

# PERSPECTIVES ON MANUFACTURING

Essays in honour of John Monaghan



Editors: Kevin Kelly & Garret O'Donnell

# Forging a Future: Pressures on Higher Education

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## 1. INTRODUCTION

The publication of a festschrift is an honourable academic tradition. I am delighted to have been invited to contribute to this festschrift for Professor John Monaghan. However, I note the irony of doing so for him, one of the least traditional of Trinity College Dublin's engineering professors. His route into Trinity began with an apprenticeship course at Bolton Street College of Technology, and the subject of his teaching and research—manufacturing technology—was new to academia when he began to teach here in 1980. Now, thirty-five years later, and due in no small part to his leadership, manufacturing is well integrated into the activities of Trinity's School of Engineering, and research in manufacturing in Ireland is strongly competitive with the best research in other countries.

The invitation to write this Foreword came from Kevin Kelly and Garret O'Donnell, Professor Monaghan's colleagues in Mechanical and Manufacturing Engineering. I wish to thank them both. Kevin leads the programme in 'Engineering with Management' and conducts high-profile research into engineering design and education, and Garret has created one of the largest and most vibrant research groups in the School of Engineering in the area of advanced manufacturing.

## 2. REFLECTIONS

The Junior Sophister class of 1985, of which I was one, were introduced to manufacturing in a course called 'Manufacturing Technology and Systems', which was jointly taught by John Monaghan and Bernard Corbally. Non-engineers rarely give a moment's thought to manufacturing: the source and cost of materials, the energy associated with production, and how products are disposed of, or ultimately recycled. But most engineers do think about manufacturing, and perhaps we should think about it a lot more. It's important to appreciate the costs, financial and environmental, of the many products now considered essential for our daily lives.

Manufacturing is truly very complex. The course on Manufacturing Technology and Systems attempted to teach us something about the processes, and get us thinking about how processes combine with people to create manufacturing systems. Professor Monaghan taught us about forging, milling, deep-drawing, and a myriad of other manufacturing processes. Many of us liked manufacturing as a subject, and there was always a scramble to get one of Professor Monaghan's final year projects on metal-forming.

The following year's Senior Sophister course was a popular elective. We dubbed it 'Man Tech'. We spent a good deal of time deriving the lengthy equations for the forces required to roll thin sheets of metal, and even more time on the forces involved in machining metal bars; tool wear was all the rage as a research topic and there seemed to be a great deal of departmental research into monitoring wear and measuring surface finish. Even though the topic didn't interest me much, I could see that it had many important industrial applications. My own research led to bioengineering, and post-doctoral research abroad. But I still value the Man Tech I learned as an undergraduate.

### **3. ENGAGING WITH INDUSTRY**

When I returned to Trinity in 1995, John Monaghan was heavily involved in leading one of Ireland's Programmes in Advanced Technology. The PATs, as they were called, provided funds to purchase new equipment and hire new expert staff. The PATs aimed to increase the technological capabilities of Irish industry. They were perhaps the first coordinated and sustained effort by the Irish state to use the engineering expertise within universities for the benefit of Irish firms of all sizes—indigenous and foreign.

Today the linkage between industry and Irish universities continues to develop apace. New Science Foundation Ireland centres are headquartered in Trinity, such as AMBER in advanced materials and bioengineering, CONNECT in telecommunications, and ADAPT in personalisation software. In each case, they are linked with Trinity's research strengths in engineering and technology; similar research centres are headquartered in other Irish universities.

Globally, the impetus to engage further with industry is only one among many pressures for change. It is said that 'perfect storms' are coming, that 'tsunamis' are on the way [1,2]. In the following section I list some of these pressures and consider the impact they may have on engineering education.

## **4. HIGHER EDUCATION—SEVEN PRESSURES FOR CHANGE**

Seven pressures for change in universities are described below. In his recent book [1], Smelser writes about forces for change creating ‘downward spirals’, and I use that idea here. Any one of the pressures identified could push universities into a downward spiral—unless universities successfully adapt.

### **1) Pressure to contribute to economic competitiveness**

Universities are important for competitiveness because they create the talent to fuel economic growth. Universities therefore attract the attention of national governments. This attention leads governments to wish to regulate universities to maximise their economic impact. Usually this regulation is justified as ensuring maximum return on exchequer ‘investment’ in higher education. Public discourse in Ireland often relates this to the labour requirements of the multinationals, as well as the talent needed to create and grow to scale start-up companies.

In responding to this pressure it is natural for universities to emphasise engineering, science and business degrees. The potential for the downward spiral arises if this expansion is done on a shoe-string without sufficient resources to ensure quality teaching in a research-led educational environment. Attracting talented students into programmes in engineering without the resources to deliver top-notch courses would be an unacceptable outcome. Neither should we forget the economic importance of sustaining a multi-disciplinary environment that includes the arts and humanities.

Overall, however, the pressure to contribute to economic competitiveness is positive for engineering education. It also provides an opportunity to overcome the artificial boundaries between engineering, business, and science which have been formed by the nature of universities’ siloed internal organisation.

### **2) Pressure to reduce state expenditure**

Many countries are slashing expenditure on higher education because of other more immediate calls on taxpayers’ money, and because of political pressure to reduce taxes. Also, the link between funding and quality is not as immediately manifested as it is in other sectors, such as health. *Pari Passu* with the reduction of expenditure by national governments has come an increase in the fees paid directly by students. This has happened worldwide, with the exception of only a few rich countries, e.g. Germany. Some countries have compromised quality by an unregulated increase in the number of students without increasing either tuition fees or exchequer subsidies. The Irish situation should not be allowed to drift into this category, and some commentators would say it already has. During the recent period of rapid expansion in Ireland; between 2007/08 and 2013/14,

overall student numbers increased by 17.3%. All social groups (with the exception of ‘other non-manual’) have increased their representation in higher education. However, social class differentials are still highly significant, with the probability of the ‘other non-manual’ and the ‘semi-skilled and unskilled manual’ groups entering higher education being about a third of that of the ‘professional’ workers group [3].

Table 1 shows that, since 2007/08, with the increase in the student contribution, the unit of funding (resource) per undergraduate EU student has decreased cumulatively by approximately 21%. The exchequer contribution decreased over that period from €7,909 to €4,126, a decrease of 48%.

**Table 1 Cumulative reduction of student funding 2008–2014**

Year	RGAM Standard Unit of Resource <sup>(1)</sup>	Fee <sup>(2)</sup>	Student Charge/ Contribution <sup>(3)</sup>	Combined Unit of Resource	Annual Increase/ (Decrease)	Annual % Change
2006/07	€4,039	€3,529	€800	€8,368		
2007/08	€4,135	€3,774	€825	€8,734	€366	4.4%
2008/09	€3,568	€4,041	€900	€8,509	(€225)	-2.6%
2009/10	€2,459	€4,149	€1,500	€8,108	(€401)	-4.7%
2010/11	€1,832	€4,149	€1,500	€7,481	(€627)	-7.7%
2011/12	€1,663	€3,649	€2,000	€7,312	(€169)	-2.3%
2012/13	€1,574	€3,399	€2,250	€7,223	(€89)	-1.2%
2013/14	€1,321	€3,149	€2,500	€6,970	(€253)	-3.5%
2014/15	€1,227	€2,899	€2,750	€6,876	(€94)	-1.2%

<sup>(1)</sup> RGAM stands for Recurrent Grant Allocation Model, which is an algorithm for dividing out the Block Grant to an individual institution. The RGAM allocates funds to a university proportional to its number of students, with weightings for different student types. Engineering has a weighting of 1.7 whereas an arts student has a weighting equal to 1.

<sup>(2)</sup> Under the “free fees scheme” the state pays EU undergraduates’ fees (but not repeat fees). For simplicity in this table the fee is the average arts fee.

<sup>(3)</sup> The student contribution set by the state and is paid by the student except when a student qualifies for a grant in which case the fee is paid by the local authority.

Universities have increased non-state income from out-of-state (non-EU) students and postgraduate students, from commercial activities and industrial research contracts, and from philanthropic sources.

Throughout this time in Ireland we have seen a steady sustained *decrease* in state funding. The state policy has been to increase student numbers without funding the increase. The higher education system as a whole has had to cope with a reduction in exchequer funding of 28% between 2008 and 2015. Regarding funding per student, the Irish Universities Association has prepared data showing a reduction in total funding per student, with an

increased proportion of that coming from the students themselves, or their parents (see Table 1 above).

Eventually, however, the pressure to increase economic competitiveness (Pressure 1 above) may become strong enough to force a reconsideration of this policy—the state may then either increase the investment in universities or allow them to charge significant tuition fees. An alternative is the creation and growth of private colleges, though as yet in Ireland no private colleges are offering engineering courses.

### **3) Pressure to maximise an individual student's return on investment (ROI)**

In parts of the world where parents, or students themselves (by taking out loans) pay significant tuition fees, there has been a pressure to evaluate degree programmes in terms of the return on money spent. Given the increased gap in earning power of various careers, we should not be surprised that course choice is informed by such calculations.

In the US, it is said that these calculations have resulted in a drop in the prestige of a 'liberal education' in favour of a more technical education because the return on investment (ROI) in a liberal arts education is less [1]. (Indeed the concept of educational 'negative equity' has emerged—more money is spent getting the education than is gained through the increased earnings that education generates over a whole career). If a drop in the number of talented applicants for arts and humanities courses manifests in fewer students taking these courses, then we have a potential downward spiral in the multi-disciplinary environment of the university.

The case for the importance to society of those with a liberal education is made forcibly by many commentators. Democracy itself is thought to depend on it. As an engineer myself—and therefore not a recipient of the presumed benefits of a liberal education—I am not convinced that democracy is preserved only by those with a liberal education; there are better arguments in favour of arts and humanities disciplines rather than burdening them with responsibility for preserving democracy. Rather, I am convinced by the argument that a society with a multi-disciplinary education is a stronger one, more robust and more capable of providing the checks and balances that maintain stability and guard against the erosion of its values. Furthermore, much of the societal change caused by technology can only be understood through modes of critical thinking and analysis of ideas that are part and parcel of the humanities disciplines. In Trinity we have not seen a drop in the uptake of arts and humanities courses, but we have seen an increase in the numbers of students applying for engineering and computer science (see Table 2 below). Table 2 shows the increase in the number of CAO applicants whose first preference is a course in Engineering or Computer Science in Trinity College Dublin. While the number of first

preferences increased so too did the minimum entry level for most courses over the same period.

**Table 2: Numbers of 1<sup>st</sup> Preference Applications and Minimum Entry Points to Engineering and Computer Science Courses, Trinity College Dublin, 2011-2014**

	2011		2012		2013		2014	
	1st pref	Min points	1st pref	Min points	1st pref	Min points	1st pref	Min points
Engineering	219	400	256	465	238	455*	233	470
Engineering with Management	13	380	17	435	26	450	30	460
Management Science and Information Systems Studies	34	385	32	455	37	480	69	515
Computer Science	109	385	139	450	169	460*	190	460*
Computer Science and Business	67	420	60	465	77	465*	60	465*
Computer Science and a Language**			21	490	33	525	19	450
Computer Science, Linguistics and French	12	435						
Computer Science, Linguistics and German	7	485						
Computer Science, Linguistics and Irish	4	460						
Total number of 1st preference applcs in these courses	465		525		580		601	

\* random selection, not all students with this number of places were offered a place

\*\* Three separate programmes combined into one entry route in 2012/13.

Further analysis has shown that approximately half of those who do not get a first preference place in Trinity *do not* go on to study technology courses at other universities.

#### 4) Pressure to pursue rankings

Many parents are convinced that an education in a ‘good’ university is the only passport to a successful career for their children. In addition, many employers choose their employees based on the reputation of the university they attended rather.

Globally, this has helped to ratchet up the competition for a limited number of places in a few high-ranking universities. In my view this is bad for everybody, including the high-ranking universities which have no immediate competition to outflank them because others are lining up behind them offering the same kind of courses and doing the same kind of research. The outcome is a simplistic ranking of universities, and pressure on young

people to secure a place in a prestigious university so as to maintain or establish a family's standing in society.

Like them or not, these rankings are having far-reaching effects. However, the influence of global rankings is becoming disproportionate. Students, their parents, governments, employers, investors, business partners, the public and the media have been subjected to their influence [4]. Their limitations are rarely adverted to.

Globally, there is a serious downside to all this which is the threat to equity. Whatever tuition fee the university charges is seen as 'worth it' because of the potential for increased earnings later on. As a result, in some countries, tuition fees have risen rapidly; this excludes many potential students from lower income backgrounds, even with 'needs-blind' admissions systems or means-tested grants support. But it is the consequences of decisions being increasingly taken at government level that should give us most cause for reflection. It has been suggested, for instance, that in Japan the pursuit of world class status for a small number of the country's universities represents a rejection of the move towards egalitarianism in the post World War 2 era [5]. I don't believe they are incompatible but recognise that, in a time of mass higher education, differentiation between higher education institutions is inevitable.

In the Irish context the competition between universities for admissions is not as evident as in other countries because the public universities have broadly similar reputations for educational quality, and there is also a strong provincial loyalty. However, there are subtle pressures, often well-hidden and hard to identify, which keep university courses open preferentially to certain groups. While means-tested grants (like needs-blind admissions as in the US) do ameliorate the financial impediments at admissions, they do not address the root cause because the financial standing of a family acts well prior to university admission due to the differential preparation in secondary schools allied to family differences in cultural capital. Levelling the playing field in favour of genuine ability and talent can be done by an admissions process designed to identify such talent and potential. However, in the Irish context the main feature of the pre-university entrance exam is predictability so that the differential preparation through additional tuition can secure advantage for admission. This is particularly relevant in the context of mathematics as a preparation for pursuing STEM disciplines at university. Many young people perceive maths to be difficult and there is also pressure to simplify courses and even reduce the mathematical content, something which is not good for engineering in particular. Will the drive for economic competitiveness (i.e., 'Pressure 1') ultimately force a reconsideration of this status quo? Given this and that rankings increasingly dictate much of the higher education agenda worldwide some universities may through their admissions policies become even inadvertently more elitist. There is a real danger that the rankings will create a downward spiral which would strike at



egalitarian principles of equity and fairness in an era of mass higher education.

### **5) Pressure to reduce cost with new forms of delivery**

Many industries have undergone overwhelming change in the last decade because of advances in technology, e.g., airline, media, music, to name a few. But higher education has not changed radically—at least not yet.

The same players that were there hundreds of years ago—424 years ago in Trinity's case—are still there in their privileged 'market' positions. Some people find this hard to believe, other people are enraged—particularly because, as they see it, universities are unable to control their costs and are delivering out-dated education that is not fit for purpose. This motivates the search for a formula to provide higher education on strictly commercial grounds. Globally, we have seen the creators of learning technologies merging with the content providers. This is a new force that presents a threat to more traditional educational institutions. Turning this threat into an opportunity will require universities such as Trinity to discern exactly what is essential to the education we provide, and how to enhance that with technology. We must work this out otherwise we will certainly enter a downward spiral.

### **6) Pressure to engage industry and society**

Let us define industry as the *Oxford English Dictionary* does: 'a particular form or branch of productive labour'. It includes a broad set of activities, and not only manufacturing and provision of services but productive organisations of all kinds, in sport, entertainment, arts practice (the 'creative industries'), and non-profit sectors.

I see three classes of engagement between universities and industry.

First, industry is engaged with much of the research of universities, ranging from blue-sky research on fundamental topics in science and the humanities to short-term consulting contracts. Such links have more positive attributes than negative ones, but do have the potential to skew academic values in terms of what constitutes worthwhile research and scholarship.

Second, industry is linked into the educational mission of universities through an increasing number of adjunct professors whose primary employment is elsewhere. Adjunct staff are now essential to the delivery of many programmes and they make a very positive contribution; however, there is a potential downside in terms of coherence of the curriculum if too much of the teaching is done by adjuncts not engaged in research, or if adjuncts are employed as a cost-cutting measure.

Third, industry is increasingly becoming a partner in education by providing internships. It is obviously important to engage industry in the

teaching programmes through student placements which provide essential experiential learning opportunities.

In Trinity the pressure to engage with industry on all fronts has been a positive development and continues to strengthen the university in delivering its core mission. However, I am concerned that there is insufficiently strong governance in academic units to avoid the potential pitfalls mentioned above and this needs continuous attention. Since the benefits as regards engineering education are so substantial it is even more of an issue to ensure the correct balance in this discipline.

‘Engagement with society’ is often described as the third pillar of university activity, alongside teaching and research. Included in this class of activities are student and staff volunteering, and other contributions to civic society [6]. The potential pitfall here is that universities assume a greater role or responsibility than is commensurate with their remit in education and research.

## **7) Pressure to be accountable using metrics**

The immediate beneficiaries of universities’ activities are the students, as well as the academic and administrative staff. The alumni also have a stake in a university’s success as they will want to see their *Alma Mater* maintain or enhance its standing. Since national governments make a crucial financial contribution to public universities, they also have an interest in ensuring that their funds deliver for the economy and wider society.

Governments also see a role for themselves in acting on behalf of the students, or prospective students, as they may not see the leadership of the university as acting sufficiently in the students’ interests relative to the other stakeholders. Often this manifests in metrics that are unrelated to the quality of the education, but can be measured—e.g., exam grades, teaching hours, or student satisfaction. It would seem to me that, in some countries, students are badly short-changed by the quality of their university education when governments, or agencies acting on behalf of governments, have neither the resources nor the inclination to ensure quality, or are attached to faulty metrics. However, this has not emerged as a serious problem in Ireland.

Furthermore, financial accountability is required. In the case of private universities this is to their governing boards, comprising independent trustees. Public universities also have boards but the extent to which national governments rely on these boards is very variable between countries. In the case of representational boards, they are rarely given a free hand to exercise their best judgement in using their resources—rather the government acts through ministers or other authorities to control expenditure.

In the Irish context we have seen increased demands for financial accountability and control. These requirements have come at a time when

the proportion of exchequer funding is decreasing and universities have to increase revenues from non-exchequer sources. These two developments—increased financial accountability to the state and increased need for non-exchequer revenue—have come along at the same time, and this has caused Ireland’s own ‘tsunami’ in higher education. It has required a professionalisation of the way universities are run beyond what was required previously. Such professional management is based on measurement of performance against budgeted investment, i.e., metrics. The use of such management techniques —dubbed managerialism— has received much criticism from commentators within universities themselves [7]; indeed there is a school of thought that holds that management *as such* is unacceptable in a university.

And indeed the potential for metrics to engender a downward spiral in universities should not be underestimated. Some of the metrics are incompatible with each other, and satisfying metrics that are not relevant to a university’s mission will blow it off course. Worse again are someone else’s externally imposed metrics that we know to be wrong but for bureaucratic reasons have to go along with.

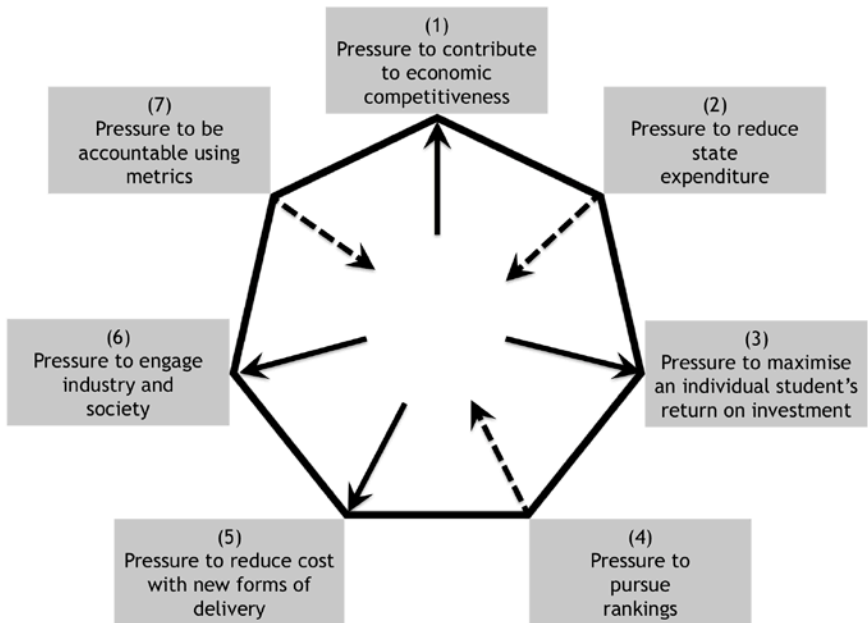
The biggest risk to Trinity is that metrification will divert the university from assuming responsibility for what really matters—education for independence of mind. We need to strive to maintain the independence of the institution in the knowledge that such institutions are crucial to a pluralistic, just, and sustainable society. We also need to keep faith that a genuine partnership between such independent institutions and the agencies of government is possible, being reminded of the continued value of such a partnership by Edmund Burke’s famous lines: ‘[Society] is a partnership in all science, a partnership in all art, a partnership in every virtue and in all perfection. As the ends of such a partnership cannot be obtained in many generations, it becomes a partnership not only between those who are living, but between those who are living, those who are dead, and those who are to be born.’

## 5. DISCUSSION

How is Trinity College Dublin responding to such pressures as I have listed above? As this is a festschrift for an engineer, and most of the readers are engineers, you will know what I am getting at when I say that these pressures are not all orthogonal to each other! Indeed, several of the pressures I have listed above are strongly coupled.

It may be useful to use a diagram to represent the coupled nature of the pressures and how they combine to affect a university’s performance. Consider the area of a heptagon to represent the performance of a university (in a very simplified sense). Each corner of the heptagon is acted on by one of the seven pressures I have listed above. Some pressures will tend to

increase the area of the heptagon and therefore tend to increase the quality of the university's activities; these pressures are represented by outward pointing arrows. Other pressures will tend to reduce the area of the heptagon; these are represented by inward pointing arrows.



**Figure 1. A heptagon of pressures acting to change universities as applied to engineering. Pressures potentially positive for *engineering* are illustrated as pointing outwards whereas those that are potentially negative for engineering point inwards. (This diagram will be specific to a discipline, and will be different for, say, medicine or Spanish, as compared to engineering).**

Whether the pressures act to increase or to decrease the performance depends on the discipline. I have analysed engineering in Figure 1 below. If the problem is to increase the space, then the solution lies in ensuring that all arrows point outwards—there are three that need looking at in my analysis.

Firstly, engineering education is costly and will be badly hit by reductions in state expenditure, particularly because the ROI for an individual student is not supportive very high fees. Investment by the state will be essential to secure the future of engineering education in this country.

Secondly, the pressure to get higher rankings could be very bad for engineering generally if it means an ever-widening gap between elite and

mass higher education institutions. Engineering needs the kind of talent not easily brought in by the current kinds of admissions processes.

Thirdly, many of the metrics used to supposedly monitor ‘quality’ are not applicable to the engineering curriculum.

## 6. CONCLUSION

I conclude this contribution by wishing Professor John Monaghan well in his retirement. It has been a pleasure to have been both his student and his colleague over many years.

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