems in the second.

55. The health sector is increasingly required to monitor policies and interventions through data collection and analysis and this is creating a further substantial recruitment need for graduates with both general quantitative skills and an appreciation of the health-related context. In addition, the need to deal with increased complexity – eg. large data sets and longitudinal studies - requires increasing numbers of specialist epidemiologists and bio-statisticians. The sector has been strongly supportive of the BCA as a means of, over time, growing its required general skills base. However, there remains a serious shortage of specialist epidemiologists and bio-statisticians. A particular problem raised by health sector employers is the current lack of training of graduates on the standard software they will need to use in their employment (particularly SAS). The high license fees for such software puts it out of the range of most universities – reflecting the point we made earlier about inadequate provision of resources for statistics teaching in universities. The same need for SAS was identified by the pharmaceutical sector, but they – unlike the health sector - have the resources to provide in-house training.

56. CSIRO and other research oriented employers – eg. those in the newly emerging bio-informatics field - need to recruit high quality PhDs whose backgrounds include a significant component of core statistics. All these employers indicated that they were seriously concerned about both the numbers and the general quality of potential recruits. The main concern expressed about quality is a perception on the part of the employers that recruits no longer have a sufficiently rigorous background in mathematics. This relates to our earlier observation about the supply of graduates with such a background having declined rapidly as traditional university mathematics/statistics departments have shrunk or collapsed. The general impression emerging is that the change is not so much in

numbers taking quantitative studies overall, but taking quantitative studies in science-oriented disciplines. Employers such as CSIRO need good quantitative graduates with the kinds of modeling skills that can only be acquired through significant exposure to scientific problems.

57. So far as the universities are concerned, the over-riding concern of academic statisticians is the long-term sustainability of the core discipline. This depends on universities continuing to be able to attract the brightest and best of each generation to continue to PhD level and then to opt for an academic career. As we have noted, there is a severe bottle-neck developing in statistics (and mathematics) from the declining numbers continuing to honours and therefore to PhDs. This is compounded by increased numbers of - and typically better paid - job opportunities outside the universities. It is further compounded by a general perception that academic statistics in Australia is in decline, which would seem to be leading those committed to an academic career to seek appointments outside Australia, particularly in the USA and the UK.

58. What overall conclusions should we draw from this? Broadly speaking, it seems to us clear – as it was to all the respondents to the review - that the economy will continue to have an increasing requirement for graduates with high levels of quantitative skills. It is important therefore to continue to use all means possible to encourage students to acquire a solid quantitative component to their education.

59. Employers seeking honours graduates with specific technical statistical skills, or PhD level statisticians, are clearly concerned about the shortage of supply. This goes back to the general issue of a decline of those attracted or motivated to follow the core discipline through to at least honours level. The Review Team sees this problem as inextricably bound up with issues of the image and profile of mathematics and statistics and an appreciation of the job opportunities linked to these disciplines. We shall therefore return to this issue in the final section of this report.

60. Employers seeking well rounded competent graduates with adequate quantitative skills seem to be content with those they recruit. However, this does not mean that they necessarily seek to recruit graduates in statistics. Indeed, many employers have adopted recruiting strategies that deliberately exclude mention of a statistics requirement, preferring instead to use terms such as: “quantitative analysis”, “risk analysis”, ‘forecasting”, “data mining”.

61 This, in part, again relates to issues of image and profile, which we shall deal with separately in the final section of this report. But it also relates to a very explicit judgment on the part of employers – expressed to us on many occasions – that when their need is for a graduate with general quantitative skills they more often than not prefer graduates who have not come through the traditional mathematics/statistics programme route.

62 The Review Team has been surprised by this and has tried to identify what it is that has led employers to this view. One clear message is that graduates from mathematics/statistics backgrounds are significantly lacking in communication, presentational and interpersonal (team-working) skills compared with graduates from, say, economics or business and management programmes. This diminishes considerably their usefulness and “fit” in the workplace.

63 A second clear message is that mathematics/statistics graduates tend to be much more inflexible in their approach to problem solving. They are perceived as having a tendency to try to match the problem to the tool-kit they acquired at university, rather than being willing to explore the essence of the problem, in discussion with other non-specialists, through simple (graphical) means and then communicate it easily to others.

64. We believe that those responsible for mathematics/statistics programmes in the universities should pay close heed to these concerns. In particular, they should note what seems to be a growing view that double degrees including a statistics component could provide an ideal way forward when a significant quantitative component is required together with the range of other skills.

65 More generally, we think much more could be done to encourage communication between universities and employers. There are already excellent examples of what university/employer partnerships can achieve: eg. the links between ABS and the University of Wollongong and ANU; Westpac and UNSW; the health sector and BCA. The Review Team was somewhat surprised that more university departments had not actively sought and developed such links.

66. It seemed to the Review Team that university departments could explore greater involvement of students with prospective employers through projects, visits by employees, especially recent graduates, vacation employment and so on. The SSAI could play a role here by publicizing successful initiatives of this kind, and by providing opportunities for academic staff and appropriate employer representatives to meet together for discussions of issues of mutual interest. Within universities, staff should be rewarded for successful initiatives of this kind.

Recommendation 3

- **We recommend that the SSAI, in conjunction with organizations and activities such as AMSI and the Mathematics in Industry Study Group, continue to broker closer links between universities and employers by publicising existing good practice.**
- **We recommend that those within universities empowered to do so (Deans, Heads of Schools) involve employers in the education process via appointment to appropriate advisory boards.**
- **We recommend that the SSAI seek to encourage the development and enhancement of graduate skills by:**
  - ◊ **including in the accreditation process a need for evidence of formal development of communication skills (encouraging the use of university provision as part of all UG/PG education/training);**
  - ◊ **setting up local mentoring/networking schemes for recent graduates; and**
  - ◊ **further encouraging the development of Young Statistician networks.**

Issues relating to Marketing, Communication and Lobbying

67. Respondents to the Review are all agreed that, in general, statistics has a poor image and profile. In general schools in Australia do little to combat this. For the most part, students leave school not appreciating the interest, importance and usefulness of statistics, and not at all seeing it as relevant to obtaining satisfying well-paid employment. This inevitably has a knock-on effect on the choice of university course, both in terms of intrinsic interest and in terms of vocational aspiration, the latter increasingly dominating student choice of degree programme.

68. There is almost universal ignorance among pupils, parents, mathematics teachers and career advisers about the employment opportunities opened up by the acquisition of mathematical/ statistical skills. Set against the well publicised proliferation of well-paid jobs in finance-related areas, among others, this clearly influences students' choices of university courses away from the straight mathematical sciences.

69 The low profile of mathematics and statistics in the 'Good Universities Guide' widely used by high-school students as a source of information about university courses, in part we suspect as a result of the failure to separate statistics from the broad mathematical sciences group, provides telling evidence of the damaging and inaccurate views prevalent among school students, teachers, parents and careers officers. The vocationally oriented view of the current generation of students, both at upper secondary level and in universities, probably reinforced by views of parents (at least, parents in professional fields) accentuates the problems caused by poor information.

70 Discussions with students has tended to confirm the impression that there is a major breakdown of communication between employers and school liaison officers, hence also with students and teachers, about the availability and attractiveness of careers in mathematics-related subjects. Currently it would seem that careers advisors are generally very ill-informed. The Review Team regards this failure to communicate the attractions of a statistics career as a major issue.

71 We believe therefore that, at this time, the single most important step that needs to be taken to try to reverse the current disastrous decline in interest in statistics is an annual major, national, professionally coordinated publicity campaign, aimed at students, parents, teachers and careers advisors, and targeted appropriately for each of these audiences. From discussions held during the course of the Review, we believe that there would be enthusiastic and active support from a wide range of employers for such a coordinated advertising campaign, particularly aimed at influencing students and parents at course selection times.

72 The remit of this Review was to focus on the problems of statistics in universities. However, given that we need to influence students well back in their school career, it seems to the Review Team undesirable – for the purposes of a major publicity campaign - to separate out statistics from mathematics in general. It seems to us better in such a campaign to emphasize the many potential careers in the wider field of quantitative, mathematics-related studies – of which a significant proportion will, in any case, be in statistics - and allow students' further experiences at universities to determine their final choices of specialization and career. The vital issue is to ensure that more accurate information is given to students at school level about the career opportunities for students whose degrees include substantial components in quantitative studies, including statistics as one major option.

Recommendation 4

- **We recommend that the Federal Government through DEST provide support to the SSAI to work with a wide range of employers to develop a professional communication strategy aimed at producing a significant change in the perception/awareness/esteem of statistics in schools among pupils, parents, teachers and careers counsellors – in particular in relation to the career/life opportunities opened up by the continued study of a significant component of statistics at schools and universities and its importance to the national interest.**
- **We also recommend that the SSAI work with universities to develop a variant of this strategy aimed at a wide range of students (including trainee teachers in mathematics and statistics) during their second and third years at university.**

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Acknowledgements

The Society acknowledges and thanks the many people who made contributions to the Review and its organisation but special thanks go to Ms Jan Thomas, AMSI/AustMS and Professor Robert Bartnik, Monash University, for making available national data from AustMS surveys. Other data was also supplied by Professor Adrian Baddeley, University of Western Australia and Professor David Finlay, LaTrobe University.

Thank you to Mr David Whitelaw of the Australian Bureau of Statistics for taking on the role of Executive Officer for the Review.

Appendices

Appendix 1—Sponsors

The Statistical Society of Australia Inc thanks the following sponsors for their support of this review:

- Australian Bureau of Statistics
- Department of Education, Science and Training
- CSIRO Mathematics and Information Sciences
- Australian Prudential Regulatory Authority
- Roche Pharmaceuticals

Appendix 2—Steering Committee

A steering group was appointed to oversee the conduct of the review by finalising the Terms of Reference and handling any procedural issues that arose. The Steering Committee members were:

- Professor Tim Brown—Chair (ANU)
- Professor William Dunsmuir (UNSW)
- Ms Jan Thomas (AMSI and AustMS)
- Professor Adrian Baddeley (UWA)
- Professor Eric Sowey (UNSW)
- Dr Murray Cameron (CSIRO)
- Ms Leonie Doyle (DEST) and subsequently Ms Maggie Crowley-Lift (DEST)
- Ms Teresa Dickinson (ABS)
- Dr Neville Bartlett (SSAI)

Appendix 3: Review Team

Professor Adrian Smith, FRS from Queen Mary, University of London and Review Team Chair, is a leading British academic statistician who held Chairs in Statistics at Nottingham and Imperial College before taking up his current appointment as Principal of Queen Mary. He is the author of the recent report *Making Mathematics Count*, an enquiry into Post-14 Mathematics Education in Great Britain, commissioned by the UK Government.

Professor David Vere-Jones, FRSNZ, University of Victoria, Wellington is a leading New Zealand academic and consultant. He has been one of the most prominent international figures in Statistics education for many years, and has been active in the International Association for Statistical Education since its earliest days. He has been involved in many academic reviews.

Professor Ian James, Murdoch University is a leading Australian academic with research interests in statistical methodology, medical Statistics and biostatistics. He is a Past-President of the SSAI, and a past editor of the *Australian Journal of Statistics*, and was awarded Honorary Life Membership of SSAI in recognition of his academic and professional contributions to advancing the discipline of Statistics.

L-R: Professor David Vere-Jones, Professor Adrian Smith, Professor Ian James, Mr David Whitelaw (Executive Officer)

Appendix 4—Terms of Reference

Preamble

The general situation that has prompted this Review is the increasing shortfall of graduates suitably educated in Statistics to meet the needs of employers in business, industry, government and academia in Australia. This has become so critical an issue for large employers such as the Australian Bureau of Statistics (ABS), CSIRO and certain commercial enterprises that the matter was taken up with the Federal Minister for Education, Science and Technology. The Minister has requested that suitable initiatives be developed in order to redress the problem.

The Statistical Society of Australia, Incorporated (SSAI) believes that the problem of assuring the future supply of statisticians, and of others with appropriate statistical skills, has to be tackled by addressing:

(a) school students, so as to instil an appreciation of the fascination and relevance of statistics in all facets of life;

(b) university students, at both undergraduate and postgraduate levels, through stimulating and relevant study programs that equip students appropriately for careers in statistics or for careers for which a reasonable level of statistical competence is essential;

(c) students at all educational levels, and other groups as well (*e.g*. careers advisors, parents, and people in statistics-based professions), with an enhanced promotion of statistics as a career choice.

Activities are in train to address (a) and (c). This review relates to (b), and focuses primarily on those students who are majoring in statistics.

The purpose of this review is to provide a sound basis for discussions with those who can have significant influence on the future development of university education – and thus university statistics education – in Australia, particularly

(i) the Minister, the Department of Education, Science and Training (DEST), and Vice-Chancellors, who are in a position to develop new educational models and structures, and review the direction of current funding, and

(ii) potential industry partners who can be a source of new funding.

While the SSAI recognises that many of the issues in statistics education being proposed for review are significantly institution-specific, the review team is requested to address them, as far as possible, from an Australia-wide perspective.

There are many parties that have a strong vested interest in the matters covered by this review. Moreover, the review team's recommendations might require major long-term commitments by these and other parties. The SSAI believes, accordingly, that the review team must have the regard and respect of all the involved parties. The members of the review team have been selected for their impeccable credentials in terms of their professional standing, judgment, experience and independence of mind.

The review team is asked to come to a view on each of the following Terms of Reference. Note that the term 'employers' is used in its broadest sense and consists of universities, business, industry, education, research and government employers.

Terms of Reference

1. Context: employer needs.

(a) What are the present and emerging employer requirements for statistics graduates?

(b) What are the university and employer views of the numbers and quality of graduates?

(c) What are the university and employer views of the important attributes for statistical graduates? What are the important fields that need coverage for employers and universities and what gaps are there in supply?

2. Context: undergraduate studies with a view to immediate employment as a statistician.

(a) Quantify changes in the number and quality of students choosing to major, do honours and do postgraduate courses in statistics, and document reasons.

(b) What factors would encourage or discourage students from studying statistics?

(c) Are current undergraduate statistics programs equipping graduates to meet the present and emerging requirements of employers for statistics graduates? Are there any significant issues that need to be addressed?

(d) What specific influences have led to the recognition of employer requirements in undergraduate statistics programs, and how is this recognition being realised in these programs?

3. Context: undergraduate studies with a view to postgraduate studies in Statistics.

(a) Are current undergraduate statistics programs preparing students well for postgraduate studies in statistics, with a view to eventual careers

(i) in business, industry or government, in positions requiring the practical application of advanced statistical skills and knowledge?

(ii) as statistical researchers in business, industry or government?

(iii) as academics?

(b) What specific influences have led to the recognition, within undergraduate Statistics programs, of career requirements in the three career directions mentioned, and how is this recognition being realised in these programs?

4. Context: structural and funding changes to improve the supply of Statistics graduates to the employment market.

(a) What changes, if any, to

(i) the structure of current undergraduate statistics programs, and
(ii) the financial resourcing of these programs should be considered that would attract more students to studying Statistics with a view to making it a career?

Proposals for such changes should refer specifically to the range of current and prospective statistics-based careers in business, industry and government as well as enhancements of the educational skills and qualifications that may be required of those providing the undergraduate statistics teaching.

(b) How essential to the proposed structural changes to current undergraduate statistics programs is increased funding? Indicate the extent to which these could be achieved with current funding, and what would require a funding increase of

(i) 10%

(ii) 50%.

5. Context: postgraduate studies in statistics.

(a) Are current postgraduate statistics programs preparing students well for careers

(b) (i) in business, industry or government, for positions requiring the practical application of advanced statistical skills and knowledge?
(ii) as statistical researchers in business, industry or government?
(iii) as academics?

(b) What specific influences have led to the recognition, within postgraduate statistics programs, of career requirements in the three career directions mentioned, and how is this recognition being realised in these programs?

6. Context: structural and funding changes to improve the supply of graduates with advanced statistics qualifications (masters and doctorate) to the employment market.

(a) What changes, if any, to

(i) the structure of current postgraduate statistics programs, and

(ii) the financial resourcing of these programs should be considered that would attract more students to studying statistics with a view to making it a career?

Proposals for such changes should refer specifically to

- the range of current and prospective statistics-based careers in business, industry, government, and academia for which an advanced statistics qualification is indispensable.
- how to capitalise on the current high standing of Australian research in statistics.
- enhancements of the educational skills and qualifications that may be required of those providing the postgraduate statistics teaching.

(b) How essential to the proposed structural changes to current undergraduate statistics programs is increased funding? Indicate the extent to which these could be achieved with current funding, and what would require a funding increase of

(i) 10%

(ii) 50%.

7. Context: possibility of additional funding via specific structural changes.

What are the prospects of attracting additional funding for statistics education in Australian universities by implementing the following structural changes:

(a) increased collaboration among statistics departments across universities?
(b) improved collaboration with statistics-using disciplines at the same university?
(c) closer relationships with industry?
(d) introducing specialised degrees (*e.g*. a Bachelor of Statistical Science)?

8. Context: other relevant issues.

In the course of its work, the review team may identify other issues that it feels are germane to the purpose of the review, yet not explicitly covered in the preceding Terms of Reference. The team is invited to provide comment on such issues.

Append to the report those areas of application of statistics in government, business and industry (e.g. official statistics, pharmaceutical, …) that came under scrutiny during the course of enquiries by the review team.

9. Setting priorities for recommendations.

Recommend the most important ways forward, towards addressing the shortfall of graduates suitably educated in statistics for meeting the needs of employers in business, industry, government and academia in Australia.

10. Reporting arrangements.

This Review will be conducted under the auspices of the Statistical Society of Australia and the Review team is to report to the SSAI Executive.

Appendix 5—Timeline

The Review was conducted with the following timeline:

- July 2004 - SSAI Central Council agrees to conduct the review
- August 2004 - Steering Committee appointed
- October 2004 - Terms of Reference agreed by Steering Committee
- February 2005 - Review Team visited Canberra, Sydney, Brisbane, Melbourne, Adelaide and Perth.
- May 2005 - First draft of report received by SSAI
- August 2005 - Responses to draft report compiled
- November 2005 - Final report received from Review Team
- December 2005 - Final report published by SSAI.

Appendix 6—Contributions to the Review

The Review Team received written submissions from the following individuals and organisations:

Australian Bureau of Statistics	
Australian Mathematical Society	
Australian Taxation Office	
Adrian Baddeley	School of Mathematics and Statistics University of Western Australia
Helen Bartley	Bartley Consulting
Lynn Batten	School of Information Technology, Deakin University
Biostatics Collaboration of Australia	
Alan Carey	Mathematical Sciences Institute Australian National University
Data Analysis Australia	
Department of Mathematics and Computing	University of Southern Queensland
Annette Dobson	School of Population Health, University of Queensland
John Eccleston	School of Physical Sciences, University of Queensland
Nick Fisher	School of Mathematics and Statistics, University of Sydney
Peter Hall	Centre for Mathematics and its Applications, Australian National University
Rob Hyndman	Department of Econometrics and Business Statistics, Monash University
Richard Jarrett	Mathematical and Information Sciences, Commonwealth Scientific and Industrial Research Organisation
Kuldeep Kumar	Faculty of Information Technology, Bond University
Helen MacGillivray	School of Mathematical Sciences Queensland University of Technology
John Maindonald	Centre for Bioinformation Science, Australian National University
Mathematical and Information Sciences	Commonwealth Scientific and Industrial Research Organisation
Michael McAleer	School of Econometrics and Commerce University of Western Australia

Michael Murray	School of Mathematical Sciences University of Adelaide
Office of Economic and Statistical Research	Queensland Treasury
Hyam Rubinstein & Peter Taylor	Department of Mathematics and Statistics University of Melbourne
School of Mathematics and Statistics	University of Sydney
School of Mathematics	University of New South Wales
Patty Solomon	School of Mathematical Sciences University of Adelaide
Eric Sowey	School of Econometrics University of New South Wales
Statistical Science Section, School of Engineering and Mathematical Sciences	La Trobe University
Bob Staudte	Department of Statistical Science La Trobe University
David Steel	Centre for Statistical and Survey Methodology University of Wollongong
Nell Stetner-Houweling	
Nihal Yatawara	Department of Mathematics and Statistics, Curtin University of Technology
University of Adelaide	

Appendix 7—Meetings

The Review Team gathered information via a series of meetings held at various locations around Australia. What follows is a list of people who attended.

14 February—Canberra

Peter Hall	Australian National University
Ross Maller	Australian National University
Michael Martin	Australian National University
Des Nicholls	Australian National University
Steven Roberts	Australian National University
Alan Welsh	Australian National University
Rohan Baxter	Australian Taxation Office
Ray Lindsay	Australian Bureau of Agricultural and Resource Economics
Terry Neeman	Covance
Frank Yu	Australian Bureau of Statistics
Matthew Pollard	Australian National University

15 February—Canberra

Dennis Trewin	Australian Bureau of Statistics
Des Nicholls	Australian National University
Michael Martin	Australian National University
Alan Welsh	Australian National University
Steven Roberts	Australian National University
Alan Carey	Australian National University
Peter Hall	Australian National University
Stephen Horn	Department of Family and Community Services
Murray Cameron	Commonwealth Scientific and Industrial Research Organisation
Geoff Lee	Australian Bureau of Statistics
Lewis Conn	Australian Bureau of Statistics
Noel Hanson	Australian Bureau of Statistics
Ruth Luscombe	Australian Bureau of Statistics
Janice Wooton	Australian Bureau of Statistics

16 February—Sydney

William Chen	Macquarie University
Robert Mellor	University of Western Sydney
Paul Rippon	University of Newcastle
Judy Simpson	University of Sydney
David Steel	University of Wollongong
Neville Weber	University of Sydney
Graham Wood	Macquarie University
Philip McCloud	Roche
Edmund Bosworth	Westpac
Anthony Carolan	Westpac
Brian Cullis	New South Wales Department of Primary Industry
Joanna Leadbetter	Eli Lilly
Helen Moore	New South Wales Health

17 February—Sydney

Steve Davies	Australian Prudential Regulatory Authority
Nick Fisher	ValueMetrics Australia
Judy Simpson	Biostatistics Collaboration of Australia
John Cucka	Jigsaw Strategic Research
Michael Cowling	University of New South Wales
Eric Sowey	University of New South Wales

18 February—Brisbane

Michael Arthur	Griffith University
Kaye Basford	University of Queensland
Janet Chaseling	Griffith University
Annette Dobson	University of Queensland
John Eccleston	University of Queensland
Michele Haynes	University of Queensland
Helen MacGillivray	Queensland University of Technology
James McBroom	University of Queensland
Geoff McLachlan	University of Queensland
Kerrie Mengersen	Queensland University of Technology
Rob Reeves	Queensland University of Technology
Tony Sahama	Queensland University of Technology
Paul Fay	University of Southern Queensland
Christine McDonald	University of Southern Queensland
Ashley Plank	University of Southern Queensland
Ross Shepherd	Central Queensland University
Sama Low Choy	Queensland University of Technology
Graeme George	Queensland University of Technology
Tony Swain	Department of Primary Industries and Fisheries
Paul Dickson	Colmar Brunton
Joanne Walker	Colmar Brunton
Burton	Telstra Countrywide
Ben (Research Assistant).	Queensland University of Technology
Christy (Undergraduate)	Queensland University of Technology
Garreth (PhD Student)	Queensland University of Technology
Helen (Lecturer)	Queensland University of Technology
Matt (Undergraduate)	Queensland University of Technology
Melanie (PhD Student)	Queensland University of Technology
Rob (PhD Student)	Queensland University of Technology
Ross (Post Doc)	Queensland University of Technology
Scott (Research Assist.	Queensland University of Technology
Terese (PhD Student)	Queensland University of Technology
Diana Battistutta	Queensland University of Technology
Annette Dobson	Biostatistic Collaboration of Australia
Helen MacGillivray	Queensland University of Technology
Gerard Davis	Genetic Solutions

21 February—Melbourne

Garth Gaudry	Australian Mathematical Sciences Institute
Jan Thomas	Australian Mathematical Sciences Institute
Ian Gordon	University of Melbourne
Owen Jones	University of Melbourne
Mei Ng	University of Melbourne
Ken Sharpe	University of Melbourne
Peter Taylor	University of Melbourne
Ray Watson	University of Melbourne
Richard Jarrett	Commonwealth Science and Industrial Research Organisation
Nick Garnham	Swinburne University of Technology
Kay Lipson	Swinburne University of Technology
Brian Phillips	Swinburne University of Technology
Max King	Monash University

22 February—Melbourne

John Carlin	Royal Children's Hospital
Gordon Smyth	Walter & Eliza Hall Institute
Paul Kabaila	La Trobe University
David Finlay	La Trobe University
Derchieh Hung	Young Statisticians, Statistical Society of Australia Inc.
Murray Hannah	Department of Primary Industries
Jan Thomas	Australian Mathematical Sciences Institute

23 February—Adelaide

Phyllis Tharenou	University of South Australia
Alan Branford	Flinders University
Chris Brien	University of South Australia
Gary Glonek	University of Adelaide
Anthony Harradine	Prince Alfred College
Bernie Hughs	University of South Australia
Charles Pearce	University of Adelaide
Philip Ryan	University of Adelaide
Amy Sater	University of Adelaide
Garry Niedorfer	Australian Bureau of Statistics
Peter Richie	Australian Taxation Office
Margaret Swincer	Workcover Corporation of South Australia
Julian Whiting	Australian Bureau of Statistics

24 February—Adelaide

Peter Dowd	University of Adelaide
Anthony Harradine	Prince Alfred College
Gary Glonek	University of Adelaide

25 February—Perth

Neville Bartlett	Statistical Society of Australia Inc.
Tim Brown	Statistical Society of Australia Inc.
Pamela McCaskie	Young Statisticians, Statistical Society of Australia Inc.
Anna Munday	Young Statisticians, Statistical Society of Australia Inc.
Adrian Baddeley	University of Western Australia
Brenton Clarke	Murdoch University
Jiti Gao	University of Western Australia
Ritu Gupta	Curtin University of Technology
Les Jennings	University of Western Australia
Robin Milne	University of Western Australia
Gopal Nair	Curtin University of Technology
Tony Pakes	University of Western Australia
Ranjodh Singh	University of Western Australia
Ross Taplin	Murdoch University
Kok Lay Teo	Curtin University of Technology
Berwin Turlach	University of Western Australia
Nihal Yatawara	Curtin University of Technology
Dorota Doherty	King Edward Memorial Hospital
Sharon Evans	Department of Health (WA)
Jane Speijers	Department of Agriculture (WA)
John Henstridge	Data Analysis Australia
David Roarty	Australian Bureau of Statistics
Ian Wright	Department of Fisheries (WA)

Appendix 8—Glossary

ABS	Australian Bureau of Statistics http://www.abs.gov.au/
ARC	Australian Research Council http://www.arc.gov.au/
AustMS	The Australian Mathematical Society http://www.austms.org.au/
ANU	The Australian National University http://www.anu.edu.au/
BCA	Biostatistics Collaboration of Australia http://www.bca.edu.au/
CSIRO	Commonwealth Scientific and Industrial Research Organisation http://www.csiro.au/
Curriculum Corporation	http://www.curriculum.edu.au
DEST	Department of Education, Science and Training http://www.dest.gov.au/
FASTS	Federation of Australian Scientific and Technological Societies http://www.fasts.org/
HECS	Higher Education Contribution Scheme http://www.hecs.gov.au/
Mathematics in Industry Study Group	See - http://www.anziam.org.au/
PG	Postgraduate
SSAI	Statistical Society of Australia Incorporated http://www.statsoc.org.au/
UG	Undergraduate
UNSW	University of New South Wales http://www.unsw.edu.au/
UWA	University of Western Australia http://www.uwa.edu.au