Seventeen percent volunteered the comment that their own health was affected by ambient tobacco smoke which is similar to the 21% response in the Canada Health Survey where a direct question was asked. It is also noteworthy that 68% favoured a prohibition of smoking on commercial aircraft, and 54% a total ban on advertising of tobacco products. Many who did not favour such bans commented on the role of tobacco companies in financial support of sporting bodies.

The polarisation of opinion between smokers and non-smokers is clear from the differences in percentages. Many non-smokers made comments to the effect that they regard smoking in the workplace as being offensive, a form of assault, a risk to their health or a distraction from their work. Conversely, smokers frequently commented that they regarded smoking as neither offensive nor dangerous to their workmates whom they perceived as unreasonable in raising objections. Both groups invoked “freedom” and “democratic rights” in support of their positions.

A resolution acceptable to both groups lies in modification of the work environment. It is to be expected, however, that such a solution is less likely to be acceptable to management, which would have to foot the bill.

References

Trends in automation and work in manufacturing
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The rise of scientific management
The current trends in automation and its relationship to the working environment are a product of a logical development within manufacturing. As the Industrial Revolution progressed, the design of mechanisms moved from being created through the practical experience of inventors possessing craft skills, to designs based upon scientifically rational rules, such as those of classical mechanics and thermodynamics. This move towards a more rational approach to engineering design was extended to the whole work process, including human labour, through the adoption of the techniques of Scientific Management.

Scientific Management grew out of Time and Motion study, conceived by Frederick Taylor and Frank Gilbreth in the late nineteenth century. It was premised on the rationalisation of the work processes. Human work was reduced to a set of movements which workers had to perform as directed by management, within the times dictated. While the simplistic techniques of the earlier writers are now considered crude, the basic concept behind Scientific Management is still “the organised study of work, the analysis of work into its simplest elements and the systematic improvement of the worker’s performance of each of these elements”.

The desire was to extend managerial influence over both production activities on the shop floor and all aspects of requisite knowledge of design and production.

Management sought possession of the generation of the knowledge of the product (i.e., the design) by separating its design from its production. Through removal of the design process from the shop floor, management gained this control. The appropriation of knowledge of the details of production, normally possessed by workers actually performing the production (gained through apprenticeship) was sought through the
application of the principles of Scientific Management.

In attempting to make the organisation more responsive to ever accelerating changes in the demands imposed externally by market forces, management embraced rationalisation as a means of exerting control over a complex process, embodying a multitude of physical and social interactions. The desire was to simplify the process, so that it could be grasped and thus controlled. Managers and designers hoped that they would be able to resort to scientific rationalisation of the human contribution to the process of production. Such an achievement would provide an objective means for design, measurement and control of all facets of production.

By rationalising all aspects of production, management had hoped to be able to make the organisation more responsive to the ever accelerating changes in the demands imposed externally by market forces. But, a major problem with using rational objectification of human work is that it ignores both human will and the desire for variety in, and control over, one's activities.

Characteristics of the automation of manufacturing

Transition from experience to science

As well as this rationalisation, manufacturing industry has moved from being experience-based to science-based. Complete knowledge required for the process of creation, by a person wielding a tool guided by the experience of the craft, was at first subdivided into a number of separate tasks at the early period of manufacture, as was described by Adam Smith in the late eighteenth century. With mechanisation, full knowledge of the process (even to produce the subdivided task) was removed, as the worker was not required to understand the physical principles underlying the functions performed by the mechanism. While the chemical and electrical industries were reliant on scientific knowledge from their inception, the metal-working industry has only recently started the transition from experience-based to scientific-based technologies.

The demands of flexibility

The manufacturing industry has lagged way behind the chemical processing industry in the implementation of highly automated systems. In the chemical industry both the desired product and the raw materials (the feedstock) have little variation; at least over some reasonable time interval. The behaviour of the processing system also remains relatively stable. These plants, therefore, are dedicated to producing a small range of products under highly stable conditions. At the other extreme exists small batch production in the manufacturing sector. Due to the frequent variation in the desired final product and the raw materials, the process often have to be reset. Changes have to be made to both the raw materials and the process. Because these changes in product usually involve considerable physical restructuring of hardware, the ability to easily and rapidly alter the production system is hampered. The system is therefore inherently inflexible.

Up to recently there has been no foreseeable way of automating such processes. Production shops in small-batch production used a range of highly skilled workers. Parts of the process which could be automated to some extent required mechanical devices, especially made for the task, to be designed and constructed. Every time the batch was changed, these devices (fixtures and jigs) had to be installed. This set-up time was quite considerable. Some parts of the production would often have to be done using machine tools which were under the complete guidance and control of a skilled toolmaker. Usually, there was also a high degree of manual work, such as assembly. The continual changes in product left these workers with much personal autonomy in carrying out the tasks.

Flexibility via computers

While process technologies were able to automate using standard analogue-based techniques for control, the manufacturing industry (in particular small batch production, which typifies Australian industry) has had to wait for the computer revolution.

With the development of the Numerical Control (NC) machine tool during the 1950s, a flexible means was created for the cutting of metals. Its precursor required special templates for guiding the cutting tool. These had to be designed and made for each task. With NC machinery, the guide was in the form of a perforated paper-tape, which was made with the aid of a large computer. While the capital cost of this equipment was high, changes could be readily made. Over the past two decades, NC equipment has been transformed into machines with their own in-built computers. Consequently, programming of the cutting strategy can now be done at the machine.

Such flexibility as that attained in machining, through the application of NC, has now become possible in some areas of materials transport, assembly and limited productive tasks via robotics. The basic mechanical components used in the making of robots have been around for a long time, and have been utilised in dedicated materials-handling devices, which in some cases looked very much like robots. The marrying of physical hardware to the programmable computers created a device which could easily adapt to variation in products from one batch to another.

Changes to the working environment

In the renewed hope of finding the technological means of conquering the ever illusive objective of a rationalised, and rational, total-factory environment, which reacts quickly and predictably in response to managerial directives, management is attracted to automated systems in which computers are used to link processes together, to tie production design to manufacturing, and to integrate business planning and control systems into a total operation.1

"To accomplish this integration requires an information intensive environment, where process knowledge is stored on software rather than in people or bits of paper. The computer demands and uses huge amounts of information to make routine decisions and to control the manufacturing process. This simple fact has a dramatic effect on the people who work in [this] environment ... [T]heir role is no longer making a product so much as it is in the care and feeding of the highly complex system."

Before focusing on these current trends, the general effects on the human well-being derived from the preceding pattern of automation needs to be discussed. Automation has affected the character of work through:

1. the reduction in the skills required;
2. the "polarisation of skill levels"; and
3. the quickening pace of work.

Skill reduction

A study of computer-aided manufacturing, which had been commissioned by the Committee of Inquiry into Technological Change in Australia (CITCA), concluded from an investigation of 21 companies, that:

"Unlike many other elements such as material and consumable tooling costs, labour cost is more obviously within the control of the company to achieve significant reductions."

This desire to use unskilled labour to operate machinery that incorporates sophisticated controls was observed by Noble. In his study of NC machinery, he
came to the conclusion that NC manufacturers were able to sell their products on the promises that all the decision-making could be removed from the shop floor, thus permitting assignment of unskilled labour for machine attendance. Authority could be tightened by concentrating all mental activity in the office. Management thereby hoped to exercise detailed control over all aspects of the production process.  

**Polarisation of skills**

A second trend which is visible across the manufacturing spectrum is the polarisation of skill levels. For example, the programming of robots and computer-based tools may not be performed by those who operate them. While the skill levels have tended to diminish, the demand for employees with professional engineering and computer programming skills has increased.

**Intensification of work**

With the move towards machinery having a higher capital intensity, there has been a quickening in the pace of work. This can be seen in the case of NC machine tools, where more operations are concentrated on one machine. The throughput time of each batch is therefore reduced which forces a quickening in the scheduling of the work. The Australian Science and Technology Council (ASTEC) reported that accompanying automation was a quickening of response to the diagnosis of a problem and corrective action. This aspect of automation is quite observable in the work associated with continuous casting of steel, where "... much time is spent watching dials without taking action, but precise and quick evaluation and action are expected if a malfunction occurs, in order to prevent disturbance of the workflow in an integrated plant with fine tolerances in timing" (#7.14).  

To accommodate this intensification of work,

companies introducing computer-aided manufacturing are often obliged to restructure their production management systems, from being based on the coordination of human activities, to being based on the coordination of the functions of a complex inanimate system. These descriptions, of the prevailing practice within industry, rest on the foundation of rationalisation. The path so formed leads to centralisation of decision making. Thus, mental and physical labour are separated, each becoming a province of different people. The complete knowledge of the process, involving both a theoretical comprehension and an ability to physically perform the necessary tasks, is therefore not possessed by a single person.

**Constraints on deskilling**

In the case of NC machinery, the desire by management to use unskilled operators, and thus reduce labour costs, has only been partially realised. CITCA's findings showed that the major source of operators tendency to be highly skilled, being 3rd or 4th-year fitting and turning apprentices or tradesmen. It was also evident that those companies manufacturing in relatively large batch sizes tended to use lower-skilled operators, and relied entirely on the programmer to select and maintain correct operating conditions. Those companies producing lower volume batches with short runs and frequent changeover from one product to another tended to employ more highly skilled operators and saw significant advantages in having the operator trained to modify programs whenever necessary at the work station.  

An investigation in Britain of 24 firms using NC machine tools found that an operator generally only required 3 months' training, compared to the 14 months' training required for a conventional operator.

**Complex systems require high-level skills**

The organisation of work processes based on the principles of Scientific Management (job specialisation, hierarchy of jobs based on skill content, incentive pay) are inappropriate when it comes to complex automated systems having highly complicated cause-effect relationships. The tracing of quality problems, requiring time consuming detective work, becomes quite difficult when there are few human operators with whom to liaise. This is further aggravated by an incomplete understanding of all aspects of the plant's performance, since the traditional avenues for obtaining skills on the job, through the formal apprenticeship system and the informal communication networks on the shop floor, have been disrupted. The severing of this important path for generating critically needed skills not only affects the maintenance of the plant, but also affects the culture of a healthy industry: the research and development of new products and processes.

While this process of rationalisation is desired by management, the reality is that the sheer complexity of the system places a counterpoise need for maintenance of the system to be undertaken by highly skilled people.

**Skilling rather than deskilling**

ASTEC found that "... technology itself does not dictate job design and work organization which fragment and simplify work. Modern computer information technology for instance, though capable of allowing much greater centralisation and control by management, also possesses the capacity to decentralise, to enhance localised decision-making, and to increase the level of skill of employees" (#7.3).  

Noble argues that there is nothing inherent in NC technology that makes it necessary to assign programming and machine tending to different people. The technology merely makes it possible. Instead, the philosophy and motives of management, reflecting social relations, dictate the way in which the technology is deployed. These relations, developed within an economic and political context, are therefore historically specific.

**Conclusion**

Historically the desire for rationalisation through scientific objectification has been dominant in the application of new techniques for automating the manufacturing industry. This has led to a general reduction in skills required by employees on the shop floor, accompanied by an increasing demand for professional skills off the floor. Consequently, knowledge and power has tended to become increasingly centralised within the organisation.

As automated systems become more complex, the cause-effect relationships become more complicated. Consequently, a centralised organisation, having all plant information and knowledge concentrated amongst a few key personnel, becomes increasingly incompetent in handling issues that arise in both the breadth and depth required, as well as becoming unable to react with sufficient haste to technical crises.

**References**


