Australian Tertiary Science Education: International Perspectives

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Tertiary science degrees in Australia are currently very much shorter than present international standards. A brief comparison is given with the major industrialised nations, leading to the strong recommendation that the international 4+2+3 system of tertiary education in science ought to be adopted in Australia, together with an increase in tenured staff numbers to competitive levels.

Introduction

There is little doubt that Australian tertiary science education is in a difficult situation. Currently, the admission scores required to enter science courses are often much lower than in other professional courses. In other words, entering students have a worse academic standing than those of many vocational courses. Despite these low entry standards, science enrolments are not increasing. In Australia, they are generally reducing, compared to overall tertiary enrolments. Some universities, like Bond University or the new Sunshine Coast University College, are now opening without offering any courses at all in the fundamental sciences. It is very unusual, in international terms, to find universities with essentially no science courses.

The result of nearly static enrolments, in a reducing funding environment, is a rapid and unprecedented decline in staffing levels - which even in the 1980's were lower than the levels found in Australia's international competition. Just as worrying is the inadequate level of funding for essential laboratory courses, with a resulting loss of functionality in the experiments. Since the sciences generally have an evolutionary path that must be reflected in new experiments, it is important to replace and upgrade equipment regularly. In industrialised countries with relatively high wages, the future of most job-seekers must rely on innovation and new technology. However, this can only happen if science, engineering and technology education is of the highest international standard.

These problems are part of a disquieting overall trend throughout Australia. For example, OECD studies of relative levels of research investment leave Australia at the bottom of the list for per capita industrial investment. This, in turn, leads to poor corporate performance and restricted job opportunities. Even more troubling is the decision of major medical schools in Australia to remove all science course-work prerequisites from their degree requirements. This is the only country in the world to downgrade medical degrees in this way. By comparison, the trend in the USA is to maintain or even increase the mathematics and science course-work requirements for medical and related biotechnology degrees. Harvard and M.I.T. now have graduate medical degrees which few Australian medical students would qualify to enter. It is possible that USA medical boards will start to question the degrees of Australian doctors.

A related problem is the lack of advanced training in science required of science teachers, together with much lower salary levels compared to other professions. It is common in Europe for a science teacher to have the equivalent of a postgraduate (master's) degree in science. In Australia, a science teacher can sometimes teach in an area that he or she has never really studied past high school. It is very hard to justify this. It is precisely at high school that a well- educated and enthusiastic teacher can play a large role in communicating the excitement of scientific discovery - as well as an understanding of the role of technology in modern life.

The tertiary sector is not meeting Australia's current needs in science.

Solutions?

There **is** an area where science job growth has occurred in Australia in recent years. This is in the federally funded research centres. However, the growth of jobs in research centres has largely been in the area of temporary research positions. With some predictability, these have not proved attractive enough to increase the number and entrance standards of prospective science students. There is truly excellent research taking place at the research centres. Yet, since research output is rather similar at universities and research centres, it would seem preferable to fund more permanent university jobs. These positions are both attractive to prospective employees, and more functional in transferring knowledge to students. Instead, many local universities have launched attacks on the tenure system, reducing permanent staff.

An impractical ‘solution’ tried at some institutions, is a general attempt to increase graduate enrolment for Ph.D. degrees. This can be achieved within the current academic framework, and is intended to improve science funding via student-based funding formulae. On the other hand, as the current number of government funded postgraduate scholarships is fixed, any overall national increase can only come from self funded students - who are relatively scarce. Foreign graduate students might help, but (as we will see) this is made less likely by the unusual degree structures in Australia. Increased research is a very worth-while goal. As a means of increasing the funding of science education, this approach is best characterised as ‘rearranging the deck chairs on the Titanic’. It can result in gains only at the expense of other universities elsewhere.

Another example of the conflict between the publicly funded university, and current attempts to induce artificial competition, is the strange tale of the ‘research quantum’, i.e., the funding allocated to universities for research performance. Most of this funding is allocated on the basis of research grant income, which of course has no direct relationship to research output, and certainly does not measure international achievement. Since the funding is variable, all university administrations try to increase it, with the result that staff are given quotas of how many grants to apply for - whether or not the grant is needed. Staff who don't comply, perhaps because they can do the research without a grant, face the harsh penalty of retrenchment.

There is a fundamental difficulty even with the approach of simply trying to increase student enrolments, without questioning the existing degree structures. This is the serious question of the goals of the Australian tertiary system. In other words, one can ask if the degrees currently gained are really sufficiently up-to-date, and appropriate for the employment of large numbers of graduates. In order to determine this, it is useful to compare our system with that found elsewhere in the world. Quantifying our educational levels relative to world standards is clearly an essential part of this. In the recent *Quality* surveys of Australian universities by the federal government, there was unfortunately **no** attempt to compare degree quality and requirements with those found elsewhere in

the world. This quality problem is underlined by recent UK surveys that suggest relatively low funding levels prevail here, which obviously begs the question of whether our university education is really of a world standard.

This question is an important one, which can be asked even of degrees offered in currently fashionable areas like biology and computer science. For example, the software industry is now becoming more and more dominated by a number of large international corporations. These will employ only a relatively small number of Australian graduates, while saturating local software markets to an unprecedented extent. In this situation, it appears that it is most likely that there will be a high demand for graduates who know about computers, together with a knowledge of the discipline where they are to be used. On the other hand, the number of operating system programmers needed may be reducing - as operating systems converge onto a few common types. Despite this, computer science graduates with a relatively narrow range of skills will graduate in increasingly large numbers out of Australian universities in the `90's.

Attempts to increase competition between universities have not solved the problems of low funding levels, unsuitably narrow degrees, and declining standards both in teaching and in research.

International standards

To describe international degree standards, it is necessary to group countries into those with comparable tertiary education systems. The main groups in the Asia-Pacific are USA-Latin America, Russia-FSU, Japan-East Asia, and China-Taiwan. All these nations - representing over half the world's population - have a rather different approach to tertiary education to that found in Australia. In the Asia-Pacific, the large industrialised nations follow a system that is roughly comparable to the US style of education. In this system, there is a broadly based four year undergraduate degree, which is then followed by two or three years of specialised graduate education. Finally, students interested in research can start on their Ph.D. thesis.

It is very common for students to change courses or Universities after completing any one of these stages, which means that **portability** and **interchangeability** of degree requirements and standards is an important factor in international tertiary education.

In the USA, students can enrol directly in a 5-year Ph.D., after a 4-year undergraduate degree. In this case, the first two years of study would include 12 or more advanced graduate courses. Thus, the initial years of postgraduate study would be equivalent to a master's degree. By comparison, in Japan, it is usual to divide the postgraduate study into distinct course-work (M.Sc.) and research sections (Ph.D). This is called the 4+2+3 system, which is therefore nearly identical to that in USA and Latin America. It is simplest to regard these countries as having just one interchangeable system. In China there is currently a 4+3+3 system - due to an industrial training component in the M.Sc.. degree. A unique feature of Japanese research degrees is that they often take place in industrial laboratories.

The situation is more variable in Europe. The largest grouping of similar tertiary systems includes the German-speaking countries, the former Soviet Union (F.S.U.) and Eastern Europe, all with roughly comparable tertiary education systems. Here, there is a 5 or 6 year undergraduate degree, usually called the *Diplom*. This is similar in standard to the 6 year master's degree in Japan or the USA, but typically includes a research thesis. Some Russian universities are likely to eventually

change to the US system, in line with other recent changes in the F.S.U.. Thus, all these leading industrial nations have very similar overall tertiary education standards. In *Diplom* granting countries, there is also a further qualification, the *Habilitation*. This is a postdoctoral research thesis, which might take a further two years, and is equivalent to international requirements of research experience for a University position. On average, this can be called a 6+3+2 system, with a higher final qualification than elsewhere.

Longer degree structures require higher staffing levels, to cover the great variety of courses that must be available, and to provide time for research and postgraduate supervision. Thus, the major research-based universities in the USA typically have tenured staff numbers in their science departments in the range of 35-100, averaging 55 (for example) in the ten highest- ranked physics departments. Chinese and Japanese universities frequently have tenured staff numbers at a similar or higher level. In Australia's universities, the range is closer to 10-25. Funding cutbacks in recent years have been rather quickly widening this gap even further.

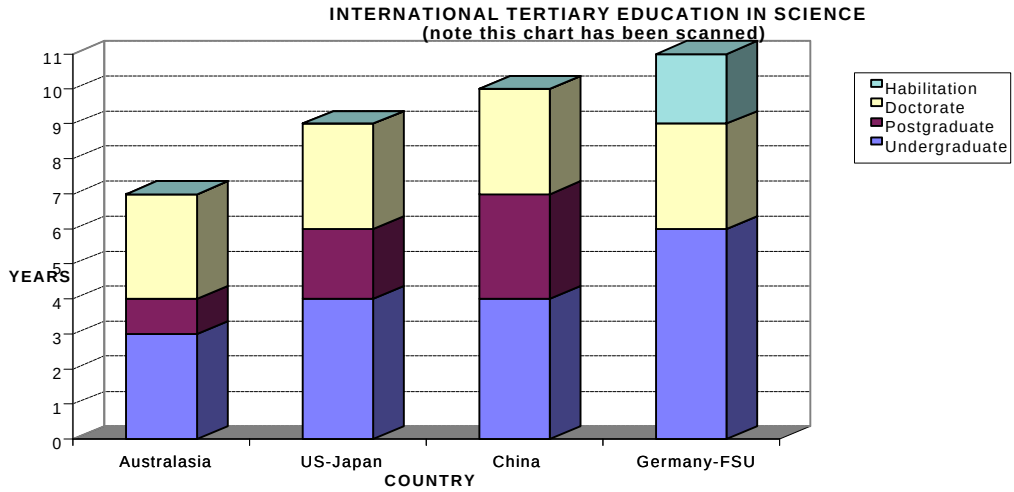
Of the other major international tertiary systems, there is little doubt that the US-Japan system is the most influential and successful. This verdict is certainly supported by the statistics on citations, publications, industrial output, patents, student numbers, and employment levels. The Nobel prize awards for several decades now, are a very strong indicator that the USA system is able to produce researchers of the highest international standards. Figures on industrial output and international trading competitiveness indicate the strength of the Japanese system, which still has one of the world's strongest exporting industries.

Major international systems of tertiary education in the Asia-Pacific are all very similar. The first degree takes four years of study, and emphasises breadth of knowledge. The M.Sc. takes at least two years of course and project work. Entrance to a Ph.D. comes after six years of tertiary studies.

Comparisons with Australia

Australia is almost unique in the Asia-Pacific, in that most Universities offer a 3+1+3 system of tertiary education. In this system, a highly specialised three year first degree is followed by a one-year honours course or postgraduate diploma. This is the highest level of course-work generally available, and can be followed directly by enrolment for research thesis work, usually towards a Ph.D. degree. This system was adopted from the UK some time in the 1960's. It is currently used only in former British colonies.

A chart showing the comparisons between international tertiary systems is given below:



Comparative international degree structures in science

The much shorter degree structure in Australia is clear, from the chart above. Given excellent facilities, a very selective intake, and high staffing levels, shorter degrees could be acceptable. Even so, it would not be easy to keep the standards high, over the whole course structure.

Great benefits accrue from longer first degrees in the sciences, which typically allows a broader education in mathematics, computation and communication skills. The additional 12 months or more of highly intensive graduate courses in the USA-China-Japan system, have substantial educational benefits also. Students can focus on advanced topics, since they start with more complete understanding of the fundamentals. Longer graduate courses are also more viable in terms of specialised industry training in technology, engineering and science. These do require larger staff numbers, which is a critical shortcoming of the Australian system.

Australian degrees are too short, too specialised and of too low a standard.

The ‘business’ model

It has been a common argument in Australian tertiary administrative circles, that all possible problems with tertiary research and education can be solved using `business models', in which accounting techniques are used to solve these problems. The counter-productive nature of the ‘research quantum’ indicates the dangers.

The first point that quickly arises out of any international comparisons, is just how few internationally reputable universities are run on any normal business model. One has to understand what a business **is** to recognise this. Very simply, modern corporations exist to return dividends to their share-holders.

By comparison, most international universities are funded directly by their governments, and internally administered by collegial democracy - rather than through a corporate autocratic hierarchy of managers. The most famous private universities like Harvard are non-profit philanthropic trusts - not typical businesses.

There are some ‘universities’ that are clearly set up to make a profit from their students, and these can usually be most charitably characterised as bottom-feeders. In the USA, they are business

colleges, or small religious and mail-order institutions whose educational reputation is highly dubious. This is not a path worth following.

Why is the collegial model successful? A university education system has for many years been regarded as a social necessity in civilised countries. It benefits the whole society to have competent engineers, skilled linguists, knowledgeable historians, trained doctors, ethical lawyers and professional scientists. Presumably, the taxpayers in most countries prefer their bridges to stay in place when they drive over them, and they like their doctors to know how to diagnose disease. They are not averse to having skilled jobs resulting from the discovery of new technology - rather than having to work as itinerant labour, third-world style.

Universities achieve these goals through a system of checks and balances, in which the three factors of education, research, and scholarship play a role. The last of these three is a vital glue that holds the system together - including the essential academic freedom to criticise, and the responsibility to review research, and to examine students.

The business educational model, on the other hand, cares nothing for educational standards, nor indeed for society as a whole. If it is cheaper to advertise well, and educate students badly, then some business 'university' will take this approach - with the rewards accruing to the managers. There is simply no guarantee that ethical behaviour or high standards will result.

Thus, for example, it is often suggested that internet delivery can provide a cheaper way to educate students. This would be completely disastrous in many professional and scientific fields, which must rely on experimental and practical experience. In addition, assessment would clearly be subject to fraud and simple copying. There is simply no credible evidence that this technology is sufficiently mature, let alone acceptable to students, for it to supplant more traditional forms of tertiary education. However, it might well help in the supply of graduate courses to smaller universities, in order to round out programs to an acceptable breadth.

In summary, the main problem is how to guarantee that the corporate business model - which rewards profit - will somehow reward the university objectives of education, research and scholarship in all fields. This is unlikely - especially given the obvious conflict of interest between the University goal of high attainment, and the business goal of high enrolment.

In any venture into voucher education, the most important requirement for success will be to create an appropriate regulatory environment to ensure that education, research and scholarship is paramount - and to reduce wasteful over-management and bureaucracy.

Recommendations

The final results of Australian Ph.D.theses have sometimes reached or exceeded the required international levels of competence. However, when they have, other factors are often at work. Foreign students in Australia have usually completed additional courses elsewhere. In other cases, local students find that they must take longer than three years for the thesis. In practically all cases, Australian science graduates are educated more **narrowly** than current world standards. This is clear from any comparison of Australian and international degrees.

These problems can only be solved in the earlier years of study, by utilising the standard America-Japan 4+2+3 degree structure. It is likely that Australia would then be more widely attractive to high

quality international students - from all parts of the world. Local students would also receive a better education, which is clearly the most important point.

It is noteworthy that some medical schools in Australia have already started to change away from the more specialised UK system - even though they have strangely enough reduced the entrance standards while doing this. There are numerous advantages to longer, international- style degrees, many of which are applicable in other areas as well as in science, provided degree requirements are upgraded at the same time:

Less specialised first degrees allow much more flexibility later on. This allows incoming students to delay their final choice of specialisation, without omitting an essential course.
Compared to the German-F.S.U. system, the 4+2+3 degree structure has the advantage that students have more options as to what type, and how much education they desire.
The larger number of graduate courses that are possible in a two-year postgraduate degree, give students greater professional knowledge than in a one-year honours or M.Sc. course.
Industry is likely to be more receptive to the master's degree level of training, as an indication of general problem-solving ability. Multi-disciplinary courses are also possible here.
For students wanting the more research-oriented career path, a Ph.D. thesis is an easier task for students with greater preparation than is currently possible with just one honours year.
Attracting international students would be easier if our degree structures were compatible with the usual international practice, already found in many neighbouring Asia-Pacific countries.

Achieving these changes is difficult, but not impossible. Degree regulations need to be changed, to require more standardised four year B.Sc. degrees. At present, this requires government intervention, since Australian universities are far from autonomous in any practical sense, due to the existing DEETYA restrictions. A strong priority must be given to the reversal of recent funding policies that are driving staff/student ratios well below acceptable levels.

Bureaucratic absurdities, like the ‘research quantum’ which evaluates research output in terms of its cost, must be replaced by more sensible, international measures (like citations, perhaps).

Internally, it is desirable to broaden undergraduate courses, so that at most 50% can be taken in one department. A helpful addition would be to provide fee-exempt admission of qualified graduate students into two-year M.Sc. courses - including course-work *and* research. It would also be useful if the major universities (at least), changed their Ph.D. admission policies to *require* this more rigorous standard of achievement.

In conclusion, it is time to change Australian tertiary science education to the standard 4+2+3 tertiary degree system, together with increased staffing levels. International levels of education, research and scholarship must be the primary aim in any Australian university reforms.

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