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Work-based Learning and the Manufacturing Industry*

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This paper is based on the Harold Armstrong Memorial Lecture delivered by the Author in the Faculty of Engineering, Monash University, Melbourne Oct 2001. It sets out to review some of the challenges facing manufacturing industry in the twenty-first century. The paper first presents an outline of the major forces that have shaped the development of manufacturing enterprises and how these have changed over time. Market, technology and knowledge forces are considered and the effect of their evolution on manufacturing industry suggested and the tensions these have created in engineering programme design are noted. The recruitment of suitably qualified graduates, the retention of experienced staff and the impact of rapidly changing knowledge resources on the people involved in manufacturing engineering is discussed. The basic principles of work-based learning are described, and its role within manufacturing industry is suggested. A case study of how work-based learning has been effectively used to improve manufacturing performance while addressing staff development is outlined. Finally the paper suggests a model for developing specific programmes to meet the needs of particular industries.

INTRODUCTION

MANUFACTURING is a process by which raw materials are processed into final products, which are marketed for sale. To borrow from Charles Dickens: *'If the cost of production is £0.95 and the selling price is £1.00 then the result is happiness. If the cost of production is £1.05 and the selling price is £1.00 the result is misery.'* Factors such as raw materials, energy, and market prices and of course people are involved in manufacturing. To achieve success an organisation must seek to gain competitive advantage. Competitive advantage is necessary to ensure a market share so that a manufacturer has the basics of a profitable company. How then do companies establish the conditions necessary to create competitive advantage? Some suggestions are:

- Apply new technology and management skills to develop more efficient internal systems.
- Undertake research and development within company resources or through association with suitable academic partners.
- Recognise that corporate/company knowledge is now a key asset. However, how do companies identify the extent of their knowledge assets and how do they develop knowledge workers?

Ducker [1] observes 'Now that knowledge is taking the place of capital as the driving force in organisations worldwide, it is all too easy to confuse data with knowledge and information technology with information'. Development of new knowledge in any organisation can be achieved by developing existing staff or by recruitment. To recruit there needs to be a supply of new graduates with appropriate skills. Recent evidence suggests that the trend in recruitment of students to engineering programmes is unfortunately not very encouraging. An analysis of recruitment in the UK is shown in Fig 1. The figures for this were obtained from the UK Higher Education Statistical Archive and show a situation that has been reported in various countries in Europe.

Recent figures from the *Scotsman* newspaper October 2001:

- 5% drop in Mechanical Engineering.
- 7% drop in Chemistry.
- 21% increase in Media Studies.
- 17% increase in Cinema Studies

Recruitment to engineering programmes in the UK has in recent years been declining and there is some evidence that this is also true in Europe.

Against this background the engineering knowledge required to ensure up-to-date use of technology in manufacturing is continually changing as a direct result of advances in all branches of science and technology. The knowledge base of skills and techniques is constantly changing, producing technical and commercial pressures to ensure that product characteristics reflect technology. Thus particular products have a much shorter life cycle.

MANUFACTURING AND COMPETITIVE ADVANTAGE

Competitive advantage provides a company's products with an 'edge' in the market place: it creates the opportunity to gain market share, increase revenue and profits so providing the

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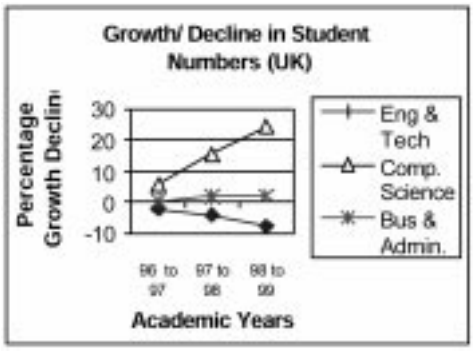

Fig. 1. Student numbers 1996 to 1998 intake. (Source: HESA Database.)

capital for further investment in product development. Many factors will influence how a manufacturing company seeks to achieve competitive advantage. However, given the rapidly expanding availability of new knowledge the following are some suggestions of key issues;

'The increasing pace of technology change has placed substantial pressures on companies to increase the speed at which they develop and apply knowledge' [2]. As the acceleration of the knowledge economy continues companies will have to give serious consideration to strategies that maintain their knowledge capital. An important element in this is investment in people to develop them as knowledge workers.

The consumer market is now global and this adds a further pressure to meet diverse expectations that are driven by technology innovation. Maintaining leading edge technology skills through knowledge generation and management [3] will be essential to ensure products and services in a global or national market reflect the features and functions that meet consumers' expectations.

Knowledge generation at the site of its application, that is, within the work place, is increasingly a feature of the expansion of knowledge. To make the most efficient use of skills and resources in both industry and academia it is evident that industry and academia will work more closely in the production of new knowledge [4].

MANUFACTURING AND ACADEMIA

How can industry and academia address the opportunities that this new dynamic knowledge-led business and manufacturing environment presents? Gibbons [5] described a new vision of the how the role of higher education in the twenty-first century might be developed. It is useful to consider what demands this new environment places on manufacturers and reflect on some of the more obvious constraints that need to be addressed to satisfy them.

Demands

Technology is continually evolving and developing new methods and processes as part of the search for greater efficiency and environmentally friendly operations. Such evolution has progressively increased the level of technical skills required of the staff, who are expected to implement and operate the outcomes.

The emphasis on the development of employees as knowledge workers adds a new dimension to the role of people management within an organisation. The provision of appropriate training and development programmes for staff at all levels is an essential part of the process of creating a knowledge environment that is integral to securing competitive advantage.

One of the most significant changes in recent years is the amount of development work that takes place in the work place. Many companies now see the investment in knowledge production as an essential part of increasing the knowledge capital of the organisation and providing the basis for further product development as well as increasing the value of the company.

Constraints

The demand side of the position outlined above is essentially centred on two issues, people and knowledge. The people issue has two aspects, people in the organisation and recruitment to the organisation. Recruitment at professional engineer level depends on the output of engineering graduates. The figures noted earlier reflect a trend that suggests a decreasing resource at least in the UK and arguable in Europe. This is further complicated by the ever-increasing expansion of 'knowledge areas' as the frontiers of science progress onwards thereby causing tensions between requirements for professional accreditation of academic courses and the needs of industry to embrace cutting edge technology. What can be taken out of the undergraduate curriculum to allow space for new technology without compromising entrenched institutional inertia?

The undergraduate curriculum of engineering programmes is structured to reflect the knowledge base considered necessary by accrediting engineering institutions to meet academic requirements. Typically this will address the facts, procedures and processes associated with a single discipline. Such a focus on a single discipline approach, while perhaps necessary to ensure a solid foundation, does little to prepare the student for the transdisciplinary nature of the product development environment and the diversity of challenges that are modern manufacturing [6]. The 'shelf life' of the degree knowledge base is necessarily being continuously reduced as the rate at which the transdisciplinary knowledge used in manufacturing is increasing.

KNOWLEDGE STRATEGY

Knowledge, its development and application are key themes in how companies gain and retain

competitive advantage in the 21st century. The increasing rate at which new knowledge is generated and the much greater access to sources of knowledge create the potential for a company's knowledge capital to become obsolete before they realize this unless some strategy is in place to ensure regular review and updating. A full consideration of all the factors that will influence such a strategy is beyond the scope of this paper but the following suggestions represent a starting point:

- Awareness of knowledge capital as a key feature of company value.
- Policy for investment in developing knowledge through alliances with other organisations e.g. universities, corporate universities, etc.
- Recognition that these alliances involve organisation personnel in development of knowledge.
- Policy for the development of key personnel as knowledge workers and contributors to the knowledge capital of the organisation.

The implementation of such strategy will rely on expertise and resources that are not wholly within the company. It would not be economic for a company to incur high specialist equipment costs unless there was a long term rationale. One solution to this is the formation of alliances with higher education institutions to pursue the development of knowledge. The nature of such alliances, have in the past often been uncomfortable because the objectives of the partners were not clearly articulated at the start of the collaboration. A clear definition of the objectives is essential if such alliances are to be beneficial to all participants. One basis for such clarity is a clearly specified company-based strategic objective

MODEL FOR ALLIANCES

Gibbons [5] explores at some length the future relevance of higher education in the twenty-first century and concludes that the role of higher education institutions has to change to reflect the changing nature of knowledge production. He emphasises the collaborative role and proposes a set of characteristics that define educational processes that take place in the institution and the work place. Institutional processes he refers to as Mode 1 and are seen as discipline-based whereas work-based processes are referred to as Mode 2 and seen as involving the individual in multiple disciplines and are therefore transdisciplinary. Adopting this basis allows the definition of a work-based learning (WBL) programme that uses the strategic objective of the host organisation to enable Industry–Academia collaboration, employee's to update their knowledge, generation of new knowledge, academics to engage in research with industry, industry to achieve strategic aims and to develop employee's [7, 8]. To facilitate these a work-based learning partnership has three components:

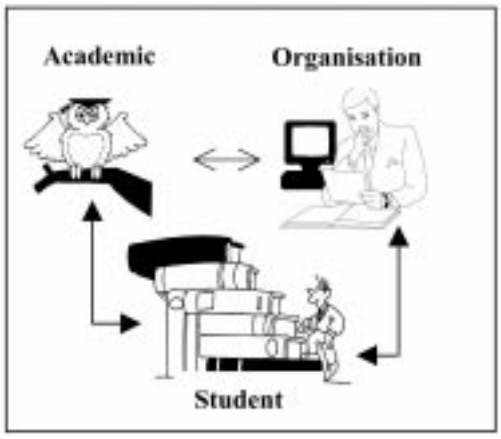

Fig. 2. Partners in a work-based learning agreement.

- the host organisation who define the strategic objective (the basis for collaboration);
- the academic partner who provides supervision and ensures appropriate rigour;
- the student who is an employee of the host organisation and who undertakes research training in order to deliver the outcomes required to address the strategic objectives as set out by the host organisation.

The work-based learning proposal

A work-based programme of study can be defined for post- and undergraduate levels [9]. However since this paper is primarily concerned with the model of alliance for the generation of new knowledge it will discuss the model as applied to postgraduate study.

The programme of study starts with the identification of a strategic objective, for example, to increase inventory turnover, to reduce manufacturing times. Based on a strategic objective a set of learning goals is defined to deliver the learning or research that will enable the delivery of the strategic objective. The outputs of the individual learning goals may form the basis of assessment criteria.

CASE STUDY

An aero engine refurbishment company needed to reduce the time to overhaul an engine from 72 days to 35 days to achieve competitive advantage.

- **Strategic aim:** reduce repair time of large engine from 72 days to 35 days.
- **Goals:** to study processes associated with repair processes
- **Outputs:** reports/recommendation to enable delivery of strategic aims.

To construct the programme it is necessary to agree what goals would achieve the strategic aim. In the example given it became evident that the work required was more than a single student could undertake in a realistic period of time. The process associated with the repair process involved

material management e.g. application of supply chain management practice; work flow though the facility; testing of components to determine replacement needs and financial implications. Each of these areas represents a major investigation, for example the material management would need to address:

1. Supplier management (supply chain).
2. Inventory management (internal processes).
3. Kitting issues—should contain sets of spares.
4. What philosophy is appropriate?
5. Some element of financial analysis.
6. Forward looking analysis—how will things change?

On this basis there are at least six goals to be addressed in examining how material management would contribute to achieving the main strategic aim. Similar consideration would be given to the other sub sections of the main strategic aim. Each goal then has to be further analysed to define the learning outcome, activities to be undertaken to deliver the outcome, resources necessary and finally the assessment mode to be adopted, in this context the supply chain management goal could be defined as follows:

- **Learning goal**. To demonstrate knowledge of the techniques and issues that are current in supply chain management. Apply this knowledge to analyse current organisation practice.
- **Activities**. To undertake a programme of directed studies. To attend appropriate lectures as identified.
- **Assessment criteria.** Students should be able to demonstrate knowledge of current theory and practice and its application to the host organisation. Students should show evidence of application of knowledge to current practices through a critical analysis and report.
- **Assessment method.** One report that critically reviews current theory and practice and a second report that gives an analysis of current practice in host organisation Specific recommendation should be made in relation to strategic aim.
- **Resources.** Access to library, computer, etc.

This outline shows how a work-based learning programme can be constructed where each major investigation is divided into a series of goals [10]. The nature of the work to be undertaken may be investigative and likely to be of masters standard. Work-based learning frameworks are also in place to consider proposals for research, which would lead to a doctoral level award.

CONCLUSIONS

The challenges facing manufacturing industry are not simply recruitment of sufficiently talented new graduates but have a much wider horizon caused by global markets and ever-increasing knowledge resources. The development of a manufacturing organisation is allied to its ability to gain competitive advantage, which is influenced by all engineers to see engineering challenges in a new multidimensional form that encourages the integration of knowledge. This approach is sometimes referred to as developing knowledge workers and transdisciplinary teams. The increasing knowledge base and development of specialist knowledge areas poses some challenges for engineering education. Institutional accreditation of engineering programmes is based on essentially a didactic process of education focusing on disciplines whereas the practice of engineering is based on trandisciplinary teams involving a range of disciplines.

Work-based learning is a methodology that has been adopted by institutions in the UK, Australia, USA, Europe and South Africa. The details of the particular frameworks differ but the essential elements of relevance, rigour and personal achievement are common. An example of potential generality of the method is the Learnership programme in South Africa. The Learnership is part of the government policy, which supports industry and individuals in achieving educational objectives related to industrial development [11]. Essentially this requires that employers and academic institutions work together to provide programmes of study for people in employment, almost exactly the model described in this paper.

The development of knowledge workers and teams able to integrate knowledge from a range of disciplines does not happen by accident. The concept of work-based learning where programmes require students to acquire and integrate new with existing knowledge provides a programme that enables the development of knowledge workers. In addition, WBL offers organisations the opportunity to address strategic objectives allied to competitive advantage through alliance with institutions where specific expertise is available. The academic institution also has the opportunity to become involved in research that realises leading edge application of technology.

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