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Article abstract

Drawing on evidence from five detailed case studies, this paper focuses on the relationship between technical innovation and non-manual skills and work organization. In none of these cases could the introduction of new technologies simply equate technical innovation with deskilling and enhanced managerial control. Indeed, one of the more interesting and important findings of the research was that technological change has been more favourable for technical than for clerical occupational groups.

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Drawing on evidence from five detailed case studies, this paper focuses on the relationship between technical innovation and non-manual skills and work organization. In none of these cases could the introduction of new technologies simply equate technical innovation with deskilling and enhanced managerial control. Indeed, one of the more interesting and important findings of the research was that technological change has been more favourable for technical than for clerical occupational groups.

One of the abiding concerns in the study of work over the past two decades has been the growth of the non-manual workforce and its increasing representation within trade unions in the public and private sectors. The reason for this continuing academic interest has been the sheer scale of growth of non-manual employment until, in the 1980s, more than half of the British workforce was engaged in non-manual work (Bain 1985)¹. This reflects not only an expanded service sector and larger central and local government administrations, but also the greater number of clerical, administrative, technical and scientific workers required to co-ordinate activities in large-scale manufacturing organizations.

But within what is now a proliferation of writings on new technology, apart from Rolfe (1986) and Webster (1986), there is little analysis of its influence on the changing nature of non-manual work. This paper focuses on the relationship between technical innovation and skills and work

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¹ In the 1980s more than half of the Canadian workforce was also engaged in non-manual work (McKittrick 1989).

organization. Has the impact of new technology been to increase constraints on non-manual workers, or to expand technical complexity and discretion?

Technical innovation will, of course, reflect the broader strategy of employers. Hence the reasons underlying it are likely to vary widely. In the "labour process" literature the central stimulus to technical change is generally seen to be the desire of the employer to deskill and control the worker (for example, Braverman 1974; Edwards 1979). For Braverman new technology constituted a further significant step in the degradation of work, while for Edwards new technology permitted not only the more widespread application of technical control over the direction of work but also the evaluation of worker performance through technical means. Through the application of micro-electronics, management is able to remove labour from the production process since its functions are increasingly assumed by the technology; accordingly, the employer has need of fewer workers.

This argument is incomplete. Technical change often leads to increases in worker skill and control, while labour considerations are often not the primary consideration of the employer at all. The state of the product market and the costs of inputs other than labour are important. Technical innovation may, therefore, reflect changes or chances in the product market or in the use of raw materials, quite independent of labour market considerations.

The exact importance of labour considerations in decisions will clearly vary according to the product process, the nature of the labour force and the nature of the employer. It is, however, possible that innovations which have been introduced for product market reasons are seen to have implications for the way in which labour is used. That is, new technology may provide opportunities or create problems in relation to the labour force which might not initially have been foreseen. The scale of the literature advising managers on the implications, particularly in organizational terms, of new technology suggests that this is often the case (for a useful review of this theme see Marstrand 1984).

The related debate on managerial control strategies focuses on two questions: the degree to which there is a discernible, conscious managerial strategy and the extent to which scientific management is representative of such strategies. It appears from recent debates and research that the answers to these questions share some common ground. Managerial strategies are seldom a coherent derivation from the "objectives of capital". To secure control of labour and other resources and markets, management has to utilize a variety of techniques. This is facilitated by a restructuring of

technology and markets which, as Rose and Jones (1985) found, do not translate automatically into predictable movements in the frontier of control within workplaces.

Drawing on evidence from extensive research allows a close look at the practice of technical and office work in Britain where incremental and often small-scale changes are taking place. (A full account of this research is presented in Smith 1987.) Research in five non-manual environments where new technology had recently been introduced strengthens findings concerning manual workers (for example, Wilkinson 1983; Jones 1988). In none of these cases could the introduction of new technologies simply equate technical innovation with deskilling and enhanced management control. Indeed, one of the more interesting and important findings of the research was that technical change has been more favourable for technical than for clerical occupational groups. And what also emerges is a tendency for overall skill polarization to occur rather than straightforward "deskilling".

The five cases covered a range of production and service environments and workplace size. They ranged from a specialist metals research organization with less than 100 non-manual employees and a textile company producing blankets with 450 manual and 78 non-manual workers, to a group of modern telecommunications exchanges with over 400 technicians, the central administrative organization of an automotive parts producer with some 1,000 non-manual workers, and 2,500 non-manual employees in local government. The environments were selected primarily to reflect a mix of occupational and organizational characteristics. These cases are, of course, not statistically representative of any sector. As with any such case study research their importance lies less in their typicality than in the insights which they provide into processes of change.

In all the case studies a variety of techniques was employed: interviews with union officials, representatives and managers; observation of work and union situations; and the analysis of a wide range of union and management documents. Approximately three months were devoted to the first stage of research in each of the case studies. During these three months of intensive research an attempt was made to become as fully aware as possible of the organization of work within the companies and the industrial relations processes as they affected non-manual workers. They were studied between April 1983 and November 1986. Contacts were not, however, terminated at the end of this period. Return visits were made two years after the detailed research had been completed in order to assess changes in the workplace. About one month was spent on these return visits in each case study.

Because of their influence on discussions about the nature of work, the insights and limitations of labour process analysis are summarized in the next section. Using the detailed evidence from the case studies, the following section examines the influence of new technologies on skills and work organization. The concluding section develops the argument that the introduction of new technology cannot necessarily be explained in terms of a concern to deskill labour.

LABOUR PROCESS ANALYSIS

In the early 1960s the study of occupational change focused on the increasing automation of industrial processes. The analysis suggested that, as technology increased in complexity, semi-skilled manual work would decline and "knowledge" related non-manual professional, technical and clerical work would increase (Kerr *et al.* 1961; Blauner 1964; Bell 1974). More recent interest in the nature of work stems from Braverman (1974). He replaced this strong technological deterministic presentation with an approach which placed emphasis on the class-related nature of technology and work organization. Essentially Braverman's thesis was that there had been a general and progressive deskilling of jobs in the twentieth century; that there was a long-term trend for jobs to be increasingly routinized and mechanical. Linking the organization of work to class analysis, he argued that the working class had become increasingly homogenous.

Braverman's arguments have stimulated an extensive debate on the nature of work in capitalist societies. In particular, more recent developments in labour process analysis have been significant as a counter argument to the view that skills will be increased and workers will become more autonomous as new computing and information technologies are introduced. For writers sympathetic to Braverman's thesis any restructuring and managerial initiatives will involve labour intensification and the enhancement of control of labour (Armstrong 1988; Thompson 1990). Furthermore, "for labour process theory, technology has no influence on work organization independently of management's need to control" (Noble 1979, cited by Wood 1989: 9). However, other writers contributing to the labour process debate have been more critical of the excessive focus on management control of the labour process; the neglect of worker resistance; and insistence that all issues between management and the workforce are conflictual.

The first area of debate relates to the assumption that the imperatives of capital accumulation (that is, the drive for profit) require management to

wrest control over the labour process from the workforce, and that one particular strategy, "scientific management", is the most appropriate way of achieving this. This argument has been questioned on the grounds that there are other strategies available to management in their quest to control labour, and that these may not involve a deskilling of jobs and reduction in worker autonomy (Friedman 1977 and 1990). Other writers have sought to question not only the primacy of deskilling as *the* management strategy, but have also challenged the idea that management control of the labour process, by whatever means, is in fact the motive force behind management concerns. This view of management reflects developments in technology and production independent of labour control (Kelly 1982; Blackburn *et al.* 1985; Littler 1985).

The second area of debate is the extent to which the implementation of management strategies are unproblematic. This has arisen because of Braverman's view of management as a homogeneous grouping, and the lack of significance by his analysis to the individual and collective response of labour to management strategies. This view seems to bear little relation to what happens in reality, and much recent empirical work within the labour process approach has sought to document the many instances of labour resistance and its capacity to modify management strategies through engaging in a "contest for control" over the labour process (see, for example, Knights and Willmott 1986).

The third area of debate is on the model of the employment relationship. For proponents of Braverman's model relationships between management and workforce on all issues are conflictual. This leads to the conclusion that the workforce always needs to be 'controlled' by management and ignores both the possibility of common interests, and what has been called "the organization of consent" (Burawoy 1979: 27). In the context of introducing new technology it is unrealistic to assume that the only response of labour will be to resist management intentions (Smith 1987). Indeed, in many circumstances labour may endorse and actively support management plans. (This overview of criticisms of labour process theory is based on McLoughlin and Clark (1988: 37-39). For important contributions to the labour process debate, see Burawoy 1979; Edwards 1979; Cressey and MacInnes 1980; Elger 1982; Littler 1982; Wood 1982; Thompson 1983; Knights and Willmott 1990).

As recent developments in labour process analysis suggest, the effects of technical change may be more complex and ambiguous than Braverman and proponents of his model have argued. Braverman and his supporters are no doubt correct in their criticism of technological determinism, especially where it leads to conclusions that the introduction of automated

technology will inevitably raise the general level of skill and autonomy of the workforce. However, the argument that the effects of technical change can be explained largely if not wholly in terms of the deskilling of work is equally flawed. To illustrate this point, the five case studies have been subdivided into three groups: technical workers in telecommunications and metals research, maintenance technicians in automotive parts, and clerical and administrative workers in automotive parts, local government and textiles (Table 1).

Table 1
Occupational Groups and Principal Findings

<i>Case Studies</i>	<i>Occupations</i>	<i>Principal Findings</i>
Telecommunications	Technicians	Increase in computer-related skills
Metals Research	Technicians	Increase in computer-related skills
Automotive Parts	Technicians	Polarization of skill requirements
Automotive Parts	Clerks and Administrators	Narrowing of range of tasks Increase in pace of work
Local Government	Clerks and Administrators	Narrowing of range of tasks Increase in pace of work
Textiles	Clerks and Administrators	Narrowing of range of tasks Increase in pace of work

EVIDENCE FROM THE CASE STUDIES

Telecommunications Technicians and Scientific Researchers

In telecommunications technical change was part of the on-going development of telephone exchange switching and transmission equipment incorporating advanced micro-electronic technology over the past decade. This study examined one part of this development: the important process of local exchange modernization. Specifically the research covered about 400 maintenance technicians working in one of three exchanges in close proximity to each other.

The new technology radically changed the work of these maintenance technicians. Under the old electro-mechanical system maintenance involved the physical inspection of the exchange equipment. Diagnosis of faults was

relatively simple; sectionalization meant that breakdowns in one part of the exchange did not affect the whole system; and the repair of broken switches required considerable manual skills.

Under the micro-electronic system switching was largely invisible. Fault finding was more difficult and required more understanding of the whole system; the system was more integrated with breakdowns having wider potential impact; and the task of repairing switches was replaced by a simple task of replacing a slide-in card or soldering a new component to replace a faulty one.

There was therefore a requirement for a different order of mental diagnostic and interpretive ability, combined with a broader system understanding compared to the electro-mechanical system, in particular since the electronic technology's appearance gave no direct visual or audible clues to its operations or fault conditions. The new skills necessary to accomplish maintenance tasks showed a qualitative change in contrast to those previously required. The electro-mechanical theory, manual dexterities and elements of tacit knowledge associated with the previous system were no longer needed. Instead, there was now a strong emphasis on mental diagnostic skills. Problem-solving involved a clear understanding of electronics and the 'common control' principle in order to be able to conceptualize the exchange as an interdependent system and to interpret information from test equipment and computer print-outs. The method of working also changed, with increased use of group working (see also Clark *et al.* 1988).

Overall then, the impact of the new technology removed the need for many manual skills but required new problem-solving mental skills. This did not involve either a uniform tendency towards a deskilling or reskilling of work tasks. Rather, both processes were in evidence. "Deskilling" occurred in so far as the manual skills were no longer required. "Reskilling" occurred in the form of a qualitatively different level of mental diagnostic and system skills.

In metals research design and development work by research officers and research technicians was linked, on the one hand, to research and development and, on the other, to production management. Micro-electronic technology was being utilized to improve the technical efficiency of established testing processes. This small specialist organization employed just under 100 technical workers on a single site.

Research officers, who were largely located in the materials processing division, were doing the work of design engineers and research controllers. Research technicians also located in the materials and processing division

were mainly metallurgists engaged in research and development; either in roles supporting research officers or in jobs requiring a small degree of responsibility, where they worked either in small groups or individually. There were other smaller groups of research technicians in the company, such as those working in the ferrous operations division. Their job was to operate tests on metals, really in a quality control function, and it was their job to advise that work should be temporarily halted if they were not satisfied with the quality of metals.

The most immediate implication of new technology revealed in this study meant that these technical workers developed all-round skills and knowledge of how to control a variety of processes. With micro-electronic technology they were to a large extent responsible for the precise quantity and quality of output, supervision being relatively limited.

Two distinct new sets of tasks relating to testing processes were created: programming the system itself and other tasks more directly concerned with production. In the materials processing division, research officers were also engaged in some computer program modifications.

With the new system, quality control involved selecting a switch on a panel diagram which corresponded to a unit which the research technician wished to activate. Activation of units in this way was then followed by an automated sequence of process control which continued until a pre-set stage was reached, when technician involvement was again required. Aspects of quality control, such as temperature or the precise amounts of material, were no longer affected by the technicians, but were all pre-set. However, technicians were still responsible for ensuring that the correct sequence of operations was followed. It was still possible to make serious errors, for example by opening a valve when it should have been closed. Research technicians still also had to monitor the process, using indicators of temperature, pressure and so on, which were also on the panel, to decide whether or not a process was proceeding satisfactorily or if they had to intervene to correct a problem.

Other tasks allied to testing processes remained essentially unchanged. Requirements for detailed processing records still had to be met and records were initially compiled by hand from the readings produced at the panel. With computerization a batch record sheet was produced automatically to record processes but research technicians still had to check this.

Micro-electronic technology did not simply replace the tasks that had been required to produce and test the metals when this had been carried out

conventionally. The process itself was modified to facilitate computerization. In conventional plants raw materials could be added to the process in a variety of physical states, but in the computerized plant they were all added in the form of solutions.

Thus new tasks associated with the testing processes of metals were created at the same time as the bulk of the process was computerized. And as these tasks were not automated they still had to be carried out by hand. The need for new mental and problem-solving skills deriving from the system interdependencies and operations control capabilities of computing and information technology, has also been identified. While automating activities previously performed manually, the "systematic" character of the micro-electronic technology meant that requirements for skilled human intervention in problem-solving increased. Furthermore, the organization of work in such an integrated system increasingly required undertaking research and development and production management in collaboration with others.

In telecommunications and metals research then, the introduction of new technology led to a concentration of skills for technical workers which were primarily computer-related: the understanding of control, production and mechanical systems; logic, systems and software skills; and general data processing awareness. In automotive parts new technology also led to a change in skill for maintenance technicians, the second distinctive group. Skill had been mainly experience-based, requiring long periods of apprenticeship and training. Skills were now based on analytic or logical ability rather than experience. Here, however, a polarization of skill requirements was taking place between, on the one hand, highly skilled testing, inspection and maintenance technicians and, on the other, less skilled maintenance technicians with the relatively straightforward job of replacing faulty modules.

Manufacturing Maintenance Technicians

For maintenance technicians in automotive parts, technical change had been more evolutionary and piecemeal than in the previous two cases and the advent of self-diagnostic routines with production machinery and office equipment and the use of modular component replacements, were reducing the traditional craft skills of maintenance technicians. But certain higher skilled electronic jobs were created.

In the main, work involved tasks confined to servicing the organization's processes of production. Although these technicians were not involved in direct production, they carried a degree of responsibility in the performance of overhauling and maintaining electronic equipment. In only a few cases were technicians actually carrying out a job without being responsible to another person. They worked in small groups, and although often required to exercise technical judgement, this was done on the basis of understanding the general principles, reasons and purposes of their work, rather than on that of skills developed from experience.

Maintenance technicians performed a number of tasks. Some were involved in routine analysis and routine testing, using laid-down sample schedules following known and proved techniques. At times several were also involved in research and development, either in supporting professional engineers in this department or in tasks requiring a small degree of responsibility. Others performed an inspection function in that they tested out new materials and checked plant before use.

The position of these technicians in the late 1970s and early 1980s can be summarized accordingly. They were highly skilled workers in that they required extensive training and continuous retraining in order to undertake the work. Furthermore, they were required to undertake this work unsupervised, with care and a degree of commitment expected in their performance. These factors are similar to those to be found among classic manual craft workers such as electricians and toolmakers.

The most important change in the maintenance technician's work was in the way faults were diagnosed and repaired. With the development of micro-electronic production and office equipment systems, skill resided in diagnosis rather than in repair. Although they remained highly autonomous workers, much of their work had been routinized by the advent of modular electronic systems. Fault repair on both production machinery and word processors generally involved the changing of faulty micro-circuits. Diagnostic equipment was far easier to operate and the use of many skills became intermittent. The full use of skills and knowledge only occurred when diagnosis proved problematic. When the diagnostic equipment failed to locate the real cause of the faults, technicians were required to use their technical knowledge and learned experience to establish the cause of the problem.

At the time of the study, a reorganization of the maintenance department was being carried out in direct response to the new technologies. It was recognized that there were greater differences between the types of maintenance required for automated technology (routine maintenance and

repair maintenance had become quite distinct activities) than between the different technologies and equipment throughout the site (computerized systems, for example, had been installed in all the various departments). Thus a change was effected as a result of the growing simplification of maintenance tasks.

As techniques had become more simplified, the work situation of technicians who only carried out routine analysis and testing, and those who were also involved in research and development was gradually favouring the latter. Perhaps this important change will result in multi-skilled, dual role technicians who will combine both electro-mechanical and micro-electronic tasks. But in the short term, the demand for specialized expertise was satisfied by upgrading those involved in research and development to temporary highly-graded electronic technical positions.

The central conclusion from this case study is that maintenance work for these technicians cannot be equated with either a straightforward deskilling or reskilling interpretation. The advent of routine analysis, routine testing and the replacement of modular components, was certainly reducing the traditional craft skills of maintenance technicians. This work had been simplified, but it remained essentially skilled although these skills were only used intermittently. Moreover, a small number of highly-graded electronic technical positions were also created.

The final illustration of the effects of new technology on skills and work organization is provided by the impact that computerization had on clerical and administrative workers in automotive parts, local government and textiles. It was in this area that new technology had the most marked effect on occupational activities. The introduction of word processing systems affected the skill levels of lower-grade clerical and administrative work: less skill was required in the layout, accuracy, execution and correction of work, since this was all performed by the machine.

Clerical and Administrative Workers

Other research on office and information technology has revealed a shift from manual task and skill requirements to mental problem-solving abilities (see, for example, Buchanan and Boddy 1983; Rolfe 1986; Webster 1986). In this research similar effects were found in automotive parts, local government and textiles.

The introduction of computers in the late 1970s and early 1980s led to an increase in the division of labour, although in its extreme form this process was only a recent development. Computers and related sophisticated

information retrieval systems had slowed down the growth in non-manual employment, but it was in the actual tasks undertaken in the office where the most marked effects were to be found. The long-term effect was to create a new division of labour in the office itself where one lowly group of workers were employed in routine tasks and were operating the machine whose tasks were rationalized and sub-divided, while above them a new group of controllers with specialist knowledge was emerging.

In recent years, there had been automation of whole office processes. Much clerical work is inevitably of a routine nature and the processing of endless streams of documents and papers characterizes much of the execution of such business. Much of the work, for the clerks in these studies, was repetitive and required merely the manipulation of fairly simple data and the application of standard rules and for most workers involved, very little decision-making of a fundamental kind was required. It was in this type of work that new technology had been introduced.

Where this had occurred there had been a resultant change in the organization of work for the clerical and administrative staff involved. Reallocation of the total task to other sites and other workers was the first result. This was followed by a reduced demand for clerical work, while demand for computer programmers and for computer operators increased. Many of the predictions concerning the introduction of this type of automated process in relation to work experiences held true for this group of workers. The working tasks were routinized, in contrast to the relatively small numbers of "career" staff who would henceforth be needed.

Indeed, those on administrative grades exercised little control or discretion in respect of their own work. Particularly as far as work with the computerized system was concerned, it was found that administrators acted as "leading operators"; that is relatively skilled clerks. Major personnel functions, hiring, firing, discipline and the organization of work itself, were carried out by the personnel departments. In short, the majority of those workers on the administrative grades could by no stretch of the imagination be said to exercise "managerial" functions. The systematization of non-manual hierarchies as a consequence of job evaluation had the effect of restricting the "clerical" title to the most routine tasks. As a consequence, it was becoming increasingly difficult to achieve internal promotion out of clerical work.

Four features distinguish the computerized system from the earlier methods. Firstly, clerks fed data directly into the computer through visual display units (VDUs) located on their desks within their office. This eliminated the need, in most cases, to complete the lengthy forms which had

previously been used. Secondly, with the computerized system the clerk keyed in the details in an "interactive mode" with the computer. That is, the VDU displayed a series of questions and the clerk had to fill in the relevant answers. The ordering of inputting was, therefore, determined by the program rather than the clerk. Moreover, the computer now did the calculations involved in determining the orders, accounts, salaries, and so on. In other words, the clerk was now required to undertake fewer arithmetical tasks. Thirdly, a great deal of the documentation which had to be sent to customers was no longer produced by hand. The computer automatically printed this out, and the documents were then sent on to the customer. Fourthly, clerks were able to use the system to call up details; hence when handling queries they made less frequent resort to the files. In sum, the key feature of the computerized system was that it reduced the amount of paperwork; it also reduced the need for clerks to do arithmetical calculations. As a result it took less time to carry out the work tasks.

But the computerized system also required new skills from the clerical staff. This, it should be stressed, was not technologically but economically determined. If the system was to be efficient then it was necessary that clerks should be able to handle a range of routine tasks. If this was not the case then inputting would be slow and the person inputting would continually have to go to ask the advice of other clerks. This was rectified by upgrading jobs in order to obtain clerical staff who would have the skills and ability to use the computer system efficiently.

In these cases the precise effect of computerization on skill varied according to the existing nature of work, the structuring of jobs around technology and the influence of non-technological changes. The general effects were, however, broadly similar. Firstly, automation of numerical functions reduced levels of technical complexity and knowledge. Secondly, simplification of procedure in information gathering and recording reduced complexity of tasks. These two developments led to a narrowing of the range of tasks in all cases. It could not be argued here that using a VDU was a significant compensation. In all cases programs were simple and allowed little scope for manipulation.

In summary, the evidence from these five case studies suggests that there were three distinctive occupational groups. Particular attention has been drawn to the impact that new technology is having on clerical work. It is in this area that technologies are likely to have a predominantly substitutive effect on labour input by allowing the automatic processing of information traditionally performed manually. In this research a similar result followed from changes in skill arising from the use of word processors. The word processors did replace some of the traditional typing

skills such as lining-up, error correction and so on, but they also provided new opportunities and the use of new skills in deciding on the form of presentation a final document would take. These new skills were akin to the job of a typesetter and in one instance, the marketing department in automotive parts, involved the operators in minor computer programming work.

The word processor also created new divisions of labour among the clerical workers. Long reports and lengthy documents were identified as being particularly suitable for the word processors and subsequently became the major word processor task being performed. There was a general consensus among the clerical workers that such documents were more interesting to work on because of the satisfaction in producing the final and complete report. Hence these case studies demonstrated that with this specialized technology there was a restructuring process occurring creating new divisions of labour and contributing to an overall job loss.

A similar restructuring process was found to be taking place among the technical workers. In automotive parts, deskilling had also taken place in the maintenance field as a result of the replacement of electro-mechanical systems by micro-electronic systems. The maintenance requirement of the new equipment was less and this had led to the deskilling of the maintenance technicians. But certain higher skilled electronic jobs were created. In the telecommunications study, the technicians, using their traditional knowledge, could contrive more effective ways of diagnosing faults than was suggested by the equipment's self-diagnostic facility, and they had developed the ability to change the programs. At the metals research centre, micro-electronics had also tended to upgrade certain jobs for highly skilled staff by removing the repetitive part of their work and allowing time for the exercise of wider professional skills.

Thus the parallel effects of the reduction in demand for existing skills and increase in demand for new skills could also be seen among the technical groups. Whether or not micro-electronics provided an opportunity for upgrading or resulted in downgrading depended in part on the possibilities for replacing displaced staff with electronic and computer-related skills. Moreover, structural barriers existed between different segments in the labour forces. The case studies showed that it was the skilled manual jobs which were being eliminated but technical non-manual work was being created.

In examining new technology, the influence of organizational factors on skill should not be ignored. For example, this trend towards standardization has crucial consequences for skill and is closely related to technical

change: both are intended to increase operational efficiency and labour productivity. Gradual organizational restructuring particularly between divisions and departments was also evident.

New Technology and Organizational Change

In all the case studies, but most clearly in automotive parts and textiles, new forms of work organization were facilitated by changing technologies. They enabled broad skills to be deployed flexibly, altered patterns of training, changed the balances between occupations and had consequential effects on pay structures. For example, occupations concerned with the filing and retrieval of information were dramatically affected by a narrowing of the range of tasks. Similarly, the use made of computers to deal with complex inventory and work scheduling problems significantly affected jobs in production control, material handling, purchasing and inspection. However, while certain occupational skills were contracting, others such as those associated with work preparation, distribution, information processing and systems design were developing. New technology was causing a further separation between the more highly skilled and the less skilled sections of the workforces. This was occurring because many clerical and administrative workers were vulnerable to technical changes while those with skills more allied to the new technology were finding further opportunities for acquiring more skills or technical status.

With the introduction of more flexible forms of computing, for clerical and administrative workers the "one person, one job" concept was becoming increasingly suspect. Computerized systems were integrating workflows and thus making the scope for individual job "ownership" much less. They were providing the opportunity to re-examine the ways jobs related to each other and the context in which they were carried out. For many clerks, work was becoming increasingly standardized and routine. Conversely, the potential available in new technology to provide information meant that some lower grade workers were now in a position to make judgements previously the province of more senior staff or specialists.

In addition to skills and qualifications, the work of the technical workers was distinguished from that of clerks and administrators by the control they had over the pace of work and the physical working environment. The introduction of word processing led to a polarization of skills and also to an increase in the work intensity of typing jobs. The variety of work was reduced and possibility for management control over the pace of work increased. The use of word processing also raised the clerks' physical

productivity by reducing the time spent retyping corrections and handling paper. The operators now spent more time typing new material. Human contact was also reduced and social isolation at work may increase stress and health problems for workers (Smith 1985). It also substantially reduces the potential for collective action through trade unions since lateral control is reduced. The studies of automotive parts, textiles and to a lesser extent local government showed that the introduction of computer systems reduced the possibilities for lateral contact and only allowed essentially hierarchical contact with supervisors or subordinates.

However, the major effect of technical change observed in the case studies was the overall polarization of skill. The general pattern was one of deskilled clerical and administrative workers and enhanced skills for technical workers. The move towards "multi-skilled" and "flexible" craft workers in industry is well documented (see Cross 1985). At first sight, the enhancement of technical skills and increased autonomy appears to contradict the deskilling theses. But the polarization of labour into a highly skilled minority and an unskilled majority can fulfil an important role for management. The highly skilled technical worker may become "privileged" labour incorporated into the managerial function as part of a "divide and rule" strategy. There are also indications of a tendency in the organization of technical work towards the separation of mental and manual skills. Further to this, as the micro-electronics-based technologies become cheaper and more sophisticated, fault diagnosis equipment will probably become more widespread. The maintenance function cannot, therefore, be considered immune from the deskilling effects of technology.

CONCLUSIONS

This paper has examined non-manual work in five environments where incremental and often small-scale changes were taking place. The case studies suggest that not all managements will seek to degrade workers' jobs. Indeed, the telecommunications and metals research case studies indicate that some managers are becoming increasingly aware of the disadvantages of a very detailed division of labour and tight controls over workers. These disadvantages can arise both from the nature of the production process itself (see also Kelly 1982) and the adverse effects of degradation on worker motivation and compliance with management goals. In addition, it was clear that new technology did not *determine* patterns of work organization (cf. Clark *et al.* 1988). Technology requires that certain tasks be performed. How those tasks are combined with other tasks which are undertaken within

the employing organization is a matter of choice. These findings confirm the recent observations of manual work (see, for example, Hyman and Streek 1988).

But the most significant conclusion of the research is that the overall effect of technical change on non-manual work has been more favourable for technical than for clerical and administrative workers. Some jobs had been deskilled and yet others had been upgraded. In some cases new technology had led to an improved working environment, while in others it had led to increased supervision and a changed pace of work.

Since Braverman's influential contribution then, the nature of work has fundamentally changed and one of the most significant changes in clerical work has been in work organization and the division of labour. The work of the clerk is often very limited in the use of discretion over methods and over organizational resources. There has been a division of clerks into those capable of answering enquiries and those processing routine activities. In these cases, technical change (combined with organization and product changes) resulted in deskilling but also led to skill polarization. Among technical workers, it was largely the nature of the technology which resulted in fundamental changes in the relationship between workers, tools, equipment and the product, but technology also polarized the workforce in terms of skill.

A consequence of technical change therefore is the tendency to polarize skilled workers (who are knowledgeable of the process and product and who make decisions) and unskilled workers (who process information and who work to a set routine). This tendency has been identified particularly in clerical work and is facilitated by technical change because it often eliminates arithmetical calculations which were previously part of the clerical process. Two types of work then result: feeding the computer with information and making decisions based on that information.

Thus a process of division according to functions is occurring and many clerical jobs are very narrow in range and discretion. It is now unusual for a clerk to see a whole process through from beginning to end and without knowledge of the whole process the chance of learning enough to be promoted is reduced (see also Webster 1986). Moreover, when clerical work involved processing large amounts of paper it was easier for clerks to control the process and more difficult for management to gain access. Control over labour and other organizational resources has therefore increased.

In technical work new technology appears to have the effect of changing the nature of the relationship between workers, tools, equipment and the product. In work which involves interaction with mechanical

machinery, the worker can see, hear and feel the parts move. Electronic technology, by embodying complex mental functions and working according to non-visual operations reduces the directness of this relationship and creates a barrier between workers, their actions and the product. This leads to a reduction in tacit skills involved in interaction with machinery, for the new equipment is harder to work by "feel" and intuition. While some jobs may become "intellectualized", requiring mental rather than manual operations, conceptual rather than perceptual knowledge, many of these jobs neither stimulate nor satisfy intellectual capacities, requiring concentration simply to avoid errors.

Weir (1977) argued that in clerical work, while "batch" systems associated with the first phase of computerization reduce skill, the development of "on-line" interaction systems may increase it. However, in clerical and technical work the reverse may be the case. On-line systems may further the automation of arithmetical functions and increase access to information and simplify procedure. While first phase computer technology eliminated many book-keeping functions, it also made access to information more difficult; indeed in some cases more so than previous manual filing and sorting systems. Clerks had to use printouts and because of delays in processing, information was often out of date. With the on-line computer access is immediate and it becomes feasible for the clerk to feed in information and figures to be processed with no delay. Ability to manipulate information is increased and although this can increase skill, work of this nature is usually performed by management.

A similar process may be identified in technical work, where first phase computer technology increases complexity of operation but feed-back and manipulation of information is poor. With more sophisticated electronic technology procedures are simpler, mistakes harder to make and information is easier to manipulate. An example of this was in telephone exchange maintenance where the electronic system had a greater self-diagnostic facility and was more easily maintained than the preceding electro-mechanical system. Again this capacity for manipulation may compensate for loss of skills if it does not become a managerial task. However, technical change encourages a division between routine processing of information and use of that information, and if, as Braverman argued, concern should be with the distribution of skill, technical change may be seen to encourage its already uneven nature.

In conclusion, this paper has evaluated empirical evidence on the impact of technical change on the non-manual labour process. The examination of the effects of technical change in this research does not indicate straightforward deskilling. This qualification rests on distinctions

between the deskilling of jobs themselves and the acquisition of new skills and a wider grasp of work processes. However, it is worth recording that one influential commentator on labour process analysis has insisted that workers' skills "are normally an obstacle to the full utilisation of the means of production of capital" and therefore that deskilling "remains the major *tendential* presence within the development of the capitalist labour process" (Thompson 1983: 118). New skills are continuously thrown up by the constant revolutionizing of production. To understand the way work is organized and controlled, therefore, requires the continuous examination of the labour process. The research on which this paper is based suggests that, despite the *general* pattern of deskilled clerical and administrative workers and enhanced skills for technical workers, there are intra-occupational variations in the development of non-manual work that may be paralleled in other areas of work. This analysis points to the advantage of empirical research that develops further the use of occupations as the benchmark for investigations into new technology and the changing nature of work.

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Les nouvelles technologies et le procès de travail des cols blancs en Grande-Bretagne

Dans la littérature traitant du procès de travail, on considère que le principal incitatif vers l'implantation de changements technologiques est le désir des employeurs de déqualifier et de contrôler le travail. Cependant, des recherches empiriques récentes sur le travail manuel démontrent que ces changements technologiques entraînent souvent une plus grande qualification et une plus grande liberté d'action pour les travailleurs, bien que ce ne soit pas la préoccupation première de l'employeur. Dans la prolifération actuelle d'écrits sur les nouvelles technologies, on ne s'arrête toutefois guère à leur influence sur la nature évolutive du travail de bureau et sur les discussions entourant les stratégies de contrôle administratif.

À partir de données provenant de cinq études de cas détaillées, nous avons analysé la relation entre les innovations techniques et les qualifications des travailleurs non manuels. La généralisation des technologies nouvelles a-t-elle augmenté les contraintes imposées à ces employés ou comporte-t-elle une complexité technique plus étendue et une plus forte liberté d'action? Les résultats sont clairs: dans aucun de ces cas l'introduction de nouvelles technologies n'équivaut à une déqualification et à un contrôle accru de la gestion. L'une des plus importantes constatations de notre étude confirme que les changements technologiques ont été plus favorables aux techniciens qu'aux employés de bureau. L'un des principaux facteurs à signaler consiste en la possibilité que la microélectronique permette de replacer les employés dont la formation se rattache à l'électronique et aux ordinateurs.

Nous avons accordé une attention particulière à l'influence des technologies nouvelles sur le travail de bureau. C'est dans ce champ d'activité que la technologie a un effet de substitution sur le facteur travail en permettant le traitement automatique de données traditionnellement compilées de façon manuelle. Le traitement de texte a remplacé certaines des qualifications habituelles des dactylographes telles l'alignement et la correction des fautes de frappe, etc., mais il offre, cependant, la possibilité d'acquérir de nouvelles aptitudes comme, par exemple, la forme de présentation d'un document. L'étude de cas a démontré que, avec les technologies spécialisées de travail de bureau, il se produit un processus de réaménagement qui donne lieu à une nouvelle division du travail et qui contribue, dans l'ensemble, à des pertes d'emplois.

Un processus semblable de restructuration a été observé chez les techniciens. Dans le cas des techniciens en télécommunication et en recherche métallurgique, l'introduction des technologies nouvelles a donné lieu à un regroupement des qualifications qui se rattachent d'abord à l'utilisation des ordinateurs: compréhension du contrôle de la production et des systèmes mécaniques, maîtrise des systèmes de logiciels et connaissance du traitement de données générales. Pour ce qui est des techniciens travaillant dans l'industrie de l'automobile, la compétence se fondait principalement sur l'expérience, qui exigeait de longues périodes d'apprentissage et de formation. Aujourd'hui, la compétence doit porter sur la capacité d'analyse plutôt que sur

l'expérience. De là, on constate une polarisation des exigences professionnelles entre, d'une part, les techniciens très spécialisés préposés à la vérification et à l'inspection et, d'autre part, ceux qui, l'étant moins, s'occupent de tâches rapides de remplacement de modules défectueux. Aussi des effets parallèles de diminution de la demande pour les qualifications actuelles et de croissance pour les compétences nouvelles peuvent-ils également se présenter parmi les catégories diverses de techniciens.

Parce que les nouvelles qualifications requises sont sans cesse rehaussées à cause de l'évolution constante qui s'opère dans les méthodes de production, nous suggérons, en conclusion, que pour comprendre comment le procès de travail fonctionne et est contrôlé, il faut en poursuivre sans arrêt l'examen. Notre recherche indique que, malgré la règle générale de la déqualification des employés de bureau et des services administratifs ainsi que l'augmentation des exigences professionnelles chez les techniciens, on remarque beaucoup de variations inter-professionnelles dans l'évolution du travail non manuel, comme dans plusieurs autres secteurs de l'emploi. Cette analyse met en évidence l'intérêt de recherches empiriques axées sur certaines occupations pouvant consister en des repères pour l'étude des nouvelles technologies et de la nature évolutive du travail.

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