Science and Technology: participating in the 'knowledge' culture

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Science and statecraft live in an unresolved crisis

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Preamble

For many practising scientists and technologists 'ethics' has been an arcanum. Particularly in so-called 'pure' science there seemed to be no impingement of broader human values upon this intellectual area of interest. While most scientists from the late 1960s on did not subscribe to the exclusory concept of the 'Two Cultures' propounded by C.P. Snow[2] where science was seen as separate culture to that of the rest of society, most even in the 1980s continued *de facto* to distance themselves from other fields of intellectual endeavour and thereby (with the notable exception of numbers of prominent nuclear physicists) distanced themselves from the possible impacts of their work on society as a whole. Similarly ethics was seen as a domain of allusions deriving from recondite philosophy and described in obscure academese. Change came gradually, notably with the establishment by universities of Animal Ethics Committees, initially as a way of justifying animal usage in experimentation to the general public, and ultimately as an element legal protection for both staff and institution. The pragmatic operation of Animal Ethics Committees was a good example of 'applying' ethics to a real societal need. With increasing public awareness of the potential dangers of certain scientific and technological advancements to human life and health and notably the near hysteria in some quarters of experimentation in genetic engineering (now more normally referred to, less dramatically, as genetic modification) universities became proactive in establishing Research Ethics Committees. These committees, while enjoying the input often of academic philosophers, are largely involved with Applied Ethics. This paper is concerned with the application of principles of Applied Ethics to aspects of science and technology operations, including recruitment, training and outputs, at governmental and university level.

Introduction

Governments in New Zealand, for more than the last ten years, have openly stated the country's increasingly vital reliance upon 'technology' for its future economic health and development. The 'technology' used in the political rhetoric was a nebulous concept varying, with the spokesperson and the time, between a vague global definition covering all aspects of engineering, applied science and computing to a very circumscribed definition covering only information technology. Latterly "reliance upon 'technology'" has largely been replaced by "participation in the 'knowledge' culture" which has the political merit of sounding focused and purposeful while having no precise definition (and thereby bypassing the need to define 'technology'). This political stance has all the direction and optimism of launching into the unknown with an cheerful lack of direction. It parallels, apoetically, the lines of Walt Whitman:

> *Joyous we too launch out on trackless seas,*
> *Fearless for unknown shores on waves of ecstasy to sail,*
> *…………………*
> *Chanting our chant of pleasant exploration.*
> *(The Explorers)*

The creative use of imprecision is standard internationally in political statements but this does not justify it, especially in an area where the future comfort of the citizens is dependent upon the development of technological strength across the nation. Indeed, if this imprecision on the part of politicians is a deliberate ploy aimed at promoting procrastination in the decision making process, whilst they are concurrently acknowledging (as is shown below) the vital importance of science and technology to the future of the country, then this could be seen as unethical behaviour. The politicians, however, are not alone in influencing and taking the responsibility for the present and future science and technology needs of New Zealand. The roles of the Universities, as educational leaders and of the practitioners themselves should also be considered.

Government and the Need for Science and Technology

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"*[3].

This reflects a growing appreciation by industrially advanced countries of the importance of the contribution of science and technology to society generally (see Box 2 p37, ref 4, for example). Indeed the President of the United States has made his conviction clear that "science and technology can promote economic growth and international competitivness"[4]. 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."[5] 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". 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.[11] Amongst New Zealand's international economic competitors there is an appreciation of the vital need for science and technology skills for the immediate future. For example, the Policy Recommendations for the Tri-State Region of New York, Connecticut and New Jersey[6] states the "path to the 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". This view is supported by 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."[7] Australia has identified the "urgency in the battle to attract the most able people to science and technology" (p28, Ref 8).The Review of Engineering Education also indicated the need for greater industry involvement in engineering education (p20, Ref 8). 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[9] . 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[11], 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 that are necessary for the training of scientists. These New Zealand needs face predicted international competition since the USA acknowledges that it is massively undersupplying 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…………

It can be concluded that the New Zealand politicians are well aware of the global crisis in science and technology and of its vital importance to the future well-being of the country.

Training Outputs in Science and Technology

In view of this crisis, 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. (Figures available from the New Zealand Vice-Chancellors' Committee as quoted in Venture Issue 2 April 2001 Published by Industry New Zealand.) Other figures from the extensive web site of the Ministry of Education (www.minedu.govt.nz) 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%

Since the explosive growth of commerce and business course in the tertiary sector in the 1980s and 1990s the relative outputs of science and technology to business graduates has declined spectacularly. 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.

Funding of Science and Technology

Funding of science and technology courses in New Zealand at tertiary level has fallen to levels which are causing abandonment of these courses especially in the smaller institutions i.e. in the Polytechnic sector. In relative terms it is necessary to cross-subsidise from non-practical courses to science and technology courses. Fiscal data for the year 2000 are shown in Table 1. (This data was taken from the Royal Society of New Zealand's Submission to Parliament's Education and Science Committee's Inquiry into Student Fees, Loans, Allowances, and the overall Resourcing of Tertiary Education 2000)

Table 1
Year 2000 funding for Tertiary Institutions in New Zealand

	Non Deg	UGrad	PGrad	ResPGrad
		NZ Dollars		
Arts/Business SR	5314	5484	7014	12614
Arts/Business NSR	4726	4896	6426	12026
Science/Engineering (Non Deg)				
Computing SR	8099	8469	11799	22999
Science/Engineering (Non Deg)	7208	7578	10908	22108
Computing NSR				
Engineering (Degree) SR	10090	10560	14490	28190
Engineering (Degree) NSR	8969	9439	13369	27069
		Ratios		
Sc/Eng/Comp:Arts/Bus SR	1.52	1.54	1.68	1.82
Sc/Eng/Comp:Arts/Bus NSR	1.53	1.55	1.70	1.84
Eng(Deg):Arts/Bus SR	1.89	1.93	2.07	2.23
Eng(Deg):Arts/Bus NSR	1.90	1.93	2.08	2.25

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 which 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[10]. 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).

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. This underfunding has been identified to this, and the previous, Government but no steps to rectify this situation have been taken.

Analysis of Government's Performance in Science and Technology

Against this background of well recognised shortages which are clearly projected into the future it seems quite clear that New Zealand politicians, from an Applied Ethics viewpoint, are behaving improperly and fiddling while science and technology Education in the country burns. It is possible to analyse this situation using the semantics of Applied Ethical Dimensions as employed in the Issacs and Massey model[12]. Analysis of the situation can be broken down into four steps: Hermeneutical, Appreciative, Appraisive and Transformative.

Hermeneutical	It is abundantly clear that the politicians have a clear insight and interpretation of the reality and scale of the problem
Appreciative	The dimensions of the problem are equally clear to the politicians – undersupply of graduates; inadequate promotion of science and technology; inadequate funding of science and technology Education. Where they fail is in the taking of Moral Responsibility. The New Zealand politicians do "Talk the talk" but they demonstrably fail to "Walk the walk".

Appraisive	The politicians, at least by their words, appear to be aware of the consequences of their inaction in the area of science and technology. They have, fairly clearly, identified the issues and problems but they have not, at least openly, taken moral responsibility for their lack of action.
Transformative	It is in this prophetic and pastoral action dimension that the New Zealand politicians have proved to be woefully inadequate. The required action is clear. Strategies of significance have not been identified. Action to further the appraisive needs (ideals) has not been initiated except in minor ways since an overall appropriate strategy has either not been formulated or has not been acted on. (The former seems the more likely.)

This analysis questions whether politicians do have, or should have, normativity. Should politicians conform to standards or, frighteningly, should they alter and reset standards? If the latter is the case how do they apply the dimension of Moral Responsibility to their actions or lack of actions? As clearly identified at a recent conference[12], Moral Responsibility is influenced by Gradients of Bias and it is the usage of bias (which is a natural part of the human condition) which may be unusually problematic for politicians. In New Zealand, like Australia, the United Kingdom etc, we live under a political structure which is termed 'democracy' and which The New Shorter Oxford English Dictionary defines as "a form of society which favours equal rights, the ignoring of hereditary class distinctions, and tolerance of minority views". To attempt to meet this requirement of 'democracy' politicians have to utilise bias in their stances and actions. For example, the poorest economic levels of society, in many countries including New Zealand, are usually the least clearly articulate in their expressions of their needs and desires. When formulating social policy a politician who biases his/her listening unequally to the voices of the poor would be seen by many to be applying a 'proper bias" by, as Theodore Adorno wrote, letting "suffering speak is a condition of truth". However in other areas of political control 'proper bias' is much more difficult to assess, judge or, for the politician, to fit into an ethical framework. The effects of social policy are, in general, perceived and understood by the public who by their comments and ultimately by their votes judge the results of actions taken and thereby provide feedback to politicians on their perceptions as to the propriety of the bias which led to action. Unlike larger societies New Zealand has failed over the years to support or even initiate programmes to aid its society to understand the importance of science and technology to its culture and economy. The United States initiated in 1973 a programme of their "best and brightest" scientists and engineers working in Congress for a year through the Congressional Science and Engineering Fellowship Program. As Jeffrey Stine, in his history of this programme published in 1994[13], observes –

> *The science and engineering fellowship program helped expand the disciplinary diversity of legislative staffs not only through the Fellows' temporary presence but also through the Fellows who remained with Congress, and by raising the awareness among congressional members that scientists and engineers can assist their work in meaningful ways.*

In this period approximately 500 Fellows participated in the programme. America also has The American Association for the Advancement of Science and Britain has the British Association for the Advancement of Science. New Zealand has to rely upon contracts for the Promotion of Science let by the Ministry of Research, science and technology usually to the

Royal Society of New Zealand or on direct Ministry initiatives. The scale of these initiatives have been relatively small and consequently the public in New Zealand[14] are poorly aware of both the nature of science and technology and on their vital importance to the economic well-being of the country. This ignorance breeds an apathy and with apathy the politicians get little feedback or comment on their bias in the area of science and technology. There is no approval or disapproval of bias in this area. There is, therefore, no guide to what Moral Responsibility is in science and technology policy.

As a current example of what can be defined as 'improper bias' the recent Budget (May 2001) provides a blatant example. The Government made various pre-election pledges to stem the spiralling costs of the fees students pay to enrol at universities. This resulted in a policy decision to 'freeze' existing university fees in 2000 at their 1999 levels. Government at that time gave some inflationary compensation to the universities. In the recent Budget the universities have been 'encouraged' to accept an inflation adjustment of 2.6%, which is below the inflation of real cost to the institutions. The 'encouragement' by government is to state that universities that do not agree to this arrangement will not receive the current 2.6% but will also lose the 2000 adjustment (together over 5%) and additionally non-complying universities will be excluded from a new contestable research pool worth around $40 million. This is effective blackmail and is a clear abrenunciation of Moral Responsibility on the part of the Government. This clearly places New Zealand well outside of the Magna Charta of the European Universities approved in Bologna in 1988 that universities' "teaching and research must be morally and intellectually independent of the political authority and economic power"[13].

In another, more honest, attempt to encourage the development of more beneficial (to the country) directions of science and technology endeavours the New Zealand Government appears to be favouring a policy of focusing public good research funding on small numbers of large, historically active, research groups. If this is indeed true this could be an example of uninformed bias, which might not be the best option for a small country. Susan Raymond of the New York Academy of Sciences notes that it "is important to recognise from the outset that policies targeted at providing a science and technology base to economic development rest within a larger context of social values and national economies"[15]. How such a policy of 'think big' research would fit into the bicultural/multicultural nature of New Zealand is unclear as are the potential benefits to a manufacturing sector which is overwhelmingly dominated by enterprises with less than 15 employees. In the latter context, it should be noted that, even in the considerably larger society of Europe a report of the Commission of European Communities[14] emphasizes the need for greater concern with the needs of the economy in the light of industrial change and one of its seven areas for action was "Giving special consideration to the education and training requirements of small and medium enterprises".

Susan Raymond[16] further comments that

> *policy for science-based development is difficult to delimit in time or in space. Educational policy that reaches all levels and maintains flexibility far into the future is often as critical a component of the S&T-economic development link as explicit institutional innovations focused on S&T or economic strategies themselves. Moreover, while the share of science, engineering, and technical education in overall national educational efforts is a critical factor in linking science and technology to development, educational exposure to S&T is important not only for future scientists, but also for the citizenry at large, as*

well as for managers, lawyers, and the like. Knowledge about and appreciation of S&T broadly in society and especially among non-science leaders paves a smoother public path for supportive policy-making."

In conclusion, the New Zealand Government has the facts, acknowledges the needs, but has failed by its inaction to address the needs for increased science and technology training in New Zealand and, thereby, is hazarding the future well-being of the general citizenry of the country. This inaction is unethical.

Other Contributing Factors

i. The Role of the Universities

However, as with any serious problem, there are many contributing parameters. While New Zealand Governments must accept a primary role in the degradation of science and technology education neither the universities themselves nor their scientists and technologists, since the Second World War, have by and large not looked critically at their direction for science and technology. Notably, and this has frustrated politicians who saw the need to balance intellectual endeavour in the universities with more practical contributions from science and technology to the practical and economic well-being of the public, the universities have been (with, to some extent, the exception of their involvement in engineering) negative about, or at best slow to implement, 'applied' courses which might lead to direct beneficial applications. Universities in the 1950s had a confused philosophy. 'Pure' subjects (for example, philosophy and history) were, often covertly, seen as somehow superior to applied or vocational subjects (for example, engineering and applied science). "Science" and "research" were traditionally defined as organically and philosophically separate from "technology" and "development"[16]. Incontrovertibly, even in subjects like chemistry, with a large practical content and a vast industrial usage and potential, 'pure' research was overwhelmingly favoured over applied or practical-oriented research. The artificial separation of research and teaching into the two categories of 'pure' or 'applied' (or vocational) (with the former seen as the far more desirable 'intellectual' activity) continued in many universities especially where governments (for example in the United Kingdom, New Zealand and Australia) directly funded institutions but allowed them a large amount of both intellectual and fiscal autonomy. This situation continued until the fiscal 'Gotterdammerung' of the 1990's. The falsely halcyon state of the 'Newmanesque' universities (New Zealand and Australian Universities derived largely from the elitist, class-focused model put forward by John Henry Cardinal Newman) has been challenged the decreased direct funding from governments and a simultaneous demand for efficiency, effectiveness and involvement in meeting perceived societal goals. Also the student populations, being forced to pay increasing fees for their education, reasonably demand quality and relevance (to their future employment prospects) of programmes. Change is not a choice for many Universities it has become an essential for survival.

Now that fiscal realities have been forced upon the bulk of Universities it is recognised, even in countries with a long record of socialised or subsidised education, such as the United Kingdom and New Zealand, that education is expensive and confers benefits on those who qualify. Those receiving those benefits are now being expected to meet more or all of the costs involved. (This situation, of course, already pertains in most Universities in the United States.) The time is now gone when a government might be so committed to the development of its social capital that it could state that it's "objective…is that every person, whatever his level of academic activity, whether he be rich or poor,…has the right…to a free education…to the fullest extent of his powers" [17]. It is widely stated that the "University is business, and big business"[18]. Further "…the roadside of University administration is littered with the debris of institutions and of educators who have come to grief because…they have ignored...fiscal realities or have supposed that whatever it is in a University that can be called 'business' was beneath their intellectual station or would somehow take care of itself"[18]. Universities, down to the level of the individual member of staff, now must consider the educational directions plus their fiscal viability. Not withstanding the significance of a number of reviews and redirection of science and technology education in recent years, there seems a propensity for science and technology faculty staff to claim this new fiscal reality as good reason to be resistant to change. But just as change is a given for the university, so to at the level of the individual, there must be a willingness to determine participate in both individual and collective strategies cognisant of these currents of change.

ii. Scientists and social, cultural and environmental issues

Additionally for the scientists themselves Bruce Smith[19] has pointed out that

> *for scientists to wrap themselves in the mystique of their craft, to resist immersing themselves in the muddy issues of policy, or to block public involvement would fly in the face of the logic of their situation. Perhaps more than ever they need public support for the enterprise of science and public understanding of what it can or cannot contribute to national objectives.*

The universities and their staff must rapidly change their attitudes to science and technology. Both universities and their staff are part of general society. They cannot stand aside from society, they must contribute to it. To contribute meaningfully they must take, to a reasonable extent, the needs of their society into account. At this time of stress in science and technology more focus on societal needs in these areas is required. Scientists and technologists must recognise their ethical responsibility to provide balanced and open-minded explanations of the ethical, social, cultural, legal and environmental implications and consequences of science and technology. However, many science and technology educational institutions have serious difficulties in understanding and taking into account the real needs of modern societies. Jean Michel, advisor to the Director of the Ecole Nationale des Ponts et Chaussees for the management of education and information[20], argues that the main reason for this failure lies in the fact that science and technology faculties cannot break their traditions (formalism, corporatism …). He continues:

> *The rarely criticised taught curricula, the power games behind discipline territories, the perennial transfer of knowledge, are some of the most important factors that prevent profound changes of education and training perspectives.*

Practitioners (whether in industry or universities) clearly have a moral responsibility to understand and work within a framework which embraces the social, cultural and environmental consequences and influences in their work. This shift over the last decade in the way the communities of scientists and technologists perceive themselves and their work, and are themselves perceived by the wider society has resulted in modification of codes of practice to incorporate ethics and sustainability[21]. These Codes of Ethics declare strategically the intention of the profession, that members of the profession, will act responsibly and for the benefit of society. In general terms, they are built on three key aspects: respect for people (for example: protection of life and safeguarding people, community well-being); respect for nature (care for the environment; sustaining scientific/engineering knowledge); the ethic of holism (professionalism, integrity and competence, sustaining scientific/engineering knowledge). These moral codes are not static, rather reflect the changing needs of society and require practitioners to make both value and moral judgements. Buckeridge maintains that "our current educational environment has not effectively met its greatest challenge: that of designing an undergraduate science and technology curriculum that produces graduates capable of reversing the inexorable degradation of the biosphere."[21] Educators, as members of professional bodies, endorse and subscribe to these codes, but are by and large inactive in translating their responsibilities under these codes into their professional lives as educators.

iii. Equity and access issues

In a similar manner, science and technology practitioners and educators cannot afford to continue to sideline (or ignore) the voices from the margins of their craft – women, Maori, Pasifika[22] etc – who argue that science and technology are inherently political serving white ethno-centred socio-economic agendas. The situation is intensified by the lack of successful outcomes of many students from marginalised groups (particularly at secondary school levels) in achieving essential understanding and thinking 'of, for and about' science . Without these 'ways of scientific thinking and understanding' (not necessarily replacing other 'personal' ways of knowing) these students are restricted in their ability to cross into the communities of SET and participate effectively and fully[23]. Clearly scientists must engage with society in demystifying their community of practice, its tools and conventions. They need to reveal how, for instance, intuition, imagination, reflection, reframing of problems are all part of the processes of science and at variance with the wider public perception of both science and 'doing' science.

Conclusion

New Zealand is facing a real crisis in science and technology. Tertiary training numbers are poor, funding of science and technology is inadequate, there are curriculum and pedagogic needs, scientists and technologists need to understand more fully the socio-cultural, ethical and environmental aspects of their work, and there are distinct equity and excellence (quality) issues. The current situation will severely constrain the provision of human capital necessary to achieve a 'knowledge' economy and society. Despite apparently full knowledge of this situation, at least from the evidence of their pronouncements, politicians have been inactive in this area which, from the point of view of Applied Ethics, can be shown to be unethical.

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