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Can Construction Learn from the Experiences of Other Sectors in Achieving the Appropriate Balance Between Organisational and Technological Innovation?

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Abstract

Studies of the use of advanced technology in manufacturing have given clear indication of the need for simultaneous changes in organisation and management practices if a successful and sustainable implementation of advanced technology is to be assured. It can also be shown that it is sometimes counter productive to introduce new technology without adapting the other elements of the processes involved. The successful use of advanced technology in the manufacturing sector has led to the introduction of post-Fordist approaches based on group work, ongoing training, involvement of the workforce at all levels, quick and effective communication in all directions, flatter types of organisational structures, the integration of major functions, and strong and long term relationships with other partners engaged in the process. A number of weaknesses have been identified in the construction industry including its fragmentation, limited commitment to R and D, and reluctance to embrace new technologies. It has been suggested that these shortcomings are explained by the uniqueness, diversity and the complexity of the construction process. However, the organisation of construction, because of its project based approach, direct client involvement and the need for flexible and responsive approaches to production, can be considered as being close to the post-Fordist model and therefore conducive to the introduction and effective use of advanced technology. This paper investigates the successful application of advanced technology in construction by examining the key elements of organisation in construction which are close to post-Fordist practices, and hence proposes strategies for transferring and implementing best practice from manufacturing into the context and culture of construction.

Key words:

Advanced manufacturing technology, technological innovation, organisational innovation, transfer of technology, manufacturing, systems integration, construction and culture.

1 The Use of Advanced Technology in Other Sectors

For a better understanding of the use of advanced technology this section of the paper reviews the experience gained in the manufacturing sectors and seeks to identify what can be learned and transferred into construction.

There is a long trend towards the convergence of manufacturing operations right through design, production and coordination into Computer Integrated Manufacturing (CIM) via intra-activity, intra-sphere and inter-sphere integration (Kaplinsky, 1984). This integration of design and manufacturing activities is extended to managing the various coordination and control activities regarding the preparation, planning and management of production (Poths and Low, 1985; Hoffman and Rush, 1988; Bessant, 1990; and Saad 1991). This integration is also creating a link between information about production and the rest of the business.

This double integration corresponds to the concept of CIM. The Economic Commission (1985), describes CIM as a combination of software and hardware comprising elements such as product design, production planning, production control, production equipment and production processes. It is therefore based on an overall "factory system" (Knight, 1984), built on an integration of functions from sales, accounting, Computer Aided Design (CAD), and manufacture, quality and production control. The concept of integration is being increasingly viewed (Ferdows et al, 1987; Bessant, 1990), as a key to successfully meeting the challenges posed by the economic and social pressures facing manufacturing today. CIM is a system where the objective is to enhance the overall effectiveness through a wide range of benefits which enable firms to cope with the priorities and the needs of the new business environment (De Meyer et al, 1987).

However, achieving such advantages, which relate to improvements in the entire business rather than a single area, requires higher levels of integration and accordingly a need for organisational change. Indeed, increasing technological integration has indicated the necessity for functional integration. For instance, Flexible Manufacturing Systems (FMS) create strong relationships between production, quality, and maintenance. CAD/CAM systems link the design with the manufacturing operations. This trend of higher integration goes beyond the limits of the firm. This, as Lamming (1987 and 1993) and Saad (1994) argue, calls for the need for a long term partnership and mutual developments with suppliers to replace the adversarial relationships which often exist. This is why many studies point out the need for organisational change if the full benefits of technological innovation are to be gained. Leonard-Barton (1988) speaks of the need for "mutual adaptations" and Ettlie (1988) suggests an approach based on "synchronous innovation" whereby technical as well as organisational innovation occur simultaneously.

The increasing application of new technological innovation also demands substantial new skills to support them. These skills are related not only to direct operations but also to management and coordination (Bessant 1990). Thus new technologies generate demand for organisational innovation as well as new skills. This shows, as Dempsey (1982) proposes, the need for a "new way of thinking" based on a total system solution involving managerial/ organisational as well as technological change.

In a comparative study, Nicholas et al (1983) give evidence that implementation of Numerical Control (NC) and Computer Numerical Control (CNC) conducted with organisational and procedural adjustments lead to a better use of these systems. They reported that British firms, where organisation was still structured to Fordist principles and formalised structures, used NC and CNC in a way which maintained a planning and control department and resulted in a segregation between the different operations and activities. As a result, activities and groups with a common objective were not merged and harmonised, and tended to be structurally isolated form each other. In Germany, for example, CNC and NC organisation was fashioned so that it linked foremen, chargehands, workers, and planners around a common concern.

Rush (1989) argues that one of the major constraints on the diffusion of Advanced Manufacturing Technology (AMT), as well as on the efficient exploitation of the systems, has been a lack of in-house skills and knowledge. Indeed, the adoption of AMT has introduced a trend towards integration of the production system, whereby the level of decision making and information processing has increased, requiring a more skilled and qualified workforce.

In addition to this knowledge and awareness, Nicholas et al (1983), Fleck (1983) and Haywood et al (1987a and 1978b) have all pointed out that diffusion is also influenced by the commitment and participation of the workforce. In Swedish as well as in former West German firms studied by the above researchers, the implementation of AMT was preceded by consultation with trade unions. Successful installation of technological innovation is associated with attention being devoted to human factors such as social and psychological aspects, work environment, work conditions, and ways of rewarding personnel (proceedings of the seminar on Flexible Manufacturing Systems (FMS), 1984). This report goes on to argue that human factors related to involvement and participation of the workforce can be influenced by training and retraining programmes.

Simply buying the physical or technical aspect of a technology is not enough, and can, as Cooper (1980) and Bessant (1990) argue, be inappropriate and counter-productive. Ettlie (1988) and Jaikumar (1986) have highlighted that the main reason underlying failure to secure the full potential benefits of AMT is the lack of organisational adaptation. Similarly, Schonberger (1982), Jones (1990) and Tidd (1991), argue that the superiority of the Japanese manufacturing is derived from their superior organisation.

Piore and Sabel (1984) report that new manufacturing priorities based on non-price factors as described by De Meyer et al (1987) need an alternative built on flexibility that the mass production organisation, characterised by the division of labour and rigid bureaucracy cannot offer. A new solution needs a closer working relationship between different departments of a business and the dismantling of boundaries. Jacobson et al (1983) suggest that the new solution requires a compatibility between technology and organisation. This compatibility refers, essentially, to the fit of new technology with existing work patterns and skill distribution. Accordingly it addresses the system as a whole characterised by a balance between technology, labour and organisational arrangements. Thus a major pre-requisite for effective management is the adoption of a total system approach. The removal of boundaries and the need for cooperation and communication between the different departments of an organisation implies, as Lui et al

(1990) and others suggest, alterations in skill, structures and procedures, and even culture.

New technology brings a new "way of thinking" based on changes throughout the entire business. Success in dealing with such changes calls also for a new approach to learning. Indeed the ability to deal with unpredictable tasks and to respond as quickly as possible to changes from the internal and external environment requires knowledge about the system as a whole taking into account the various interactions. This form of learning must also include understanding about the strategic and organisational implications. Bell (1984) argues that learning which encompasses the intra-firm managerial and organisational capabilities is needed to provide an environment generating effective change. It is precisely the lack of this type of understanding which is responsible for the ineffective management of new technology (Simmonds and Senker, 1990). Chief of all the elements of the new approach is the necessity to change the culture of the organisation (Saad, 1993).

Therefore, the key determinant of the successful use of advanced technology in manufacturing is the development of a new way of thinking based on organisational changes requiring better communication and cooperation, flatter and less hierarchical structures, and a better trained and more participative workforce. These emerging ideas are increasingly seen as a new organisational paradigm (Post-Fordism) which can be used to explain the changes in economic structures and activity that have characterised market economies in the later years of this century.

2 The Relevance of the Emerging Organisational Paradigm (Post-Fordism) in Construction

Although construction is often perceived as technologically stagnant with a culture resistant to change, a review of construction in the UK during the post-1945 period reveals a great deal of change (for example Ball, 1988). There have indeed been significant shifts in the structure of the construction industry, its products and processes and its employment patterns (Bowley, 1966). This suggests that construction has changed and been an integral part of the dominant technological-economic paradigm of the past fifty years. There is evidence that clusters of interrelated technical, organisational and managerial innovations, based on Fordist and Taylorist principles, coupled with ideas imported from other industries, have led to improvements in product performance, productivity and a shortening of construction cycles. There is no evidence to suggest that construction will not respond similarly to the new business era based on Post-Fordism with its emphasis on the use of advanced technology, customerisation and the adaptability to meet market forces. Yet these developments will continue to be structured and constrained by the economic, social and technological trade-offs defined by construction's contracting system which emerged over 150 years ago in the early part of the nineteenth century.

The process of adopting Post-Fordist approaches will, however, involve identifying the needs of construction's clients, undertaking a fundamental review of the present construction process (Latham 1992), scanning other sectors of the economy and other countries for ideas, identifying mechanisms to transfer these ideas across the boundaries between the different cultures involved, and developing strategies to modify and adapt these ideas so that they can be sustained within the specificity of construction (Saad and Jones, 1994).

Although some aspects of the contemporary technology-economic paradigm are already reflected in the design and production of buildings and civils works, most notably in computer aided design (CAD), knowledge-based design, communications, scheduling and financial control, they still have not been totally integrated and fully exploited (Wing, 1989). Also the principles and practice of AMT, a significant element of post-Fordism production in manufacturing, has not yet significantly penetrated the industry.

Many reasons have been postulated for this slow adoption of new design and production methods (Drewer, 1990). These mainly relate to the present technical limitations of the emerging technologies, the culture and structure of the construction industry, the complex nature of site-based work tasks, the reluctance to repeat the mistakes of the industrialisation of construction in the 1960s and 1970s, and the present lack of communication between the advanced technological, manufacturing and construction communities (Jones and Cusack, 1992).

A further key factor in restricting the diffusion of new technologies into construction is the lack of educated and highly trained people which impedes creativity and participation of the workforce. Construction employers' efforts to ensure an adequate supply of skilled labour have been contradicted by their encouragement of subcontracting, narrow specialisation in an expanding range of standardised tasks, and offering high wages to secure ready-trained labour when demand allowed or required (Winch 1968). However, shortages of supply do not only apply to the traditional building skills. Changes in the construction process built on post-Fordist principles will introduce requirements for increased technical, supervisory and managerial skills (Gann, 1988) resulting in a distinct lack of congruence between the processes of skill formation and work reorganisation.

3 Conclusions

Advanced (and increasingly flexible) Manufacturing Technology is an assertive and integral part of the contemporary technological-economic paradigm and as such is likely to exact a significant shift in construction's present production paradigm.

The application of AMT requires the organisation to undertake significant changes and undergo a significant period of learning through which understanding, knowledge and new skills are acquired before being able to exploit the full benefits offered.

The effective use of advanced technologies based on systems integration requires strong and stable intra and inter-organisational relationships in order to respond quickly to market changes including a more customer orientated approach and increasing global competition. The development of long and stable inter-organisational relationships in manufacturing have led to better cooperation with suppliers and more effective joint investment in advanced technology, R&D, training and quality improvement.

The diversity and complexity of the construction process implies a total production function incorporating different skills, materials, organisational structures, technologies and perspectives which suggests that construction does have many characteristics which probably make it unique among other economic activities. It is this perceived uniqueness of the construction industry that contributes to some of its present deficiencies and accounts in part for the industry's reticence in adopting new technical and managerial ideas and organisational structures.

This paper argues that the construction industry - with its project based approach, direct client involvement and flexible responses to market conditions - is already embracing some of the ideas and innovations associated with post-Fordism. However, progress in applying the new ideas associated with the current paradigm to construction is currently inhibited both by the degree of fragmentation and specialisation which exists in the construction, advanced technological and manufacturing sectors, and by the lack of a common and effective means of communication.

Strategies are needed to develop an appropriate synergy between the construction community (and its technologies and practices), the mechatronics industries (and their developing devices) and the manufacturing community (and the lessons already learned from the use of AMT).

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