THE OVER EDUCATED ENGINEER?
The Work, Education and Careers of Irish Electronics Engineers

James Wickham

Introduction

In 1986 over a third of all Irish electronics engineering graduates emigrated, a higher proportion than for nearly all other Irish students (HEA, 1987). While this 'brain drain' has received some media attention, there has been little research on those engineers who do actually work in the Irish electronics industry. This article aims to remedy this. After a brief review of the expansion of engineering education in the last decade, it describes where engineers work within the electronics industry, how they evaluate their education and how they perceive their future careers. As such it gives a description of a group crucial to Irish high technology industry. It also raises a fundamental question about the relationship between education and industry. Is the present problem simply one of 'over-production', or is the wrong sort of engineer being produced?

The article is based on research carried out in 1986 as part of the National Board for Science and Technology's study of the manpower needs of the electronics industry (for a preliminary account see NESC, 1985: 199). The NBST project drew up a list of electronics employers in Ireland; all were asked to complete a questionnaire on the structure of their work force. Of 186 firms contacted, 144 firms responded. It was estimated these firms employed 81% of the industry's labout force. This firm-level data was used to analyse employment trends in the industry as a whole (Wickham, 1988).

The next stage of the research began with exploratory interviews with engineers in several Dublin factories. Firms were then divided (a) into five product categories (computers, components, telecommunications, instruments and consumer) and (b) into four categories based on their nationality of ownership and plant size (Irish-owned, small, medium and large foreign-owned). From each of the 20 groups one firm was randomly selected; in each such firm semi-structured interviews with senior management and formal questionnaire-based interviews with a sample of

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IBAR—Irish Business and Administrative Research, Volume 10, 1989, pp 19-33

technicians and engineers were undertaken (this paper refers largely to the latter). In all 65 technicians and 116 engineers were interviewed.[1]

Manpower Planning and Engineering Education

During the 1960s and 1970s enrolments in Irish secondary and third level education rose steeply. Although it was assumed that this expansion promoted economic growth, there was no attempt to fine tune the educational system to produce clearly specified skills. By contrast at the end of the 1970s electronic engineering was expanded in the universities and NIHEs to tackle a skill shortage in the new electronics industry. The number of electronic engineers graduating in Ireland rose from 163 in 1980 to 385 in 1986 (NESC, 1985: 324; HEA, 1987: 93).

However, as pointed out at the time (Murray and Wickham, 1982), the predicted manpower needs of the electronics industry were based on nothing more substantial than IDA employment projections. These predicted that by 1985 there would be approximately 30,000 employees in electronics, of whom 2,500 would be engineers (Killeen, 1979: 15). Such figures could only have been produced by assuming that aggregate employment in electronics would rise at a similar rate to that already experienced in the USA and the skill structure of the workforce would be similar to that of the US industry. In other words, it was assumed that the Irish industry, although based on the 'branch plants' of MNCs, would resemble the electronics industry in Silicon Valley!

The reality has been rather different. Certainly, skill levels in the industry have been rising: "professionals" (including engineers) comprised 5.5% of the workforce in 1981, but 10.2% in 1985; by 1985 engineers themselves amounted to 5.6% of the workforce (Wickham, 1988). Nonetheless, this meant that the *total* number of engineers in the industry was only 900, less than half the number of originally predicted.

In 1980 the Manpower Consultative Committee estimated that 200 extra engineers would be needed annually from 1985 in the electronics industry (Corcoran, 1980). Surprisingly, firms' actual recruitment has even exceeded this: the 1985 survey firms reported that they employed a total of 734 engineers, but claimed to have recruited 217 in 1984 and to be planning to recruit a further 255 during 1985. Thus, while the 1980

Note

[1] The individual engineers and technicians were interviewed by Ms. Mary O'Hara, Research Assistant in the Department of Sociology, Trinity College; the management interviews were carried out by the author and Dr. Tom Brazil, Department of Electronic Engineering, University College Dublin; the industry survey was organised by Mr. John Dineen, Research Assistant. Department of Industrial Engineering, University College Galway, and directed by Professor M.E.J. O'Kelly. We would like to thank all those individuals who participated in the study for their generous assistance.

projections for total employment of engineers have turned out to be wildly inflated, actual recruitment has exceeded expectations.

Part of the explanation is clearly the continued expansion in the number of engineering jobs, even though total employment had probably stabilised by 1985. Yet the major factor must be high turnover: engineers in the industry are moving out of engineering posts into other positions and/or are leaving the country altogether.

The planning of the early 1980s was therefore based on a completely inaccurate projection of the demand for engineers. An even worse mismatch between supply and demand has only been avoided because one error (the over-estimation of total numbers) has been partly cancelled out by another (the under-estimation of turnover).

Turning from the mere quantity of engineers to the work of engineers reveals another deficiency in the planning. There was no attempt made to find out what engineers were needed to do. Indeed, the closest the proceedings of two conferences on the theme of "Engineering Manpower and Economic Development" came to defining the work of graduate engineers in industry was to repeat a UNESCO definition of the professional engineer (O'Donnell, 1980).

Of course, it is easy to criticise manpower planning after the event. Manpower planning is notoriously inaccurate — and the finer the occupational categories, the greater the likelihood of error. Yet despite calls from NESC and others, there has been no monitoring of the work experience and careers of highly skilled graduates beyond the HEA's annual (and essential) collation of college career officers' data on first jobs. The whole story justifies the comment that decisions in the manpower area have been made on the basis of 'intuitive judgements' rather than substantial research (NESC, 1985: 196).

The Location and Function of Engineers

Engineers' work can be approached by locating the type of firm that employs them and their area of work. For each firm responding to the 1985 survey we have the total number of employees described as "engineers", but more crucially, the functional area of all those with engineering degree qualifications.

The proportion of engineers in factory workforces is highest in the computer sector (8.3%) and lowest in the consumer products sector (2.9%). The computer sector is not only the largest sector of the industry in terms of employment, it provides a disproportionate number of engineering jobs: it employs 32.8% of the industry's total workforce, but 48.7% of its engineers (Table 1).

Table 1: *Engineers as a Percentage of Total Employment, by Industry Sector and Product Innovation*

	Product Innovation		All	
	No (%)	Yes (%)	(%)	(N of engineers)
Sector				
Computers	7.2	11.4	8.3	(358)
Computers	2.3	5.4	3.3	(131)
Telecommunications	2.4	5.6	4.0	(70)
Instruments	6.9	9.9	8.2	(31)
Consumer	2.7	3.1	2.9	(45)
All	4.8	7.1	5.6	(735)
(N of engineers)	(397)	(338)	(735)	

Note: cells give the number of engineers employed in the relevant group of firms expressed as a percentage of total employment in the same firms.

Source: Industry Survey

Table 1 also shows that the proportion of engineers in the workforce is strongly related to product innovation: within each sector engineers comprise a higher proportion of the workforce of innovating than of non-innovating firms: the proportion is at a low of 2.3% in non-innovating components firms, and rises to 11.4% in computer firms with product innovation. However, the data in Table 1 also shows that sector still has an independent effect when product innovation is controlled; the proportion of engineers in the workforce is higher in non-innovating computer firms than in other non-innovating firms. The high number of engineers working in the computer sector is therefore the result of three factors: the absolute size of the sector, its general tendency to employ relatively large numbers of engineers, and finally the existence of some firms carrying out product innovation.

Within the industry as a whole, product innovation is most prevalent in Irish-owned firms. Of all Irish firms, 66.7% claimed to be carrying out product innovation, as against only 33.3% of all MNC firms. Because product innovation and firm nationality are linked, engineers form a higher proportion of the workforce in Irish then in MNC firms: in Irish owned firms as a whole, engineers amount to 7.8% of the workforce, as against 5.4% in the MNC firms. However, Irish-owned firms only make up a small section of the whole industry and so, despite their different occupational structure, in absolute terms they provide few jobs for engineers: in 1985 firms reported a total of 735 engineers employed, but only 97 of these were in Irish-owned firms.

Engineering as an occupation and engineering as a qualification are not of course identical. Firms in the survey reported a total of 842 qualified engineers (ie employees holding at least a primary degree in engineering), but only 735 people in the *occupational* category of "engineer". Many employees with an engineering degree were working in "management" and therefore are not considered to have an engineering *job*. Conversely, the individual interviews showed that not all those working as "engineers" do have an engineering degree. Of 115 engineers, approximately 60% had an engineering degree, but over a quarter had no degree level qualification at all.

Outside the industry — and perhaps even in engineering education — it is widely believed that engineers in electronics carry out primarily research and development tasks. In fact, of the five functional areas into which we have broken down engineers' work, "manufacturing" is the most important, occupying 44.3% of all qualified engineers; information support (which includes research and development) occupies 25.1% (Table 2). This is confirmed by the individual interviews: over half of the engineers described themselves as working in "production" as against under a quarter in "Research and Development".

Table 2: *Qualified Engineers by Function and Firm Nationality*

	Irish %	MNC %	Total %
Management	32.0	16.3	19.1
Administration	9.2	5.4	6.1
Manufacturing	13.1	51.2	44.3
Information Support	43.8	20.9	25.1
Customer Support	2.0	6.2	3.5
Total	100.1	100.0	98.1
(N)	(153	(689)	(842)

Source: Industry Survey

The extent to which engineers work in R&D depends on three factors: industrial subsector, level of product innovation and firm nationality. In the computers and components sectors, manufacturing is the main activity of engineers, while by contrast in the instruments and in particular the telecommunications sectors, information support is more important.

The proportion of engineers carrying out R&D related activities is also higher in innovating firms. A higher involvement of engineers in R&D type activities correlates with each of three measures of innovation (product innovation, product modification, process innovation).

Finally, R&D activity is also related to firm nationality: Irish firms are more likely to use engineers in this way than are MNC firms (Table 2). The absolute figures here are also revealing. Although the MNC firms in the 1985 survey had a total of 12,000 employees as opposed to the 1,000 of Irish-owned firms, they had only about twice as many engineers in R&D type activities.

A more detailed regression analysis shows the interrelationship of nationality and innovation (Table 3). The major determinant of a high proportion of engineers within R&D is whether or not the firm is introducing a new product, although the number of R&D personnel and Irish ownership also have some independent positive effect.

Table 3: *Regression Analysis: Qualified Engineers in Information Support as a Percentage of All Qualified Engineers*

Independent Variables	Beta Coefficient
Irish-Owned	.053
New Process	– .001
Number of R&D Workers	.199*
Modifying Product	.033
New Product	.398*
R squared	.268

* = Significant at .05 level.

Source: Industry Survey

The underlying cause of these differences is the structure of the Irish electronics industry. Most MNC plants in Ireland are primarily manufacturing operations: this manufacturing is, however, a relatively sophisticated activity — hence the high number of engineers employed both within MNC firms and within the manufacturing function. By contrast, the much smaller Irish-owned firms are either sub-contractors to MNC firms or developing their own niche-oriented products. It is in the latter that engineers are working in R&D related jobs, although the absolute numbers are small in comparison to the MNC sector.

The Use of Educational Qualifications

Engineering education has been expanded in Ireland because it appears self-evidently "useful". However there is remarkably little investigation of what exactly such usefulness involves. This section of the article shows that an educational qualification (such as an engineering degree) is useful in different ways. Furthermore, engineers themselves do not consider the technical aspects of their education to be particularly "useful" for their own work.

The work of engineers is pre-eminently technical work. However, it is also of necessity work that occurs in an organisation within a wider social context. These non-technical factors create 'non technical' activities for even the most technical workers. Engineers in the electronics industry are employed in firms competing on a rapidly changing market: for their work they need to understand the commercial implications of their technical decisions. Furthermore, some engineers also supervise production workers: part of their job is therefore the ability to motivate, supervise and control other employees.

Engineering work occurs within firms and individuals have careers. These two rather obvious facts also bear on the "usefulness" of engineering qualifications. An educational qualification can be an entry ticket for a person's initial job in an industry and/or for his or her current job. Of course, it is usually claimed that there is a relationship between what has been learned in acquiring qualification and what the individual will actually do in the job; but this claim may or may not be true.

Furthermore, individuals have their own career strategies. This is particularly relevant in Irish electronic engineering, where most engineers are young (the mean age of the sample was just under 28) and hope to improve their position either by gaining promotion or by changing employer. Consequently, an educational qualification can be useful because the education led to useful contacts in the industry.

Even when we turn to the technical core of the work itself, a qualification can be used in three different ways. It can provide a detailed knowledge which is applied directly (knowledge of particular products, components etc): it can provide a general knowledge which is a background resource (more theoretical knowledge of the fundamental principles involved); it can provide a problem-solving methodology. Clearly, in different jobs (and even at different times within the same job) one or the other of these dimensions will predominate.

Researching the usefulness of qualifications involved operationalising these considerations. In the interviews the engineers were asked to evaluate their qualifications on six different dimensions. Two dimensions are concerned with the qualification as entry qualification — to the first job and to the current job; these are the different ways in which the qualification can contribute to the technical work task; one concerns the qualification as a career resource. For each dimension respondents were asked whether they considered their qualification "very important", "important", "desirable", "not important", or "irrelevant". The responses are reported either as the percentage ranking a particular aspect "very important" or as the mean score for that dimension when the responses are scored from 5 (very important) to 1 (irrelevant).

Table 4: *Relevance of Qualification at Work by Functional Location: All Engineers*

Proportion considering qualification	Functional Location			
	R&D	Prod'n	Other	All
"Very Important" for:				
Entry to Industry	57.1	75.5	76.5*	71.3 (112)
Entry to Current Post	57.7	49.2	29.6	46.4 (115)
Detailed Knowledge	25.9	18.0	11.1	18.3 (115
Background Knowledge	33.3	14.8	18.5	20.0 (115)
General Approach	22.2	14.8	11.1	15.7 (115)
Personal Contacts	3.7	4.9	11.1	6.1 (115)
Total	(27)	(61)	(27)*	(115)

**For 3 of the engineers in the production area their current job was their first job in the electronics industry: they were therefore not asked to evaluate their qualification in terms of its relevance to entering the industry as such.*

Source: Engineers Survey

Engineers clearly perceived their qualification to have been more important for entering their jobs than for carrying out their current work. Table 4 shows that when asked about their qualification "as a qualification for applying for my first post in the electronics industry", 71.3% of the engineers rated it "very important" (mean 4.6). As a qualification for applying for their *current* post the proportion fell to 46.4% (mean 4.1). In terms of its relevance to the actual work, the proportion fell further still: to 18.3% for detailed knowledge (mean 3.4), to 20.0% for background knowledge (mean 3.8) and 15.7% (mean 3.4) for general approach. Finally, it is noticeable that a minority did value their education highly as a route to useful social contacts.

For these engineers, therefore, their education is *primarily* an entrance qualification to their work. While very few considered it actually irrelevant in the task itself, nearly all believed it was of less importance here. This remained the case even for those with the most relevant technical qualification: of those engineers with a B.Sc. in electrical/

electronic engineering, 77.8% believed their degree was "very important" for entering the industry, but only 16.7% believed that it was "very important" in terms of a detailed knowledge used in their current work (mean scores of 4.7 and 3.6).

The relevance of the degree is clearly related to the functional area in which the engineer works. Table 4 also shows that R&D, presumably the most technical area, is clearly where an engineering qualification is more directly used in work itself. This is especially so for graduate engineers. Whereas 50.0% of the electronic engineering graduates working in R&D found their qualification "very important" for providing detailed knowledge in their work (mean 4.2), this was the case for only 4.8% of those in the production area (mean 3.3).

The extent to which the qualification can be irrelevant is confirmed when we look at how engineers evaluate their qualification as a whole. Asked "In general are you able to use most of what you have learnt (in this qualification) in your current job?" a mere 20.0% of engineers were able to answer positively. When only degree-qualified electronic engineers are considered, the proportion falls to just 12.5%. Once again, perceived usefulness was concentrated amongst those working in the R&D area; yet, even here, the majority believed that their qualification was not of general use. Certainly, most engineering graduates claimed that they had not expected to use their education in work. However, it is noticeable that of those who had expected to do so, the majority were disappointed.

Finally, engineers were asked what they believed their education should have included and what additional knowledge they had acquired on the job. In response to these (unstructured) questions they made clear that the lack of "practical experience" was the main deficiency of their education. Thus, there was little demand for formal business skills, with the exception of personnel issues, but they stated strongly that they lacked an awareness of the demands of business for engineering, and in the technical area, that they lacked practical experience of using equipment. Correspondingly, these were the areas where engineers believed they had gained knowledge and experience on the job. Once again, the engineers working in R&D had a rather different perspective, being far more likely to suggest areas of technical knowledge where their education was deficient.

In taking this attitude the engineers were very much concurring with the views of their managers. In the management interviews managers showed little interest in particular weaknesses of education. For them, the overall academic quality of Irish engineering education was if anything too high, since it tended to orient students towards research issues rather than production. Indeed, "technical" deficiencies tended to be seen in terms of over-specialisation. A few managers believed students needed to study analogue as well as digital electronics, others that more mechanical as well as electronic engineering would have been desirable, still others bemoaned engineers' lack of software skills. What unites these disparate comments is that managers believe that engineering graduates lack much of the knowledge required to work in the production area of an electronics factory.

Such critisisms were relatively reticent. By contrast, managers vociferously criticised Irish engineering education as "impractical". Like the engineers themselves, they saw this as involving two aspects. First, students were seen to lack *practical* engineering skills, a view epitomised by the manager who found university students weak because "they have never held a soldering iron". Second, students were seen to lack "business sense". Managers did not expect engineering students to have a knowledge of accountancy, but they did frequently criticise students for lacking any sense of the time and cost constraints of a commercial environment. Interestingly, unlike the engineers themselves, managers commented rarely on the lack of personnel and supervisory skills transmitted by education. For them such skills could be acquired by experience and were not particulary important. By contrast, the engineers, with their daily involvement in this area, were less likely to see such skills as the prerogative of management proper.

In conclusion, both engineers and managers subject engineering education in Ireland to criticisms which mirror those made for decades of other areas of education. Education is "impractical", it is "too theoretical". This is a curious irony given the extent to whch engineering education has been sold, both to its recipients and to the taxpayers, as the supreme example of "practical" education.

Career Expectations

The growing number of engineers in Irish electronic factories can contribute to future industrialisation by becoming technological entrepreneurs or by providing firms with a skilled workforce. However, if either of these two objectives are to be achieved, the engineers must stay in the industry and, crucially, they must stay in Ireland. This final section of the article, therefore, examines how satisfied engineers are with their jobs and how they see their future careers.

Engineers see their careers as involving mobility. Over a third (39.8%) expected to move companies within the next three years, and of those that expected to stay with the same employer, most expected promotion. A few (9 from 116) did expect to set up their own business, although the numbers involved are too small to analyse in detail.

Engineers' main grievance about their work is quite simply the level of taxation. Dissatisfaction with the tax situation in Ireland has beomce part of the culture of the industry, yet while managers complained about taxation in general, engineers added a note of their own. As *employees* (however well paid) in manufacturing industry, they resented what they saw as the tax advantages of the self-employed in the service sector. As one interviewee put it:

> "I have a job offer from a company which is extremely good. It's in a R&D environment, but for purely tax reasons I won't take it. I'd pay something like a thousand pounds a month deduction. I look at friends of mine that are accountants and solicitors and they're driving BMWs and I'm driving a motor bike."

Engineers often commented that their jobs were not as technically challenging as they had hoped they would be. In particular, some test engineers commented that their jobs could be carried out by technicians; one stated:

> "It's hard to say what is the difference between a technician and an engineer. . .like some people would say that the job here as test engineer is really a technician's. Engineer is the most abused term, what is an engineer in one company could be a technician somewhere else."

And another believed that the position of Ireland within international industry ensured that challenging work was a rarity:

> "We're a manufacturing facility so we're not allowed to design the machines. . .We have a problem out there now, it's a design problem and we fixed it great, but we only get a chance like that about every six months. There are very few places in Ireland that can offer it."

Finally, some young engineers bemoaned the lack of promotion prospects *within* the technical area. To them it seemed that promotion necessarily led out of the technical area into general management; one commented:

> "I think I would prefer to stay in the technical side of things. I think it's strange that when you are very good at the technical side, that's when they take you out and put you into management. I think it's an awful waste in some ways."

The survey results put such comments into a broader perspective. Interviewees were asked to rate six different dimensions of their current job on a 5 point scale (from "very bad" to "very good"). As Table 5 shows, 43% of engineers in R&D consider their job "very good" in terms of technical challenge, whereas this is the case for only a quarter of engineers in production. By contrast, *all* groups of engineers gave their job a low rating in terms of promotion prospects.

Table 5: *Evaluation of Current Job: All Engineers*

	Functional Location			
	R&D	Prod'n	Other	All
Proportion considering current job "very good" for:				
technically demanding work	42.9	24.6	18.5	27.6
secure employment	32.1	24.6	33.3	28.4
good promotion prospects	7.1	6.6	11.1	7.8
good salary	7.1	16.4	29.6	17.2
good fellow-workers	39.3	36.1	25.9	34.5
high responsibility	10.7	15.0	22.2	15.7
Total	(28)	(61)	(27)	(116)

Source: Engineers Survey

Respondents were also asked to rank these dimensions in terms of their relative importance for choosing a future job. Strikingly, here "technically demanding work" turns out to be the most important for engineers in production as well those as in R&D. Indeed, amongst electronic engineering graduates working in production this is even more important than for their colleagues in R&D: graduates in production are clearly dissatisfied that their jobs are not technically challenging.

Surprisingly, perhaps such frustrations are not directly linked to a desire to emigrate. All respondents who claimed they were considering emigration were asked what steps they had taken to realise their plans: 15.4% of all technicians and a quarter of all engineers had already taken practical action. The two main reasons given for planning to emigrate were taxation, followed by a desire for more interesting work.

However, these 'serious emigrants' rated their current job more positively than non-emigrants on all dimensions apart from promotion chances. What does distinguish them is their age: while 18.2% of those over 35 planned to emigrate, this was the case for 32.4% of all engineers under 25.

These young engineers consider themselves in an international labour market and therefore believe that Ireland has little to offer them. Their concern with technically challenging work must also be seen in this career perspective. For them, technically challenging work is almost identical with high technology work: access to such work is not only intrinsically rewarding, it also ensures that their qualification and knowledge remain up to date — and hence that they can continue to be in demand on the international job market. So long as emigration is included in their career options, then there is no contradiction between intrinsic and extrinsic rewards. As one of our interviewees put it:

> "I'm not going to stay. I'll stay for a while, but my ultimate aim would be someplace like California. There are more opportunities there. I think anyone that's driven technically enough, that should be their ultimate goal."

Conclusion

Engineering education in Ireland was expanded to meet the needs of the electronics industry, but the actual experience of engineers has differed from the policy makers' expectations. Irish electronics engineers work primarily in production and find their education too theoretical; rather than providing the labour force of the future for firms in Ireland, a sizeable minority of them intend to leave the country.

At first sight, the best interpretation of these findings is provided by the core-periphery model of dependency theory (for a general application to Irish industrialisation, see Wickham, 1986). Within such a perspective, Irish electronic engineering education appears as an example of *inappropriate* education: just as dependent countries accept inappropriate technology, so they accept inappropriate institutions (Mouzelis, 1978). In a dependent country the local elite hankers after metropolitan status symbols and forms of life, even though the social structure cannot support them. Irish technological education could be such a status symbol. It provides glamorous 'high tech' education which 'peripheral' Irish society pays for but cannot use; it ensures 'core' countries receive a free supply of qualified labour (for a general account see Irizarry, 1980).

Arguably this has occurred for three reasons. First, policy makers misunderstood the Irish situation and produced an inflated estimate of the future demand for engineers. Second, educational institutions ensured their own expansion by promising to produce more 'useful' graduates, while academic career structures favoured research-oriented education. Third, individual students clearly benefit from an education that gives them a good position on the international labour market.

However, such an argument is open to two objections often made against dependency theory as a whole. First, some features that are taken as indicating a dependent situation may also be observed in core countries (Lall. 1975). For example, the extent to which graduate engineers in industry *anywhere* actually use the 'scientific' knowledge they acquire at university appears very dubious. Thus in Britain:

"Even many experienced R&D engineers extol the virtues of practical experience and complain that 'some of the new graduates can't even use a soldering iron', and then take pride in wielding it themselves." (Whalley, 1986: 58).

On this basis the problem may not be engineering education itself, but that it is being over-sold to students and to managers as *training.* One difference between education and training is presumably that the latter contributes directly to work tasks, the former does not.

Second, dependency theory ignores the ways some 'dependent' countries *do* develop. Argurably the whole critique of Irish industrialisation strategy in terms of dependency rests on a false assumption. Both policy makers and their critics have assumed the extent of R&D is a useful measure of technological sophistication and hence of industrial achievement (see for example, Cogan and O'Brien, 1983).

However, this emphasis on R&D ignores the evidence that both historically, and in the contemporary world, countries which have industrialised as 'latecomers' (Germany in the 19th, century, the 'Five Tigers' of South East Asia today) developed by concentrating first on production — by consistently improving the quality of their manufacturing. Actual innovation came later. The very obsession with increasing the extent of R&D may be a preference for the outward trappings of industrialisation over the more mundane substance. If this argument is correct, then a 'useful' *Irish* engineering education woud be much more oriented to Irish industry as it is, and less to how we might like it to be.

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