SHAPING TERTIARY SCIENCE AND TECHNOLOGY EDUCATION IN NEW ZEALAND: A RESPONSE TO THE FOURTH TEAC REPORT

Heather Stonyer (Auckland University of Technology, Auckland, New Zealand, heather.stonyer@aut.ac.nz)
Roy Geddes (Auckland University of Technology, Auckland, New Zealand, roy.geddes@aut.ac.nz)

ABSTRACT
Since April 2000 the Tertiary Education Advisory Commission has considered how the tertiary education system can contribute to the development of a knowledge society and economy in New Zealand. The contribution of science and technology to this development is widely appreciated. Less appreciated, is the crisis in under-supply of scientists and technologists in both New Zealand and globally. TEAC with the release of its fourth report – Shaping the Funding Framework - has attempted, within an overall tertiary strategy, to address some of the reasons for this under-supply through a variety of measures such as: priority indicators for programmes; proposing caps on funding postgraduate programmes which do not meet a requisite research ‘threshold’. While TEAC proposes a significant rethink on the mechanisms for distributing the tertiary education ‘cake’, it does not appear to have embraced the complexity of the tertiary science and technology education/research environment. This omission has serious implications for tertiary science and technology education. It may be that universities will be unable to ensure, with any degree of certainty, that science and technology graduates will leave a tertiary education system with the necessary competencies for full and effective participation in the ‘knowledge society and economy’.

INTRODUCTION
The New Zealand Government, apparently without cross party dissent, stated that: the enhancement of New Zealand’s future quality of life will be increasingly reliant on scientific knowledge and technological know-how (Upton, 1996a). More recently, the vision of a ‘knowledge society and economy’ has seen the appointment of the Science and Innovation Advisory Council – its core mission to identify how New Zealand could ride the knowledge wave. Earlier this year, the significant ‘Catching the Knowledge Wave’ Conference generated over 100 recommendations on how New Zealand can lift its economic and social performance and create a knowledge society.

This reflects a growing appreciation in New Zealand and shared by industrially advanced countries of the importance of the contribution of science and technology to society generally (Carnegie Commission, 1994). Indeed the President of the United States has made his conviction clear that ‘science and technology can promote economic growth
and international competitiveness’ (ibid). The Science Policy Research Unit (SPRU) of the University of Sussex has identified that ‘science and technology are now strategic resources to be deployed as effectively as possible’ (Martin et al, 1999). There has been a consequent escalation in economic and industrial competition between countries. The SPRU authors also maintain that ‘companies and countries must innovate if they are to thrive, with knowledge-based industry and services becoming more crucial’ (ibid).

It is clear that the competitive pressures engendered by the international appreciation of the crucial role of science and technology skills are spreading rapidly into the educational world since tertiary institutions provide the training for the staff and the future leaders in the knowledge-based industries. Within New Zealand, the Royal Society of New Zealand clearly articulates this: ‘Education and training: not just in terms of volume but also matching supply with demand for a skilled workforce of scientists, technologists, technicians and support staffs but also into developing areas of science and technology’ (RSNZ, 2000).

Obviously, the role of tertiary science and technology education is crucial in realising this ‘knowledge society’. The ‘path to the [any] region’s long term future will not be trod by the workforce of today….It will be trod by the young. Hence the quality of …education, both in terms of basic skills and in terms of technological literacy, will contribute greatly to determining whether that path leads to economic prosperity or decline’ (NYAS, 1996).

This view is supported by Dr Jim Watson, founder and chief executive of the successful New Zealand biotechnology company Genesis Research and Development, who states that ‘the ‘young’ are the standard-bearers of our scientific revolution …. they must be encouraged to discover the paths of the future, not trained in the ways of the past (Watson, 2000)’ Australia has identified the “urgency in the battle to attract the most able people to science and technology” (PMSEC, 1996).

In recognition of this and of the inextricability of science and technology education with research New Zealand increased its public investment in research intending the annual amount of $530 million committed in 1996 to reach $1330 million fifteen years later (Upton, 1996b). This necessary focus on research has caused speculation about the ability of the existing tertiary teaching organisations and structures to provide sufficient competitive, educated and skilled research talent in science and technology to service the sophisticated needs of research. The Royal Society of New Zealand (RSNZ, 2000a), for example, advocates a review of the student loan scheme which systematically favours those studying shorter courses which take them into service industries and disadvantages those doing masters or PhD courses essential for the training of scientists and technologists. These New Zealand needs face predicted international competition since the USA acknowledges that it is massively under-supplying its own requirements for scientists and technologists. (Figures of estimated shortages of Software Engineers alone are often stated as 300,000+.) The Chinese have stated that they will be short of 1 million engineers………..
TERTIARY EDUCATION ADVISORY COMMISSION

The Tertiary Education Advisory Commission (TEAC) was convened in April 2000. Its task was to propose how the tertiary education system can best develop a knowledge-based society and economy. The subsequent release of the four TEAC ‘Shaping’ reports (TEAC, 2000, 2001abc) – covering Vision, System, Strategy and Funding Framework – during 2000-2001 signal a further ‘rethink’ of the provision of tertiary education in New Zealand. One of the key messages of this policy framework, as specified in these reports, is quite explicitly, the development of a knowledge society. The reports propose mechanisms to enable the Government to ‘effectively steer the education system in a strategic manner’ (presumably towards the realisation of a ‘knowledge society’), principally through a new funding framework and adoption of centres of research excellence (CoRE).

An analysis of the current crisis facing science and technology in New Zealand is given and the ability of the TEAC ‘Shaping’ reports to effectively respond to this situation is presented in the following sections.

TRAINING OUTPUTS IN SCIENCE AND TECHNOLOGY

In view of the crisis of under-supply of scientists and technologists outlined in the introduction, it is necessary to analyse the current and future outputs of science and technology practitioners by New Zealand’s tertiary sector. Analysis of the production of graduates in New Zealand shows very clearly how tertiary outputs do not reflect the stated needs of the country for science and technology: in 1998 67.3% of New Zealand graduates qualified in the areas of Arts, Business or Social Sciences; 5.6% qualify in engineering and technology; 2.6% as physical scientists (NZVCC, 2001). Other figures from the extensive web site of the Ministry of Education (MoE, 2000) show the enrolment situation in the whole tertiary sector (includes both universities and polytechnics). The figures (1999) include certificates, diplomas and degrees:

- Engineering: 4%
- Industrial Trades: 5%
- Natural & Applied Sciences: 8%
- Commerce/Business/Humanities/Social: 40%

Further in degree and post-graduate enrolments (1998) there is a similar picture:

- Engineering: 6.9%
- Physical Science: 11.8%
- Commerce/Business/Humanities/Social/Law: 51.8%

While there are a number of complex, interrelated reasons for this reduction in relative outputs of science and technology to business graduates, the situation is, for the most part, a result of the increasingly competitive environment of current tertiary education introduced through education policy in the previous decade (1990-1999). Competition is promoted through the funding model, Equivalent Full Time Student (EFTS) system, which funds tertiary education institutions on the basis of enrolled student numbers. The
institutions have tended to compete in courses where entry costs are low. Business courses (other than accounting), for example, do not require professional accreditation (cf engineering), and infrastructure costs (eg equipment, laboratory space and library material) tend to be less than those required in science and technology. The resultant growth in business, commerce, information systems and management based degrees has been significant. In the period from 1996-2000, bachelor degrees increased from 27 to 38; master degrees from 24 to 35. Such growth is also a response to student demand, as the perceived individual positional benefits of business courses are high relative to the costs and time involved (Kingsbury, 2001). To ensure that each institution is responsive to this student demand and captures its share of the students and related funding potentially available, institutions have diverted funds from academic interests into expensive and extensive marketing campaigns and departments. Further, when the profile of the science and technology graduates is further analysed, there is continued under-representation of women and certain ethnic groups.

The rapidly increasing international demand for those with science and technology qualifications, combined with the weak New Zealand dollar, would seem to indicate that the tertiary sector is not configured appropriately to meet additional needs of the area. Additionally only 11% of the population have tertiary qualifications as compared to 49% in the United States of America. While the increase in participation rates in tertiary education has taken NZ from the bottom of the OECD to somewhere just below the middle, this figure (11%) suggests that the demand driven reforms of the last decade have failed to position New Zealand in a strong position from which a ‘knowledge society and economy’ can emerge.

**TEAC Recommendations: Solving the problems?**

Even before the TEAC reports were released the Government has signalled (since 1999) a shift away from the competitive model, and is seeking an agreed nationwide plan for tertiary education provision, and an environment in which providers collaborate rather than compete. TEAC has proposed that ‘collaboration’ becomes measurable criteria for access to funding. The message is that we must collaborate in order to compete for funding. While the universities have in the main, welcomed an end to market forces thinking and embraced a system based on incentives and partnership (albeit partnerships competing for access funding), there is concern at the imposition of ‘collaboration’ in such a pro-active manner. Cooperation is alive and well in and between institutions, arising from contact between academics (Kingsbury, 2000). So too, is academic competition, since academic excellence and reputation are not achieved in isolation, but require stimulus of opposing views, values and positions. There is concern that [academic] competition, which is critical for successful collaborative partnerships to be forged, will be minimised, raising issues of academic freedom and institutional autonomy.

These issues of autonomy and freedom appear to be replaced with principles of ‘differentiation and specialisation’, in that TEAC believes that reducing duplication and encouraging specialisation amongst providers and programmes will ensure more effective allocation of government resources and promote quality in areas of focus (Marshall,
Their mechanisms for achieving this are functional classifications and profiles (which will enable an institution to be able to offer certain ‘types’ of courses and not others). Universities have expressed concern in these mechanisms as their activities are a mix of functional classifications (which will have implications for compliance/administration costs), and that some degree of duplication of disciplines between universities is desirable on the grounds of geographical and social equity and access. TEAC proposes that, based on available funding, the ‘top’ (ie postgraduate) and ‘bottom’ (ie foundation) courses receive most attention and funding priorities. This will have the effect of constraining undergraduate degree levels, and when added to the proposed higher merit-entry levels for undergraduate degrees, may further diminish enrolments in science and technology. Most ‘knowledge’ societies support both broad bases in education and selected specialist/research foci in their universities. The underpinning of the requisite generalist education for a knowledge society (ie humanities and science in undergraduate levels ensures the populace has awareness and skills to contribute to the knowledge economy) does not appear to be a focus of the reports to date. TEAC does have equity provisions for marginalised groups (on the basis of ethnicity, not socio-economic status) in tertiary education, but does not acknowledge (apart from funding mechanisms to ensure more foundation courses are available) that there is serious work to be done at both primary and secondary school levels. This is critical for all ethnic groups in science and technology, particularly for Maori and Pasifika students.

**FUNDING OF TERTIARY SCIENCE AND TECHNOLOGY EDUCATION**

In a report to TEAC investigating trends and international comparisons in university funding states:

> Over the last two decades, real Ministry of Education funding per EFTS has fallen at an increasing rate, the number of EFTS per staff member has risen and the proportion of academic staff to total university staff has fallen. … Although New Zealand’s lower level of spending per EFTS (compared with the OECD average) is in part a reflection of the level of GDP per capita, the country does spend less than would be predicted from GDP levels. Of concern is the deficit of just over US$3000 per EFTS compared with Australia (Scott & Scott, 2000 p4,5).

The result for science and technology courses in New Zealand at tertiary level is that funding has fallen to levels that are causing abandonment of these courses especially in the smaller institutions ie in the Polytechnic sector. In relative terms it is necessary to cross-subsidise from non-practical courses to science and technology courses. Similarly, at the postgraduate level, although postgraduate EFTS are funded at higher rate than undergraduate, current subsidies fall short of costs in sciences and engineering where cross subsidises to postgraduate from undergraduate programmes has become a necessity. it has been necessary for some cross-funding support of programme costs from other sources. Fiscal data for the year 2000 are shown in Table 1 (source: RSNZ, 2000b).
In addition to the grossly unfavourable ratios of funding utilised by the Ministry of Education to distribute Government grants for science and computing qualifications in New Zealand, attention must also be drawn to the similarly unfavourable ratios that apply to the teaching of engineering disciplines. In the United Kingdom the ratio of engineering funding to that of arts is between 2.4 and 3.6, depending on the speciality. The New Zealand ratio is approximately 1.9. Again this must necessarily impose gross stress on the quality provision of education and training. This stress is evidenced in the tension existing between the requirement for more multi-skilled graduates, as articulated in policy by successive governments, and the effect of the diminishing resources of most science and technology faculties available for teaching related areas. Funding pressures can mean faculty staff are unable to invest time and resources in essential curriculum and pedagogical tools, such as defining new approaches, inventing new ways of teaching and integrating new elements (for example, distance learning modules) required to educate and train qualified multi-skilled professionals for the future.

It must also be recognised that the absolute costs in New Zealand are very significantly less than the costs in the UK. The average governmental cost for degree training in Science and Engineering training in the UK is 3465 pounds (1998-99) which converts to $NZ11180. This is exclusive of central administration or academic services costs. New Zealand support is $8099/7208 (StudyRight/NonStudyRight) for science and computing and $10090/8969 for engineering (UK Arts $6152, NZ Arts $5314/4726).
Tied into the EFTS funding system is a significant proportion of research funding known as the research ‘top up’. One of the problems with funding research through this mechanism is that it is inherently dependent on student numbers and therefore is more difficult to predict and guarantee on an annual basis.

**Teac Recommendations: Solving the problems?**

It is very clear from these figures that the funding of science and technology in New Zealand is inappropriately low and it has had a negative consequences on the training of science and technology practitioners. The degree to which TEAC will remedy this situation is unclear, partly due to the fact that the 4th report relating to the funding framework, does not appear to recognise the urgency of the situation:

…that universities are bleeding now, have reluctantly accepted an interim funding arrangement for next year and simply cannot afford to have that situation continue (McWha, 2001)

While accepting that the current EFTS funding situation does have benefits, TEAC believes that an effective tertiary education system can be redeveloped through the redistribution of existing funds. This means that there will be little or no more funding available to the sector in the foreseeable future. Precisely how the Government will meet its objectives of a ‘knowledge society’, when it has been proposed that New Zealand needs six to eight universities with around 110,000 EFTS to form the ‘powerhouse for a knowledge society’ (UoC, 2001) is therefore, unclear.

The proposed model has the majority of tuition funding delivered through a single funding formula (SFF) with indices that can be used to ‘steer’ the system. The Priority Index (PI) for example allows the government to vary funding according to the perceived value of a programme or discipline in meeting national goals. The Learner Index (LI and Learner Add-on (LA) enable the government to provide increased funding for specific groups of learners, most notably Maori and Pasifika. While the mechanisms seem to be available to correct the imbalance in science and technology funding (and there is some indication in the report of this intention), the actual levels of funding are not made explicit in the report and so comparisons with current funding levels cannot be made. What is clear, however, is that these funding changes will have a negative impact on most universities due to reduced funding in business courses (see earlier comments on explosive growth and associated funding benefits) which, given current enrolment levels in science, will clearly not compensate for the diminished income.

**Teaching Research Nexus**

Possibly the most controversial aspect of funding proposed by TEAC is the separation of research and teaching and its related funding. Admittedly, this is an international trend, adopted to varying degrees by different economies. The main advantage of this separation is that a substantial part of research costs will be funded apart from student numbers which should provide predicability and security of funding for research endeavours.
This aside, TEAC’s decision is not simply to separate research and teaching funding. Rather, TEAC appears to have adopted a ‘negative or null nexus’ model of the relationship between teaching and research, resulting in the recommendation that legislative requirements regarding the teaching of undergraduate degrees be amended. From a situation requiring these degrees to be taught mainly by people engaged in research, TEAC recommends that degree staff have ‘comprehensive knowledge of their discipline and the ability to communicate this knowledge effectively’ (TEAC, 2001c). The basis of this recommendation is appears to be the so-called ‘scarcity model’ (Hattie & Marsh, 1996) which argues that teaching and research, being inherently different activities, compete for academic time. As a result neither are done well. Hence, TEAC’s arguments that the split of teaching/research funding will encourage quality outcomes in both spheres.

This separation will not support science and technology education. In fact, it suggests a serious misunderstanding of both the theoretical understanding of academic work adopted in the report (ie Boyer’s (1990) model of academic work is based in inter-related, not distinctly separate, spheres of academic ‘scholarship’) and how novices (ie graduates become enculturated into the community of science (Hodson, 1998)). Over the past decade, fundamental changes have occurred in the ways professional qualifications are offered, accredited and related to economic goals and national productivity (Butterworth and Tarling, 1994). These changes have been informed by efforts to adapt, modify and extend traditional models of professional education. It is recognised graduates need to have key professional (or occupational) competencies, a deep appreciation of the relationship of their field to the wider societal, political and historical context, as well as specialised knowledge. For the scientist, although much of that development necessarily takes place in the work environment, economic and social shifts over the past decade have firmly located the initial development of ‘practice competencies’ as the responsibility of academe. This implies that the primary concern to science educators must be the formation of a full range of capabilities that underpin effective practice. Competence emerges from personal, intellectual and professional development nurtured and urged through learning experiences set in appropriate educational frames of reference. For tertiary science education to effectively deliver ‘work-ready graduates’, these frames of reference must include interaction with scientific research and practice, and their practitioners. This argument applies equally (and moreso) to the postgraduate research programmes. TEAC uses the term ‘research training’ throughout its document – a term which fails to address the complexity of the ‘apprenticeship’ to the community of science occurring during postgraduate studies.

As it stands, the funding and potential number of postgraduate programmes, will undergo significant change if the TEAC report is adopted. In their concern for ‘quality’ at the top end of the tertiary system, TEAC proposes to restrict postgraduate programmes to academic units which meet a specified ‘quality’ threshold. ‘Quality’ will be measured using the quality measure in the Performance Based Research Fund (PBRF), and ultimately whether a programme will continue (or even begin) to be funded will depend on the ‘research intensity and quality’ being sufficient to support postgraduate teaching. Rather than research ‘top-up’ accompanying student enrolments in postgraduate
programmes, TEAC has recommended the transfer of post-graduate research top-ups into the PBRF. While this fund will be used to ‘partly subsidise’ research-based postgraduate programmes, the remainder coming from SSF. TEAC in these recommendations attempts to support, and ultimately strengthen, the role postgraduate students play in significant research programmes, particularly in science and technology in New Zealand. However, this is at the risk of damaging the underpinning base of scholarship in a wide rather than narrow variety of fields essential for the development of a ‘knowledge society’. There is a sense, also that Government or its nominated parties, must pick as ‘winners’ those who currently meet the threshold. This is, despite the fact, that within the research environment foci of excellence often have limited ‘lives’ as knowledge changes. This may well force individual institutions themselves to support science and technology researchers whose research efforts are predominantly within fundamental research categories. Fundamental research must, by the very nature of the research environment, precede technology transfer which is the research area widely supported by many of TEAC recommendations (nb applied research appears to be redefined and limited to technology transfer by TEAC). This situation must necessarily impact on TEAC’s emphasis on encouraging ‘multidisciplinary and trans-disciplinary thinking, learning and research, that looks beyond the traditional classifications and boundaries of knowledge for the intersections that can produce new areas of knowledge, services, and products, and which address national priorities’ (TEAC, 2001b, p26).

CONCLUSION

New Zealand is a small country. We need to make best use of our resources to ensure that the appropriate mix of quality tertiary education and skills training is available throughout the country. The Government wants to build a coherent tertiary education system where each institution is encouraged to play to its strengths according to an agreed nationwide plan …. The Government is clearly signalling that we want to be an active and careful steward of our public tertiary institutions. (Maharey, 2001)

Accordingly, since April 2000, TEAC has released four reports addressing how the tertiary education system might build the quality of learning, focus on the learners at the top and bottom of the system and develop the skills and environment for a distinctive knowledge society.

Based on these reports, New Zealand’s tertiary education sector is about to be redesigned (again) – this time into a single integrated system, which the Government will be able to ‘effectively steer in a strategic manner’. Given that science and technology are cited as significant contributors to the ‘knowledge society and economy’, we would hope to see support for encouraging their development within tertiary education so that the limitations currently faced no longer constrain the provision of human capital necessary to achieve a ‘knowledge’ economy and society. Indeed, there are many recommendations which suggest that this is the case: promises of a higher priority index category; increases in funding for postgraduate programmes; research initiatives for funding ‘excellence’ etc.
However, the extent to which these measures will support growth in tertiary science and technology education is unclear. Given that these reports are the basis of wide consultation across the range of tertiary education, there are (not surprisingly) internal contradictions within the reports which will have significant impact on tertiary science and technology education. Tensions exist between competition and collaboration - we collaborate with researchers to compete for funding. Between tertiary education and ‘research training’ – a lack of understanding how professional programmes such as science and technology are not simply ‘content’ driven. Between funding a broad base of research and ‘thresholds’ for research funding – there is a very real fear of a diminishing of the base of scholarship necessary for both excellence in research and a populace equipped with the skills to participate in a knowledge society.

TEAC has, by and large essentially redistributed a shrinking cake … it has failed to address the chronic and worsening under funding of university education in New Zealand. But then, it is clear that TEAC was never given any more ingredients for the ‘cake’ in the first place …

References
MINISTRY OF EDUCATION (MOE) (2000) see figures at www.minedu.govt.nz
NZVCC (2001) see figures available from the New Zealand Vice-Chancellors’ Committee as quoted in Venture Issue 2 April 2001 Published by Industry New Zealand


UPTON, S. (1996b) The Future of Science and Technology in NZ The Second R.D. Batt Memorial Lecture August, Massey University, NZ.

See also www.teac.org.nz for a comprehensive overview of reports, consultation process, responses, submissions which have informed this debate.

**Keywords:** funding; tertiary science education, TEAC, knowledge society