Relevance of Experience-based Work in Modern Processes

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Abstract: The increasing use of computer-cont rolled automation systems has brought with it a bias towards a purely "scientific" approach to work. This tends to undermine the significance of experiential knowledge and sensory perception when working with highly automated processes. This paper argues for a recognition of the importance of "subjectifying action" in carrying out work practices. Without it, complex technical systems cannot be effectively operated. Moreover, the contradictory demands that arise for workers could have negative consequences in terms of work burdens and health risks.

Keywords: Automation processes; Computer-aided technology; Experience-based work; Objectifying action; Subjectifying action; Work design.

1. The Need for "Practical Experience"

The discussion on work change in the face of high levels of automation, has been dominated up to now by two theses and prognoses. One is that advanced automation reduces work demands to mere "leftover" tasks, that is, simple highly restrictive auxiliary or operator tasks in the production area. The other is that automation leads to new demands on the qualification of workers, especially greater demands on theoretical knowledge for the comprehension of technical relationships and the capacity for abstract thinking. The debate in scientific circles as well as in practice has moved mainly between these two "poles".

New studies, however, have revealed a development that has remained largely unarticulated up to now: auxiliary tasks do indeed arise, but they are in no way the exclusive trend; particularly in the case of flexible automation. A considerable interest still exists on the part of firms for using skilled workers in order to make effective use of information and control technologies. One example of this is the development of skilled workers for CNC-controlled machine tools in the machine building industry. At the same time, the prognoses that the new demands on workers primarily involve a broadening of "theoretical" knowledge is not accurate. More theoretical knowledge

is indeed necessary, just as the ability for abstract thinking. However, these alone are not decisive factors for recognising skilled workers as imperative in automated production. What is much more important are knowledge and abilities that can at least partially be characterized by the expression "practical experience". Such skills have proven to be indispensable in automated production.

This is because, in practice, a total technical mastery of the production process and the necessary "ex ante" understanding of all the relevant parameters that accompany this mastery have their limits. Uncertainties and imponderables remain which cannot be precisely determined and can only be coped with by workers with the experiential and tacit knowledge.

To demonstrate this point statements of engineers, manufacturing managers, foremen and workers we interviewed during the course of our research are presented.

When working with metal, the properties of the material and the actual machining processes cannot be entirely pre-planned and thus cannot be completely transformed into objective data. This means that the experience and practical knowledge held by employees is necessary in all cases. In this context the companies repeatedly stress that the programmes have to be adjusted to "actual operational conditions or emphasise the fact that "it is not possible to plan everything from the start". We would like to quote a typical statement by the owner and manager of a machine building company: "As long as one is working with metal it is impossible to plan everything and one must acknowledge the limitations of theory. CNC-machines relieve the workers only of the physical burdens. Skilled workers remain a necessity due to the inevitable imponderables. During the process of optimization, the program has to be adjusted according to the data resulting from different materials".

Such findings lead us to the question as to whether or not we are being confronted with the basic limits of the technical-scientific planning and controlling of production and work sequences affected by the use of modern information and control technology, and whether this does not also show specific and essential problems of artificial intelligence.

Such questions, however, can only be answered when we have precise information on the particular nature of the "empirical knowledge" held by employees. It also requires our understanding of what this knowledge is based upon. To date, there have been relatively few empirical investigations on this topic, and therefore it was our objective to pursue this questions in a more systematic manner.

2. What is Experiences-based Work?

It is widely believed that a job is skilled when a high degree of theoretical knowledge and abstract thinking is required. This automatically means that planning activities are rated higher than practical, executing activities. The distinction between "mental" and "manual" and the hierarchical positions they are given, are based on such criteria, and as a result, "mental" work is more highly valued than manual practical work.

Sensory perception does not play any special role in such an approach to skill demands. It only has to be oriented toward registering information from the environment as precisely and objectively as possible. An important precondition for

this is a switching off of subjective perceptions, and a highly factual unemotional interaction with working materials as well as with colleagues and superiors. The model in this case is therefore "rational" action. We will use the term "objectifying" action for this model because the word "rational" is often used to connote "reasonable". This designation underlines one important dilemma: Although the criteria identified with the model of skilled work stress responsibility, individual initiative and creativity, they largely eliminate subjective factors such as emotions, sensations or impressions derived from personal experience. These may have significance for individual motivation and subjective satisfaction, but for the "correct" dealing with technical working material and an efficient, goal-oriented mastering of working demands they are perceived as disruptive and the cause of errors.

It is, of course, not denied that experiential knowledge has practical uses. However, in the objectifying model, experiential knowledge is viewed as something that basically can be improved, enlarged and ultimately replaced by scientifically grounded knowledge. Thus experiential knowledge is seen only as a preliminary step for theoretical, scientifically grounded knowledge. In this context experiential knowledge is equated with "everyday knowledge" or "rules of thumb".

Recent studies have broadened the understanding of so-called tacit knowledge or experiential knowledge in some essential ways, not only in metalworking, but in the process industry as well. (Böhle, Milkau 1988; Böhle, Rose 1992; Böhle, Milkau, Rose 1992; Institute for Ergonomics, Kassel 1192). According to these studies, experiential knowledge that derives from learning from experience is neither basically inferior to theoretical-scientifically grounded knowledge nor is it completely replaceable by it. Hence experiential knowledge is of great significance as an autonomous form of knowledge both for planning and practical action as well as for creative, innovative processes that form the basis for managing situations. What is vital about this realisation is that "experience" isn't only seen in the sense of "having acquired" experiences, but is looked at from the perspective of "experience-acquiring". In this view workers' experiential knowledge arises form specific "methods" of tackling concrete situations not only in terms of a cognitive understanding, but also in a practical sense. In contrast to "objectifying" action this can be called "subjectifying" action. This emphasizes that subjective experiencing and feeling are acknowledged as important basis for such action.

Using the concept of "subjectifying action", an attempt will be made to show the various components of an action, e.g. intuitive action, sensory perception, and associative and intuitive thought, in their interactive context as elements of specific forms of practical action. In doing so, we shall adopt findings from a wider range of interdisciplinary research and apply them to this analyses.[1]

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[1] Particular mention should be given to studies and concepts of sensory perception based in phenomenological approaches and Gestalt psychology (Straus 1956; Merleau-Ponty 1966 etc.); approaches in psychological research derived from the criticism of the "cognitive transition" in psychology and in which feelings are seen as being more than merely subordinate or disturbing components of action and whose significance interims of practical action are examined (Ulich 1982; Mandl, Huber 1983 etc.); studies of the systematic quality of eidetic and associative thought and intuitive cognition (Goldberg 1985; Watzlawick 1982 etc.); investigations into the social function and meaning of non-rational forms of behaviour which are significant in terms of cultural psychology (Boesch 1980; Boesch 1983; Lorenzer 1981) and, finally studies within the framework of philosophical epistemologies in which the contemporary concept or rationality is modified and extended. See, in particular, the pathbreaking work of Langer 1965/1984.

3. Subjectifying Action and its Characteristics

Characteristic for such "subjectifying" action is a simultaneous complex sensory perception that takes place via several senses and body movements and is not detached from subjective feeling. It goes beyond an orientation to precise and clear cut features, to handling more diffuse and stratified sources of information.

It is, for instance, imperative that skilled workers check and identify defects and disturbances using the sound of the machine and the various processing operations. What it is exactly that skilled workers hear and how they recognize whether "everything is running smoothly" during operation, "cannot be precisely described and measured", to quote one skilled worker. It is clear that "feeling" plays a particularly important role. This becomes evident when workers describe how they can recognize faults by the sound of the machine. Comments are made such as: "You have to hear, to feel if it is running smoothly". The same is also true for tactile contact with equipment, for example, in the use of the hand: "You feel it in your hand. The hand recognizes something. To mount a work piece, you need that feeling in your hand. You couldn't do anything with just a gauge. A gauge is only important in confirming what your hands feel and tell you." And in the case of visual perception: besides having to read off measured values and scales, you have to have the "right eye" for material properties and tool wear and tear. Here, too, it is emphasized that, "only a skilled worker with a feeling for it would see that".

This kind of sensory perception also includes a connection between what is currently being perceived and a sensory picture of past, concrete situations. A typical example of this is that skilled workers, when they are writing or correcting programs at the machines, not only orient themselves to general rules of programming, but also imagine the tooling processes at "their" machines in their minds.

Such sensory perception is closely linked with a particular type of thinking. Because of this, certain parts of the production process can apparently be remembered as a kind of picture which contains movements, smells and noises. The "holistic" comparison of an actual with an already experienced situation is based on this memory of "comprehensive" processing situations (cf. Dreyfus & Dreyfus 1988). Nevertheless this is no stereotyped transfer from earlier experiences. Rather the current situation is compared with past events whereby a variety of past events are drawn on, and differences between current and past experiences are registered. The so-called "antenna" for sensing malfunction is based on such "holistic comparisons"; it is the ability to more or less intuitively sense especially complex disturbances at a time when no clear indicators exist. A typical description for this is; "One has a feeling that something is going to happen."

A further application for experience-based working practices, in contrast to methodical, and rational procedures is one in which "planning" and "execution" are not separated, but are rather highly intertwined with each other. The characteristics of these practices can be described by procedures which are dialogical-interactive. Typical of this practice is the so-called "trial and error" method when diagnosing malfunctions. In this case the "planning" of single working steps takes place gradually and is influenced by each respective result of every single working step. Another characteristic is ways of acting in which the fundamental elements are empathy and subjective involvement in the sense of "getting involved". The mimic, identificational

reproduction of motions as well as dialogical ways of acting in which the subject neither influences nor reacts to his environment one-sidedly, but rather strives for a certain result through a process of mutual exchange, and "shared endeavour", are vitally important. A constitutive element is the receptiveness to the possibilities inherent within and offered by both objects and persons which only come about or are developed by coming into contact with them. Action is therefore characterized by the union and simultaneousness of action and reaction; the effects of one's own action are experienced directly and at the same time have the effect of directing action.

Feelings and subjective sensations are not eliminated in the working method outlined above, since they are an important part of work. Thus, experienced workers are sensitive to their "feeling-based premonitions" that "something sounds funny" or "something isn't quite right" (without knowing what is wrong). This encourages them to take seriously the recognition of their surroundings as an important element of their training.

The basis for such subjectifying action is a relationship with the environment which can be termed "sympathetic". The subject doing the acting experiences the environment (things and people) not as unfamiliar, external objects, but as belonging to himself or herself; in the process of taking action they form a "unity". While in action the person seeks to synchronize his/her action with the environment. In this way, non-human things are made quasi "human". This does not mean that human qualities are projected onto them. The crux is that in performing an action, the subject identifies with characteristics and properties of the environment so that the person acting and the object being acted upon draw closer together and become more similar. In this sense, the environment becomes a subject.

4. The Importance of Subjectifying Action

Of course, the usual criteria of rational work and planning have nothing to do with integrating feeling and individual perception into the work process. A more differentiated understanding of what is rational, however, will easily show that the consideration of such factors is by no means "irrational" but is simply based on a different kind of rationality and logic.

As described here, subjectifying and objectifying action are not hierarchically related, nor can they be reduced to nor substitute one another because each does something different. The fundamental point is the proposition that both subjectifying and objectifying action can focus on gaining knowledge about the environment which is relevant for action and organizing that action in a suitable way.[2] The relevant insights and rules governing subjectifying action could be "supra-individual", that is shared and effective at the collective level. What is crucial is that they are integrated into concrete actions and can only be experienced, imparted and learned in this way; they cannot be isolated and in this sense "objectifying".

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2 In this context it should be pointed out, for example, that within the framework of a philosophical theory of cognition even as late at the nineteenth century, "identification" was labelled an important principle of cognition (Böhme, Böhme 1985).

We do not, therefore, consider it a correct scientific premise to attribute subjectifying action only to certain social areas, e.g. to the so-called cultural sphere or processes of interpersonal interaction and communication. Rather, it is our thesis that subjectifying action is indeed significant in the work process, particularly in dealing with things, i.e. work materials, tools and machines.

As our findings show in working with automated production, workers have to be able to think and react in the "logic" of the technical system; however, this is not enough. Skills and work practices which follow another sort of "logic" are also necessary. It is only in this way that uncertainties in complex technical systems can be dealt with, and that discrepancies that arise between "ex ante" assumptions and concrete circumstances in practice can be compensated for.

5. Repression of Subjectifying Action at Work

According to the finding of our investigation, skills, qualifications and empirical knowledge and feeling for materials etc. can only be acquired, developed and applied in the working process. This process requires establishing and maintaining an adequate relationship to machines, tools, materials, work processes and sensory perception. It is in this respect, however, that we encounter a number of problems.

In this context the term "tacit skills" (Wood 1986) is most telling for, in the majority of cases, the experience-based work is taken for granted, or "goes without saying". But as our investigations show, this is far from being the case.

Particularly when computer-aided control technologies are introduced in industrial production processes and technology, a pervasive scientific abstraction tends to occur. Through this, there is an ever increasing technological intervention between those working on a system and the production processes. These developments lead to a situation in which the worker influence on what is happening in production is – and must increasingly be – carried out using a technological-scientific operation structure. This, in turn, forces the development of a technological-scientifically driven "objectifying" form of working, which simultaneously limits and restricts the possibility for an experience-driven, subjectifying form of working (Böhle, Rose 1992, p.140).

By considering the changes occurring in the machine building sector as an example, it becomes evident that the utilization of CNC-machines results in changes in the areas of technology, work organization and personnel policies which undermine and restrict the development of such skills in a number of ways. The causes of these changes are not individual, isolated factors, but an entire syndrome which includes: changes in control technology and the external design of machines (encasements, etc.); flexible deployment of employees; the integration of the machines into the overall manufacturing process. These factors bring about complex changes in the relationship between workers and machines, and the overall work methods and procedures. A number of points may serve to illustrate this: the individual skilled workers no longer have "their machine", but are assigned to various machines; different processing phases must be planned further in advance, and immediate sensorial experience is restricted by the encasements of the machines and partly their higher operating speeds, while the individual machining processes can no longer, or only to a minor extent, be immediately adjusted or regulated.

These developments place the employees in a contradictory work situation: They must make use of their empirical knowledge and their skills acquired on the job and recognize faults by certain sounds arising (in the case of tool breakage, for example) and thus avert system failures. The workers must also, in spite of measuring devices

and instruments, be able to assess and judge, to "get the feel of" materials and tools on the basis of acquired empirical knowledge. At the same time, however, the design of technology, work organization and personnel assignment makes this increasingly difficult to put into practise. Present day skilled manufacturing work finds itself beset with a number of new problems. This is evidenced by the rising insecurity and feeling of being overburdened among workers, as well as the occurrence of mental stress and even conflicts with superiors and violations of safety regulations - for example, when machine covers are removed in order to improve the view of machine action etc.

6. New Issues in the Future of Work and Design of Work

On the basis of our results up to now it is clear that the repression of subjectifying action as well as the contradictory demands made on workers cannot merely be limited to dequalification as in the case of Tayloristic work forms. The greater weight placed on objectifying actions at work can result in the maintenance, and even the creation of "qualified tasks", as well as an expansion in the scope of job discretion and decision-making for workers. The main issue here, however, is the qualitative changes in the skills necessary in the work process. Therefore, it does not make any sense to put these changes in categories such as "more – less" or "higher – lower".

As our findings show, even though "empirical knowledge" is expected from workers, the foundations and preconditions for the necessary (subjectifying) work actions are endangered. The design and development of the technical system are overwhelmingly oriented to the objectification of work actions.

In terms of the design of technology and work organization, we are not trying to portray work forms for the skilled worker on conventional machines nostalgically. It is impossible to ignore the existing strains and restrictions that have characterized conventional tasks in the industrial production up to now. The question is not one of a return to "old" technology. The decisive point is to discover whether it would be possible and which practical approaches might exist to set up future developments in technology and organization systematically so as to facilitate the use of subjectifying action at work.

In order to make experience-based work possible, certain technical and organizational prerequisites have to exist. The most important are:

- Access to processes or possibilities to use a variety of information (for example, technical displays as well as machines noises).
- Possibilities for direct manual control of technical systems, especially intervention in automated processes.
- Comprehensive work tasks (not broken down into simplified parts) especially the absence of a strict separation between planning and execution, as well as room for "practical trials" (trying things out).
- Possibilities for constructing a personal work environment (relation to work methods and tools, cooperation etc.).

Such technical and organizational prerequisites, which support experience-based work, are not systematically taken into account in prevailing developments; in fact, they are often jeopardized in those companies or company areas where an interest in the development of skilled workers exists.

As we mentioned before some examples are: 1. difficulty of access due to encapsulation of machines, 2. the removal of control and monitoring areas from processing areas, 3. the limits of sensory perception in favour of exact "measurements", 4. the strict user procedures determined by the operation of technical systems, 5. the separation between planned and open tasks and execution, etc.

Targeted support of experienced based work is thus a new challenge in the design of technology and work organization.

In order to clarify this issue and to point out perspectives for future developments, BMFT in the research program AuT (Arbeit und Technik) has created the research group "Computer Aided Experience Based Work" (CeA). Several technical and labor science institutes participate in this organization. One of the research group's central concerns is the clarification of how the transparency of machining processes and their manual control can be improved at CNC-controlled machines. Some approaches are: constructive measures for increasing transparency in the production process, the use of sensors through which not only values and signals are transmitted but also complex process information, the means for intervention for direct feedback, links between software construction and process control. A further focus lies in the technological and organizational prerequisites for the promotion of experience-based work in production control, tracking orders, and work planning and scheduling. Finally, the research group deals with the issue of qualification and training under the aspect of experienced based work (Institut fur Arbeitswissenschaft 1992). In another international research project (EUREKA-Project PROFIL), the design of a production facility as well as the control and monitoring of a technical system is being tested and examined using the guide-lines of experience-based work in the framework of developing a new flexible production concept in the food processing industry (dairy processing) (Rose, Macher 1993).

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