

A Statement on Higher Education Policy in Australia

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Summary

Policy on higher education in Australia has become highly political since the massive expansion which occurred under the prime ministership of Bob Hawke in the 1980's. We believe that many of the changes which have been imposed upon the higher education sector during the Dawkins period and thereafter have been driven by ideological concerns rather than any careful considerations of the role of education in society and the best forms of support and delivery of education.

Here we present a variety of considerations and facts relevant to assessing the role of higher education in Australian society, the form of delivery of education, the management of that delivery and the extent to which education should be supported by public finances. The main points we make are:

- It has become widely acknowledged outside Australia that public educational spending is a crucial determiner of future economic well-being. We directly support this view with an analysis of OECD data.
- Australia has fallen well behind OECD average in its support for education. It is falling further behind every year.
- Research is integral to the educational mission of Australian universities and requires governmental support.
- “Rationalizing” Australian economics has led to significant erosion in support for industrial innovation in Australia. Given the wide-spread failure of Australian business to support innovative product development, it is irrational to expect Australian business in present circumstances to fulfill any role of supporting basic research in universities abandoned by government.
- Australian business will not profit from university education being diverted from its traditional role in providing an education in fundamentals toward a more vocational education; vocational education is far less suited to the growing requirements of adaptability in an economy that is both more technological and more internationally integrated.
- The attack on tenure in universities, if successful, would make work conditions *inferior* to those in the business world, much to the detriment of academics in the first instance and the wider community shortly thereafter.

- The Internet is not a solution, it is a tool.
- Almost all predictions about the ways in which new information technologies will change educational practice are false.
- Educational policy leadership in Australia is either absent or ill-informed.

1 Education pays for itself

Under the ministry of Simon Crean every reduction in financial support for higher education was publicly hailed as an “efficiency gain.” The not-very-hidden assumption behind these proclamations was the notion that the product of education would in all cases remain constant. Many of us in tertiary education have been wondering when those politicians who believe in such fictions will figure out that under their assumptions an infinite efficiency gain is ready to hand. The proposal to fund all future pay raises by “efficiency” offsets does come fairly close to this insight: as inflation forces pay rises ever higher, the self-funding requirement will force the total real support for higher education from society into a continuing decline. It is apparent that many politicians believe in free lunches and other nice stories.

Amongst those opposed to cheap and easy “efficiency gains” are those who believe that education has a “higher purpose” which society has some obligation to support above and beyond whatever return education may deliver to society as a whole. We do not agree. First, although we agree that learning is beneficial to the individual both materially and otherwise, we do not believe that society should support such purely private benefits, no matter how large those benefits or what their nature may be. As they accrue (by definition) entirely to the individual, the individual ought to be willing to pay for them in full. Second, many in the community at large do not recognize or believe in non-material benefits. Appeals to them, therefore, are more likely to be detrimental to the cause of supporting education than to be beneficial to that cause. Third, finally and most importantly, appeals to private benefits are entirely unnecessary: the public benefits of education are enormous, pervasive and well-documented.

Every history of civilization begins with the observation that it was only with the arrival of “leisure time” that civilization could make a start. In Mesopotamia, Egypt, India, Peru and China the precursor to civilized life was respite from the busy life of hunting and gathering afforded by the invention of agriculture. We suggest that the true precursor of civilization was the invention of organized education. In each of those societies, and in every other civilization, the so-called leisure time was expended either in leisure, which did not contribute to the building of the civilization, or in learning and its application, which did. The priests, scribes, administrators in those societies learned how to record and use statistics, laws, beliefs about society and nature so as to develop commerce, industry and nation. Throughout the entirety of human history education has been the driving force of civilization and industry. Those who put themselves in opposition to education, whether out of ideological pique or in the belief that the money is better applied directly to society’s problems, put themselves in opposition to industry, wealth and well-being — to civilization itself.

The correlation between educational spending and economic well-being is as clear as any correlation in economics and is as well documented. Indeed, there is a large recent literature supporting high correlations between educational investment and economic growth, and the fact that they are higher than those for other forms of public investment and economic growth (Cullison, 1993). Beyond that, we can find a direct causal relationship between educational spending and economic growth. We have constructed Figure 1 (see also Table 1 at the end) from OECD data (OECD, 1981; OECD, 1995a; 1977 population data are from Wallechinsky and Wallace, 1978). This demonstrates high correlations between total public expenditure on

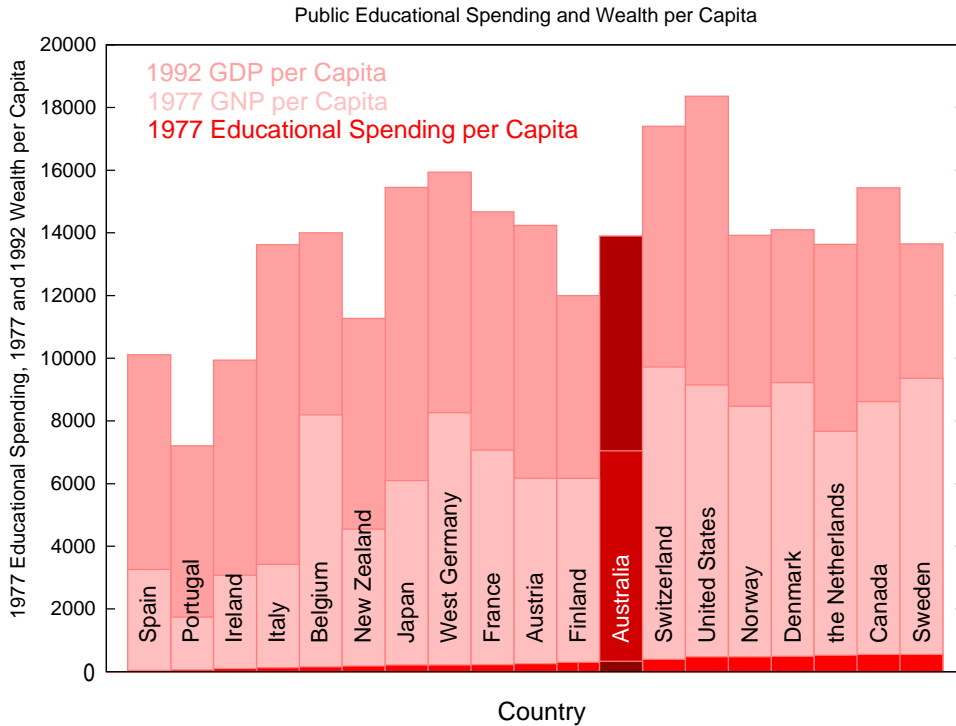


Figure 1: Public Educational Spending and Wealth

Countries are ranked by educational spending. The scale is common to each of the three values (i.e., histograms are overlaid, rather than additive).

education at all levels during 1977 and per capita gross national product in 1977 ($r_{12} = 0.8212$) and, when we might expect to see the impact of such spending, fifteen years later in 1992 per capita gross domestic product ($r_{13} = 0.5816$). The correlation between expenditure and per capita wealth declines over time. This will suggest to some that the whole of this relationship consists in two facts: first, that educational spending, not being an immediate necessity, benefits from current wealth in society, which suffices to establish the strong correlation r_{12} ; and second that current wealth causes subsequent wealth, hence inducing a residual, but degrading, correlation between educational spending and future wealth r_{13} . In other words, instead of educational spending causing wealth, there are two relevant facts, namely that wealth causes educational spending and current wealth causes future wealth. We believe that these latter two facts are both correct and relevant. If they were the whole of the story, education could be dispensed with — assuming that our entire public concern were to generate future wealth. However, that is by no means the *whole* of the story. The most plausible story is that current wealth causes current educational spending and future wealth, while *additionally* current educational spending causes future wealth. This is a testable hypothesis, and, indeed, can already be tested with the data in Table 1. If this hypothesis is false — if the simpler story that educational spending is related to future wealth *only through* current wealth is true, then, if we hold current wealth constant, we should find no remaining correlation between educational spending and future wealth. Assuming that the relationships involved can be approximated by linear relationships, this can be tested by examining the partial correlation between current spending and future wealth with current wealth partialled out, namely $r_{13.2}$. If this value is zero, then educational spending is useless for creating wealth. In fact, however, we find $r_{13.2} = 0.7279$, which is statistically significantly different from zero at the very strong level $p < 0.001$ — a level rarely attained in social science statistics.

The causal model with constant dollars implied by these numbers can be seen in Figure

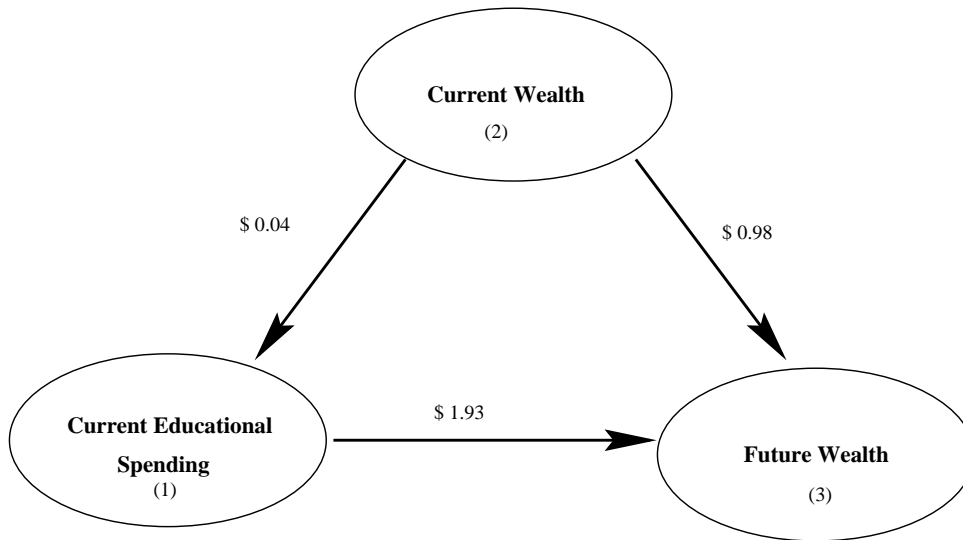


Figure 2: A Causal Model

The dollar amounts indicate the direct impact of adding \$1 to the causal variable in 1992 upon the effect variable (in 1992 US dollars).

2 (the parameters are derived in the Appendix). Let us assume for discussion that the same model approximates also the situation from 1992 to 2007 (again, fifteen years later). In that case, if Australia had invested an additional \$US 100 million per annum above the actual 1992 educational expenditure of \$US 13,946 million (and, presumably, sustained such additional expenditure), then the model implies that Australia’s gross domestic product by 2007 would be increased by \$US 193 million per annum in constant dollars as a direct result (assuming a continuation of current trends in growth rates: an OECD GDP growth rate of 1.8% per annum, proportional changes in OECD GDP standard deviation, and a 1.5% growth rate for the Australian population). But the beneficial impact of a marginal increase in educational spending is actually much greater than the two-for-one return on investment implied directly by the model. Because in fact current wealth feeds future wealth, and indeed is clearly the most important factor for future wealth, the gains in future wealth due to educational spending not only endure but are self-reinforcing: given the strength of the association between current and future wealth, the benefits of educational spending compound at a very high rate beyond the initial fifteen-year period addressed by the model.

Granting the relationship between support for education and economic health, the question arises as to what extent education should be supported. It is clear that there must be an optimal level of support for any society, in analogy to Arthur Laffer’s infamous “supply-side” tax curve: at zero support, there will be no benefit; were education to consume *all* of a society’s resources, there again would be no benefit, because industry would cease. Given that there is an optimum, we need to find it, or at least to make informed guesses about where it lies. We do not have space for a careful analysis here, however we do point out two important considerations. First, a positive correlation such as that established above would be impossible to find if any large number of the nineteen OECD countries sampled were spending more than the optimal amount on education. Hence, the mean OECD spending on education per capita *cannot* have been beyond the optimal. Second, from 1977, when Australia’s educational spending was 0.19 standard deviations *above* OECD average (Table 1), to 1992, Australia’s educational spending per capita has fallen to 0.7 standard deviations *below* OECD average

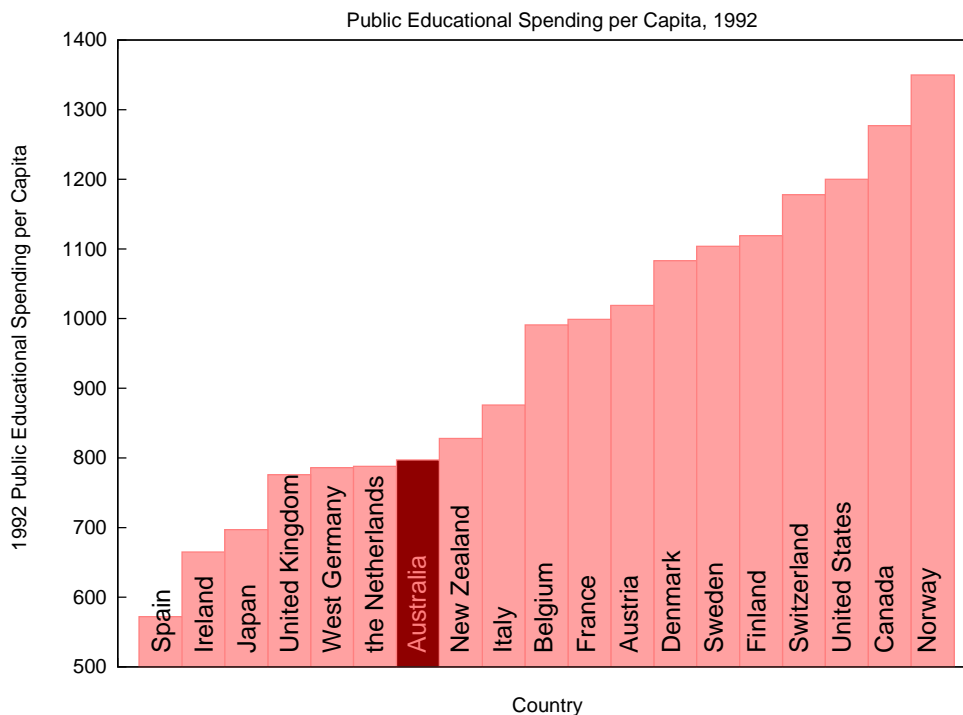


Figure 3: 1992 Public Educational Spending

(see Figure 3 and Table 2).¹ Since then Australia’s spending on education has been further savaged by both federal and state governments.

We believe that, despite some steps to “rationalize” the economies of the UK and the US, Australia’s dramatic relative decline in educational support is at odds both with the growing scientific consensus about the economic importance of educational spending and with the actions of the considerable majority of industrialized countries. If not redressed in the near future, Australia’s failure in public support for education will be setting the stage for mediocre or poor economic performance in the medium and longer terms.

2 Research versus teaching

Higher education is distinctive in combining research and teaching. TAFEs and, in the United States, junior colleges concentrate exclusively on teaching, whereas some government institutions, such as DSTO and CSIRO, concentrate exclusively on research. In the universities, however, academics are generally expected to perform at a high level in both activities.

There has been growing pressure to segregate the two activities. With the massive amalgamations of the 1980s many teachers have found themselves translated from teaching institutions to teaching and research institutions, without any commensurate translation of their training or abilities to perform good research. Some of these people could, and have, acquired training appropriate to research. Most have not. (This despite, in some cases, astonishing rates of growth in publications from former CAE organizations; given the rewards of the research quantum, it is inevitable that such measures will lose value over time. Already Barzun (1945) remarked that “publish or perish” policies had produced a surfeit of intellectual rubbish.) It is understandable and justifiable to consider that their educational contributions have not diminished and, so, they should not be penalized for not contributing to research

¹This drop is only slightly exaggerated by the replacement of Portugal by the UK in Table 2.

productivity. At the same time, however, we should not lose sight of the fact that the universities' combination of research with teaching has compelling advantages over pure teaching or pure research institutions.

It is commonly averred, but uncommonly explained, that research informs teaching. Of course, all teaching ultimately depends upon research, but that simple observation supports no claimed advantage of university education over teaching schools: teachers, obviously, read the products of research and subsequently can teach their contents. What teachers not active in original research are less prepared to do, however, is to teach students how to engage in research. They can, certainly, teach out of methodology texts or texts on critical reasoning. But there is a vast distance between, on the one hand, repeating methodological rules of thumb, describing statistical inference procedures or admonishing students to avoid the fallacy of *post hoc, ergo propter hoc* and, on the other, informing students from personal experience what works and what fails in research and why. The *best* way to learn about research is to learn from a good researcher who is also a good teacher. Why should we want our average students to receive such benefits? The answer is that all of them will engage in research in their subsequent employment to greater or lesser extents, whether in industry, government or education. Report writing and decision making in any of these settings which is uninformed by high quality research is the cause of no end of damage to society. All of them will benefit from exposure to the first-hand experiences of society's best researchers, many of whom are employed by universities and spend great energy attempting to explain what goes into good research. Informed judgment and decision making are the heart and soul of a healthy economy, and the better prepared our citizens can be for such activities the better the society we will live in.

There are many other benefits arising from an intimate understanding of current research in one's teaching, including improved understanding of the merits and limitations of what textbooks report about research. What is less widely acknowledged is that teaching aids research in its turn. Perhaps the most obvious aid is simply the supply of new ideas and energy that arises from teaching bright students who directly contribute to the teacher's research. But also the effort expended in making one's own research, and that of one's peers, intelligible to students of various abilities and backgrounds forces the researcher to synthesize and integrate what she or he knows about a research area, inevitably to the benefit of the researcher's own understanding. The best and quickest way to learn a subject area in depth — or to reconceptualize it — is to teach it.

In short, we believe that there is an important place in society for the traditional role of the universities in combining research and teaching. Research activities must be defended, but not by isolating them from other educational objectives and activities.

3 The Business of Academia — an Industry Perspective

The traditional model of academia's interaction with industry is that of the university as the provider and industry the consumer. Graduates are imparted an understanding of fundamentals during their time at university, and then industry provides them with practical experience; the combination equipping him or her with the ability to solve independently complex real world problems. A graduate with a blend of hands-on skills and fundamentals is then expected to progress up a career ladder, performing tasks of increasing complexity as his or her experience grows, eventually to lead other professionals. This model is traditional in the Western industrial economy and has served us well during the massive postwar economic expansion.

During the period of the Hawke government, and the Keating treasury, Australia experienced some significant changes in policy and circumstance which have conspired to damage

the long-term potential of our economic base.

The foremost of these changes were insufficiently prepared tariff reductions, higher interest rates, higher taxation. Combined with a failure to reform government purchasing practices, which often favour foreign manufacturers, and an investment culture with a deep-seated mistrust of high technology, this created an environment which is clearly hostile to the manufacturer of high technology products, such as computers, software, test and communications equipment. Let there be no doubt, during the eighties and early nineties Australia experienced a record number of high technology equipment manufacturer collapses. The folding of Acet, Webster Computer, Labtam, Solbourne, L&L Computer, Terran Computer, Stanilite, amongst others, together with the severe curtailment of original product development efforts in a host of other companies is testimony to a government's poor understanding of the needs of its potentially most important sector of industry.

One of the authors, Carlo Kopp, during this period was tasked with designing and managing the domestic production of computer equipment. His experience was that after the implementation of Keating's Fringe Benefits Tax the wider effects of a contraction in domestic automotive manufacturing greatly complicated life in the computer industry. As the demand for locally built automobiles plummeted, a large proportion of the small to medium size component manufacturers died off. As a result, the economies of scale which previously existed in the manufacture of mechanical components and electrical assemblies, such as cable harnesses, were lost. The computer industry, a low volume consumer of such parts, was no longer able to source them domestically at competitive prices. In turn, this forced a greater reliance upon imported components and has reduced the competitiveness of domestically built computers. This is a good example of how an ill-considered policy can produce results which propagate into areas which the author of the doctrine did not anticipate and, probably, was not even equipped to comprehend.

In addition to those problems, a series of extensive changes to the tertiary education system, seeing the amalgamation of a large number of educational establishments with the existing university system, and a shift to a funding structure rewarding quantity over quality have caused technology-oriented industry further difficulties. Colleges of advanced education and TAFE establishments, geared to produce Certificate and Diploma level para-professionals with little fundamental training but a strong base of vocational skills were indiscriminately coalesced with Universities, geared to produce Degree level professionals with strong fundamentals and minimal vocational training. Unfortunately these changes to the tertiary system coincided with a significant increase in quantity, and an average decline in quality, of tertiary entrants.

The governmental changes outlined above combined with a world-wide recession to put great pressure on industry. Industry responded by restructuring. Salary freezes for professionals became common, likewise forced redundancies, with downsizing being the perceived solution to the cash flow crisis. Planning shifted from long- and medium-term objectives to short-term survival objectives. Staffing policies became increasingly oriented toward buying the experience and skills which produce an immediate return. The prospect of having to train newly hired staff became increasingly unattractive, more so given the glut of experienced professionals who were retrenched or disaffected. Hiring on short- to medium-term contracts, which allowed the rapid shedding of staff to accommodate market fluctuations, became a preferred strategy to the hiring of permanent salaried staff. In a shrinking market environment, this was a viable short-term survival strategy.

Graduates without experience were severely disadvantaged in such an environment, as they had little to offer in the short term and would become a drain upon resources, requiring training. Because of the decline in the quality of graduates, their ability to climb the steep learning curves often encountered in industry fell, thereby increasing the training demands upon a potential employer. The early nineties were not an easy time for new graduates.

One of the authors' experiences during this period were typical. In 1993, Carlo Kopp needed to hire a graduate for a computer manufacturer's design office. Thirty six applicants for a junior design engineer's position were interviewed, and short-listed applicants given a two-hour test, intended to determine their grasp of fundamentals and thus suitability for the position. Only one graduate achieved an acceptable score, and was subsequently hired. The remaining thirty five applicants displayed a poor knowledge of fundamentals, despite many having second class honours degrees in engineering or computer science. Most showed little practical problem-solving ability, a key metric of performance in the computer industry. The practical problems used to gauge ability were specifically chosen to be trivial, but requiring a good grasp of fundamentals and a systematic problem-solving approach. An interesting finding of this exercise was that the successful applicant had just completed a first class honours dual major in computer science and engineering, a five year degree. The poorest performance amongst the applicants was found in three-year duration single majors, from establishments with a vocational orientation. Some of these applicants scored as little as 10% in the theoretical fundamentals test. Those with scores above 40% were given the practical test (comprising the isolation of a sabotaged power lead to a computer, amongst other tasks). Most failed dismally.

The author was alarmed with these findings and discussed them with a number of his peers in the industry. The response was identical in all instances, with the advice being "don't hire graduates, they take too long to train" or "these days graduates are too dumb to train." In the author's view, this represents a systemic failure of the educational system to fulfill the needs of Australia's high technology industries.

The danger of "lightweight" university degrees with little training in fundamentals and a strong emphasis on immediately marketable vocational skills is that the product of such degrees will later become non-performers in a highly competitive, aggressive and changing economy. Vocational training skills are highly perishable, because of the rapid rate of technological evolution. The ability to learn quickly under pressure is critical, and a good grasp of fundamentals is the best insurance a graduate can have against obsolescence. Should a graduate with a poor knowledge of fundamentals survive in the workplace, and eventually be promoted onward to management, he or she will be penalized in the long term by a reduced capacity to understand the relevant technology base. Strategic decision making skills, critical to the performance of a manager or leader in industry, require a solid grasp of the technology base!

This is not a unique perspective by any means. Jerry Ellis, BHP Chairman, says much the same (Ellis, 1996): "The best graduates are those who have received a very good training in the fundamentals . . . , the theoretical side, the philosophical side of the subject matter; the understanding that will last a long time irrespective of changes in technology or changes in the marketplace. . . . They will learn their technologies at work." BHP is one of Australia's outstanding companies, and it is no accident as BHP is very selective about the quality of the graduates it hires.

The long-term risk which Australia's industry will face in coming years is a diminished pool of professionals with good fundamental skills and problem-solving ability. Making do with what is available, industry will suffer from the timid decision making which is typical of managers who do not understand the technology they are working with. Given that this disease has a long incubation period, as new graduates work their way up the management ladder to positions where they can do serious damage, we will not see the symptoms of this for a decade or two — but by the time they manifest themselves, it may be too late to take corrective measures.

The relationship between corporate success and strategic decision making skills is well documented (see, for example, the writings of Hamel and Prahalad, 1989, 1990, 1991, 1993, 1994). Since strategic decision making skills are directly dependent upon fundamental problem-

solving ability, there is a clear causal relationship between the success of an organization and the quality of fundamental skills possessed by its personnel, particularly at the management level. This relationship has been long recognized by the military, who literally live or die by its application or misapplication, respectively. Napoleon Bonaparte's well known quote "There are no bad soldiers, only bad officers" still rings true two centuries later. The fundamental reality is that poorly educated graduates evolve into incompetent leaders, who can and will cause tremendous damage to the organizations who employ them.

Academia acceding to short-term market demands for vocational degrees which provide immediate return on investment will not serve the interests of either industry or graduates, in the medium to long term. Unfortunately, current moves to "user pays" funding, especially where fees are set according to short-term returns to the student rather than in light of the long-term returns to society, reinforces the emphasis on utility in the near future. It is not reasonable to expect universities to self-destruct financially in order to uphold standards, and therefore a fundamental change of approach to funding is called for.

Industry is about the technological base which is the foundation of a modern technological society. Knowledge is the critical asset which enables such an industry to perform efficiently. A lack of knowledge will result in poor decisions, no matter what level or type of industry we are dealing with. Poor decisions in turn cause losses, which damage profitability directly and indirectly. Therefore, the quality of the pool of knowledge in such an industry is a good measure of that industry's ability to perform, other things being equal. Staffing policies based upon the model of "staff expendability" will produce a steady haemorrhage of corporate knowledge from organizations. In turn, this means that such organizations will become increasingly less competitive against their "smarter" peers, domestic and foreign, which build and protect their pool of corporate knowledge by more conservative staffing policies.

In a hyper-competitive world economy an organization must be smarter than its peers to be successful. Being smarter requires hiring smarter personnel and encouraging the retention of highly skilled personnel, as they are the decisive resource. Again: any policy model which encourages high staff turnover will produce a haemorrhage of corporate knowledge. The best way in which the university system can support industry is in the production of high quality graduates, with excellent fundamentals training and thus medium- to long-term potential to generate superior revenue.

Having explored the industry side of this equation, let us consider the universities and their staffing policies. In recent times it has become fashionable to advocate "the application of industry management practices to universities" (e.g., Dodgson, 1996). Indeed, most academic staff are now hired on short-term contracts, at the end of which they may be retained, but are frequently replaced. In this respect, contemporary Australian university management practice does resemble the short-term survival staffing policy becoming more popular in industry — but it is actually worse: few companies hire the *majority* of their new employees on short-term contracts.

The now broadly based attack on tenure in the universities just is the attempt to burden them with a fuller reliance upon contract, temporary workers. Yet, if the central objective of the university system is to generate, maintain and distribute knowledge, a staffing policy designed to retain and grow knowledge would be a far better adaptation than a model which is designed to minimize short-term staffing costs. And it is no small consideration that each reduction in the quality of working life at universities, such as the abandonment of tenure, is paid for by a corresponding diminution in the universities' ability to attract quality workers to one of societies' more vital roles.

It is also misleading to compare industry management practices in research and development with university management practices in research in a way suggesting that they are the same process. The label used is the same, but the activities are different. In industry, R&D is primarily the D and involves the conversion of fundamental knowledge into marketable

products. Primary research, the discovery of new fundamental knowledge, requires a very different skills set to the applied research and product development of industry. Research in the university environment has a strong bias toward the production of fundamental knowledge, and university researchers systematically develop the skills to support this.

University and industry research activities are complementary in nature, and not interchangeable. Some have suggested that we compare the “performance” of university researchers against industry researchers by using the remarkable metric of patent applications filed. This deeply misunderstands the two research processes involved. University research is aimed at generating fundamental knowledge and the early and free dissemination of that knowledge to the benefit of the community. Industry research and development is aimed at gaining a competitive advantage, and then protecting that advantage. A patent is a device to prevent the use of a piece of knowledge by another player, and one which incurs a significant cost to implement. Those products of industrial research which are not patented are hidden as “proprietary knowledge,” and those privy to them are typically bound by non-disclosure agreements. Industry and university research practice could hardly be more different than in their treatment of the products of research. It would be interesting to contemplate the implications of a university system which patented and withheld knowledge to maximize its competitive advantage.

Successful university research requires a culture of teamwork, the free flow of ideas, mutual trust between participants and the willingness to risk time and effort to explore new ideas. Successful industry R&D requires the production of a marketable product at a minimal cost and in a minimal time scale; indeed, where this policy is prosecuted over-zealously, corners are cut and the product suffers. Good examples would be DC-10s falling out of the sky during the seventies, or more recently the abysmal quality of many consumer software products, such as personal computer operating systems, or again the defective floating point operation in the early Intel Pentium processor chip.

The dangers in subordinating university research management policy to an inappropriate model is that the result may be a major systemic failure. Just such failure was the subordination of fundamental research in genetics to ideology in the former Soviet Union. The story of the ideologically sound, but ultimately inadequate, Lysenko theory of genetics, which set back research (and then application!) not just in genetics but in the many related sciences as well, should be ample warning to those who believe that ideology is more important than reality. Ideology is a selling tool, no more and no less. However seductive an ideological model may be, unless what it is selling works, the short-term profit will be swamped by the long-term costs.

If the university system is to continue to fulfill its primary role in the economy, it must be firmly oriented in its management policy and funding support to the discovery of fundamental knowledge, maintenance of that knowledge, and dissemination of that knowledge. Any policy which reduces the corporate pool of knowledge in a university is damaging its primary function. Staffing policy must reflect this unconditionally. Tenure is an excellent example of how a pool of knowledge can be consolidated, maintained and expanded. A Chair in a given discipline, who leads researchers in that area, represents in practical terms a pool of knowledge which may be drawn upon by undergraduate and graduate students, and then also industry.

We also now hear calls for increased industry funding of university research effort, this with the expectation that industry funds can supplant government funds withdrawn that had been used for fundamental research. This is a curious notion, given that the hostile environment which much of Australia’s high technology industry must endure has forced our industry to minimize its investment in R&D activities. The expectation that an industry lacking support from the financial sector and under intense overseas competition can find sufficient spare cash to replace government funding of university research is at best naively optimistic and at worst dangerously irresponsible. In any event, the research skills possessed by Australia’s

universities are often irrelevant to the application-oriented product development skills sought by industry. University researchers used in product development simply have to acquire new skills that industrial researchers already have, which then distracts and undermines the efforts of university researchers to do what they do best, namely basic research.

4 Vapournet education

It is a surprisingly wide-spread belief — not merely among politicians and journalists, but also among computer scientists and Internet cognoscenti — that the wonders of the Internet, more than simply enhancing the delivery of education by providing ready access to multimedia materials, will actually *replace* educators in the classroom. We have yet to see the rationale behind this assertion articulated in any sensible way. Any such rationale would have to suppose that a typical student’s interaction with a computer server would be as educationally productive as that student’s interaction with a living teacher. In contrast to many Internet pundits, such as Negroponte (1996), we do not believe that the techno-solution to our educational problems is a live prospect for the foreseeable future. Consider some of the obstacles to such a solution. Computer-aided instruction, despite being a subject area nearly as old as computers themselves, has yet to make any significant impact on general education, even (or especially?) in the education of students in very simple domains, such as primary school arithmetic. Most such instructional systems use the potentially awesome computational abilities of computers as glorified page-turners, as do the various CD-ROM encyclopedias. The most successful computer-aided instruction has been in very narrow procedurally-oriented training applications, such as training ship pilots and military personnel.

In educating people in intellectual disciplines we believe the most relevant fact is simple: as the ratio of students to teachers increases the measurable educational impact declines. Although there is some controversy about this relationship, the controversy is itself driven by political and economic considerations, rather than scientific considerations: the many studies supporting such a relationship (such as the massive Tennessee experiment reported in Mosteller, 1995; see also Blatchford and Mortimore, 1994; Pate-Bain et al., 1992) we believe to outweigh the few proposed as undermining it (Akerhielm, 1995, uses statistical techniques related to those we have applied to OECD data to remove confounding variables in some such studies that reduce the apparent benefits of smaller class sizes). Furthermore, the relationship is supported by the elementary observation that at the extremes the matter is clear: individual tutorials are more effective than attempts to educate the masses as a whole. Although educational effectiveness need not in principle decline monotonically as the student-teacher ratio increases, so that there may be a maximum of educational effectiveness at some ratio greater than one, no one has adduced serious evidence to that effect. Absent evidence against, and in light of evidence in favor, we propose that common sense should prevail. This has a direct moral for judging the use of the Internet to replace teachers: the prospect is not there. However wonderful the Internet may be, and however wonderful “applets” running on computer client systems may be, they are very far removed from how wonderful individual, living teachers can be in dealing with the queries and problems of individual, living students. Replacing teachers with the Internet is no more likely than replacing them with books. Books, far more than computers, have made the fantastic world-wide educational gains of recent decades possible, but they have not done so by replacing teachers; they have done so by providing them with material with which to teach.

For the Internet (or, more exactly, computers) to replace academics will require computer systems and programs to first acquire the teaching abilities of academics. This means that they will have to acquire the ability to present educational material visually and orally, if not in just the way academics do — lecturing, gesticulating, advising, commenting, coaxing, motivating,

haranguing, responding to queries, etc., then in modes and methods equally effective, whatever they may be. To be sure, virtual reality promises support for presentations which simulate live performances, although such support is not imminent, as some commentators would have us believe. But more importantly, and much more remotely, computer systems and programs will have also to manage the educational process as intelligently as do academics. The main impediment to “conventional” computer-aided instruction has always been that such systems cannot effectively interact with students: in some cases they can detect that a student is deficient in a particular subject matter and return to it, but in no cases can they respond intelligently to the problems and queries of students and engage in any natural dialog with students. What the Replacement Thesis requires is no less than the completion of the quest for an Artificial Intelligence. We believe in the value of artificial intelligence as a research area in computer science; we do not believe that artificial intelligence — or any other major scientific research area — is close to “completion.” Therefore, educational policies which depend upon such completion are, to say the least, premature.

5 Information Technology and Higher Education

Here are a few recent newspaper headlines to ponder — “It’s cyberspace or go bust” (*The Australian, Higher Education Review* 27/11/96); “School, as we know it, is out” (*The Age, Education* 10/12/96); “Virtual competition hots up” (*The Australian, Higher Education Review* 11/12/96). These articles, which report the opinions of technologists, educators and even ministers of education, mark the development of a new educational ‘cargo cult’ mentality based on the virtual campus, the glittering CD-ROM, the optic-fibre of knowledge. The cyber-porn scare seems to be just about played out, but perhaps we should also note — “Con artists of the internet” (*The Age, Computer Age* 10/12/96). The hyperbole about information technology is unfortunate because there are good things that can and are being done in higher education with information technology. But many of their effects will be unpredictable and they are as likely to cost money as to save it.

Let us learn from the past: **Almost all predictions of the effects of new technology are wrong.** If we examine predictions that were made in the past about the effects of technology on education and life in general, the vast majority of these predictions are seen in hind-sight to have been wrong.

Take the once-new technology of television, for example. When television was young, some hailed it as a device that would enhance the cultural life of the nation by broadcasting “uplifting” works such as those Shakespeare into homes on a daily basis. Well, yes, television can do that and it has certainly had a large impact on the national culture, but generally in ways that were unforeseen — consider soap operas, domestic furniture, TV dinners, MTV, NBC, the ten-second “sound bite” and so on. Television was also going to revolutionize education with lessons beamed into every home. The UK’s Open University (OU) has certainly been useful, and successful, but it has had little effect on other universities. The OU did overcome initial prejudice and is now considered “respectable.” It is likely that the extra channels available on cable TV will offer more scope for broadcast education, yet it is hard to see this having any sudden effect that is orders of magnitude greater than that of the OU.

Programmed-learning machines were popular in the 1960s. (They were about the size of a television set, contained a roll of 35mm film which was back-projected onto the screen, and had several buttons. The film contained pages of both instructional material and questions which were answered by pressing the buttons. A correct answer lead on to the next concept, a wrong answer lead to correctional pages.) These machines were, and are, excellent for some very structured topics (one of the authors learned the basics of Fortran on one) but programmed-learning machines did not revolutionize education either.

It is interesting to note that much of the so-called new instructional material on CD-ROMs and the Internet (i.e., web pages) resembles that of programmed-learning machines in style, except that it includes glitzy pictures, film-clips and sound.

Videotex is another technology that offered many of the facilities of the “new” Internet back in the early 1980s. Brody reports (1991) that Knight-Ridder spent \$60 million on a videotex service that lost money and was later abandoned. Consumers could go on-line with their computers and browse through encyclopedias, news, weather and stock reports — but consumers of the day were not interested.

The photocopier, the fax machine and the mobile phone are technologies whose successes were under-predicted rather than over-predicted. The photocopier has had a profound effect on universities by increasing the volume of notes that is now prepared for students. Who can remember the Roneo machine? Sometimes the timing of predictions is way off. The fax is very useful in businesses and universities. It has been available since the 1940s, but caught on only in the late 1980s.

The computer is but one more technology whose effects have been and will continue to be mis-predicted. We can recall some of the more infamous mis-predictions:

- The world market for computers is about five machines (Thomas Watson, chairman of IBM, 1943).
- Australia does not need a computer industry (after the CSIRAC success).
- The home computer will never take off (“Why would anyone need a computer of their own?” Ken Olson, chairman of Digital Equipment Corporation, 1977; quoted in Rifkin and Harrar, 1990).
- 640K RAM is the most anyone could want (Bill Gates, chairman of Microsoft, 1981).
- The paperless office, ha!
- The cashless society (this may yet come about, but still not overnight).
- The electronic cottage — working from home, a few do, but how many?
- The leisure society (this did *not* mean high unemployment!).

For each of the above possibilities, someone advocated it, often the obvious expert of the day, and someone else disparaged it. It is only with hindsight that we know who was correct.

Having seen that most predictions about technology made in the past are wrong, we infer that most present and future predictions will also be shown to be wrong. We will nevertheless make a prediction. Before doing so, the authors admit that they work in a computer science department and have been using computer networks and email for a collective 50+ years, and use the Internet (ftp, world wide web) for research and teaching — we have an unhappily close association with the technology. Nevertheless, we have great confidence in our prediction. Here is our prediction: Information technology will change universities.

5.1 Teaching

Already we have educational “course notes” being made available on CD-ROMs and on the world wide web, and this will increase. At the simplest, these are just traditional printed notes, but now available online. The (minor) advantages are that: the notes are available 24 hours a day, even without going to the campus; the cost of printing is shifted to the student; better graphics, and even movies and sound, can be included.

Tests can be put online. Multiple-choice questions are easiest to implement, but short-answer questions can be automatically marked if carefully specified. Such developments may

have unforeseen consequences; for example, it has been reported that females perform better at long-answer questions and males perform better at multiple-choice questions — on average. Note also that the initial effort of creating a good online testing system is much greater than for a manual pen and paper system.

Automatic marking of the performance (only) of computer programs submitted for programming exercises has been used by computer science departments for more than twenty years for some problems that can be very precisely specified.

Simulations of dangerous, expensive and ethically restricted experiments can be created. For example, airline pilots can now be certified to fly a new aircraft entirely on simulators and can practice many kinds of emergency situations with them. Note that to create realistic simulations is still very expensive.

In a university, where the creation of new ideas is central, one must question how far a simulation can model the real world with all its “imperfections.” The minor difficulties of doing, say, real physics experiments such as bad connections, contaminated samples, and breakages, may be an essential part of the experience. The life-expectancy of a clumsy chemist may be limited in the real world. The success of the flight simulator is due to the very fact that it has been studied to death, but it would be of no use in a new flight regime — until that too had been studied to death.

The heart of a university is not its buildings and equipment, important as they are — it is rather the generation and exchange of ideas between thoughtful people. New technology may be glittering, it may save (or cost) several percent of the budget, but unless it happens to be the object of study in a technological department it is almost irrelevant to a university.

Teachers and students certainly can “meet” in cyberspace using an Internet link and computers equipped with small cameras. This might save travel time and reduce the need for so many university buildings. Will it enable more economical virtual tutorials and virtual laboratory demonstrations? Well, video-conferencing has been available for many years. The reports are that its first users, business people, find it better than the telephone but worse than a physical meeting. There must also be doubt about the numbers of people that can interact meaningfully through a video link. A video meeting of just a few people may work, but what meaningful communication is possible in cyberspace between a dozen or more? (Economic pressures are driving universities to larger, not smaller, tutorial groups.) In a real meeting body language, background noise and peripheral vision are important; all are severely restricted with computer cameras.

5.2 Research

The Internet allows technical reports, conference proceedings and other articles to be made available electronically anywhere in the world. An online report can be retrieved from Glasgow, say, in a few minutes — if it can be found.

Email, mailing lists and (electronic) newsgroups allow scattered groups of researchers to cooperate on projects. This is good, but it seems to be a fragile sort of enterprise. Sloppiness and laziness are also possible outcomes — it is easier to ask your online clique than to search for foundational material in a good reference book.

The ease of “publishing” on the Internet means that readers have to be even more critical about quality. It has long been a good bet that a text book from a worker at a reputable university and published by a well known publisher is probably sound. As special interest groups and companies go online and service providers, such as Microsoft, embrace “infotainment,” readers will have to become more cautious.

5.3 Infrastructure

The early (say, 1995) fuss about the possibility of the Internet and world wide web killing journals and text books seems to have died down. Journals and books will be with us for some time yet. However, libraries have been changed by information technology, and now contain more terminals and computers.

A characteristic of new systems is that they do not wholly replace old systems. A university may put information online but this will not soon reduce the number of telephone queries that it must handle or the number of information kits that it must mail to schools. Typically extra staff must be hired to run the new system in parallel with the old system. For example, banks have had to coerce the public to use automatic teller machines and other electronic means of making transactions even though some customers willingly move to them.

Information technology solutions can also run into implementation problems, as the Uni-Power project seems to have done (“Unis sue software firm for breach,” *The Australian*, p. 33, Wed 9 April 1997).

In short, developments in information technology have myriad impacts upon the ways that universities pursue their business. But the heart of a university is the generation and exchange of new ideas. Information and communication is necessary for this, and information technologies will change the surface appearance of the process, but more slowly than vendors would like and in ways that educators and politicians are unlikely to predict.

6 Conclusion: A nation of sheep?

The massive changes to Australian higher education implemented over the last ten years appear to have been conducted in accord with industry *worst* practice: without due consideration to known facts about the relation between education and the economy; without understanding of the history of higher educational practices and their rationale; without understanding the role of research within education, or the role of technology within either; and with little concern for a time horizon beyond the next election, echoing the benighted practice in industry of planning to the next quarterly report.

The question which Australians must answer is whether or not for the next century they wish to be a nation of sheep, waiting to be shorn by others. Reliance upon natural resources to hold up a comfortable standard of living just is the attitude of sheep. Whether comfort survives in such circumstances is the result of good or bad fortune: the economic state of the shearers. Sheep have no say in the matter, whether or not they have an interest. The slogan “the lucky country” really does sum up the prevailing attitude in Australia in the past. We suggest that the attitude is unworthy of Australia and its potential for the future.

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Country	1977 public educational spending per capita* (X_1)	1977 GNP per capita* (X_2)	1992 GDP per capita† (X_3)
Australia	330.55	7046	13900
Austria	256.18	6174	14240
Belgium	152.41	8191	14000
Canada	547.54	8615	15440
Denmark	490.80	9221	14100
Finland	297.74	6170	12000
France	223.59‡	7064	14670
West Germany	215.75‡	8261	15940
Ireland	97.36‡	3078	9940
Italy	128.12‡	3422	13620
Japan	213.42	6098	15450
the Netherlands	522.66	7670	13630
New Zealand	184.99	4545	11270
Norway	476.21	8466	13920
Portugal	56.12	1742	7210
Spain	40.27‡	3262	10110
Sweden	551.22	9362	13650
Switzerland	397.35	9723	17400
United States	473.73	9148	18360
mean	297.68	6697	13623
standard deviation	172.69	2438	2645

Table 1: Wealth and educational spending

Sources: OECD (1981) and OECD (1995a). * 1977 figures are in 1981 US dollar amounts. † 1992 figures are in 1985 US dollar amounts. ‡ These figures are from 1976, since 1977 figures were unavailable.

Country	1992 public educational spending per capita(*)
Australia	797
Austria	1019
Belgium	991
Canada	1277
Denmark	1083
Finland	1119
France	999
West Germany	786
Ireland	665
Italy	876
Japan	697
the Netherlands	788
New Zealand	828
Norway	1350
Spain	572
Sweden	1104
Switzerland	1178
United Kingdom	776
United States	1200
mean	953
standard deviation	221

Table 2: Public educational spending per capita 1992

1992 figures are in 1992 US dollar amounts. Source: OECD (1995b). Note that differences in membership between Tables 1 and 2 simply reflect the availability of the appropriate statistics in OECD publications.

Appendix

The path model between the three variables X_1 (1977 educational spending), X_2 (1977 wealth) and X_3 (1992 wealth) suggested in the text (with X_2 causing X_1 and X_3 and with X_1 causing X_3) together with the sample correlations derived, leads to the following equations (where p_{ij} is the linear path coefficient from variable j to variable i):

$$r_{13} = p_{31} + p_{12}p_{32}$$

$$r_{12} = p_{12}$$

$$r_{23} = p_{32} + p_{12}p_{31}$$

Solving these leads to the path coefficients:

$$p_{12} = 0.8212$$

$$p_{23} = 0.5899$$

$$p_{31} = 0.0972$$

This gives us a standardized path model, i.e., with variables having means of 0 and standard deviations of 1. Figure 2 results from destandardizing the variables. (For a simple introduction to the statistical techniques used here see Asher, 1983.)

There are a few caveats that should be borne in mind in interpreting this causal model. We have not gone to the trouble of estimating confidence intervals for the parameters. Certainly, the form in which they are presented suggests a spurious precision. Also, the use of five 1976 GNP numbers in Table 1 may very slightly inflate the correlations r_{13} and r_{12} while depressing r_{23} . There is no reason to believe that the true parameter values are interestingly different in their ratios from those we have estimated, however.

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