28th February 1996

# ACCORDING TOOLS WITH MEANING

## *WITHIN THE ORGANIZATION OF CONCRETE WORK SITUATIONS*

*Erik Axel, Copenhagen University*

## INTRODUCTION

Way back in the fifties just after the advent of computers the US Navy Special Projects Office developed a planning system called Program Evaluation and Review Technique, PERT for short. It was used to assist the construction of the Polaris nuclear submarines meeting schedules, and it is said to have saved the US Navy many dollars. The well known PERT diagram was developed for that occasion, and the scheduling facilities were gradually computerized. This is an early example of computer supported cooperative work, where human activity and electronic computing meshed in interactions never seen before. The last decade or so has seen a spate of such systems, their development enhanced by facilities such as networking and graphics. Examples of this kind of computerization are office automation, CAD/CAM, systems for the maintenance of plant components, and computer supported regulation in control rooms.

However, the employment of this kind of systems has produced many surprises and has not always met expectations. For example, one hears about architectural firms having stopped using CAD/CAM programs, which they have implemented at great cost. One can hear contractors of computer systems for the maintenance of plant components admit that they are said to be hard to use, but the contractors claim that the proper use is a matter of schooling. From a different angle on a similar problem Henderson (93) reports on the difficulties using CAD/CAM: The systems are said to impose one way of designing as the correct one, and we hear about how the designers surmount the problems and incorporate the systems in the working methods of their preference according to the task at hand. Taylor et al. (96) reports on a police force where new computer based communications technology was introduced and the police dispatchers substituted with less qualified personel at the same time. The authors demonstrate how these changes revealed the more supple judgements the police dispatchers had performed in assigning tasks to the police force before the introduction of computers, judgements which the computer system was not incorporating. The introduction of computer systems thus reorganize the work place, its work patterns, its personnel and it is also changed in many other respects. The broad scope of changes is well known to the system developers. One can hear many interpretations of the changes, differing according to the work place at issue. For example engineers setting-up computerized control rooms state that the new technique makes boredom a core problem in control room jobs. They say there is nothing to do in the control room for long periods, the operators may doze off, and when dramatic events happen they wake up to a panicky situation and react irrationally.

It becomes evident that the introduction of computers in cooperation is not a straight-forward task. There are many problems, and the nature of some of the problems is not clear. Some contractors defend their babies by claiming that the operators must be educated to know how to use the equipment, or by calling them irrational when they make errors. Researchers with investigating minds talk about the constrictions of the gear on the organization of work; others unveil supple judgements performed by work forces and not recorded until the introduction of computers. Thus problems are claimed to stem from the machinery or the work force, and although the explanations need not be mutually exclusive, they are sometimes used as if they were. Hence, not only the nature of the problem is unclear, but it is also contested.

Whatever the nature of the problem may be, the introduction of computers implies a set of challenges: a reorganization of the work force, and like in any other introduction of new technology this involves changes in training, wages, employment etc.. From previous experience there are some resources and routines - be they adequate or not - with which to handle these challenges. It is however clear that a striking and specific feature of the challenges can be found in many investigations of the introduction of computers to work places. It is the apparent importance of until now hidden and lowly regarded aspects of work tasks. Until the advent of those investigations it was much easier for a scientific investigator to adhere to a notion of job performance as following rules. When a superordinate in a work organisation told a subordinate to do something to be finished by tomorrow, the superordinate was intent on results and from contact with the shop floor or from his own previous experience he would probably know what went on while the job was performed, and this helped him to evaluate how to pull the strings in order to get optimal results. A scientific investigator of work organization or a system developer was not determined to get practical results in the first place, but to get facts, he did not need the intimate knowledge of the superordinate, but was bent on minimal, essential knowledge, which to him gave an overview. Thus it appeared reasonable to him to stick to the belief that the subordinate accomplished the job by following rules, this allowed the investigator to perform formal scientific analysis. But the problems popping up during the computerization of work tasks has forced the scientific investigator into another level of surprising particularity. The interaction between computer and human being compels the formal analysis to a level of detail not necessary earlier. Sometimes the fine-grained analysis makes a computerization possible, at other times it is of no use. At the end of the road the shortcomings of the fine-grained analysis and its diminishing returns become conspicuous, and other ways of description appear. It becomes clear to some that human beings do not manage a job by blindly following formal rules like a computer. It is the computer which necessitates the detailed analysis, a human being only needs a general description of the job to get the general idea, and it will fill in the details while acting. As in the examples above, when human being acts, we find the supple judgements made by the work force in order to fulfill the job.

We hit upon a phenomenon which the present author among others understands as a limitation of formal analysis. The limitation runs parallel to the fact, that an automated machine is never let alone. A human being is always brought in to monitor an automaton, it is not considered safe to let the automaton loose, be it the auto-pilot in an airplane or a robot in a factory. Something may come up, which only the human being would be able to identify and handle, a situation might occur where the human being would juggle with goals and means to cope with it. A human being works by making ends meet, goals and means are modified and changed according to the needs of the situation. This also implies that errors are identified and modified according to the shifting interpretations of the ongoing activity. According to such a notion it proves to be necessary to identify the dynamics specific to human activity so that the technology can be implemented as a proper enhancement of the human powers.

## THEORETICAL DISCUSSION

A whole group of investigators recognizes the necessity of identifying the dynamics specific to human activity, among them can be mentioned Harold Garfinkel (1967), Jean Lave (1988), and Lucy Suchman (1987). Their way of investigating situated human activity has set off a trend, which is more or less opposed to a formal analysis of human activity, and in which the work of the present author is also inscribed. The trend is contested by people working within the tradition of cognitive science (e.g. Vera and Simon (1993)). The issue up for discussion between these many groups is the relation of the dynamics of human activity to the formalizations which can be programmed into a computer. The positions in the debate are not clear cut, but two main viewpoints can be distinguished.

It is a common notion in cognitive science that human thinking works according to principles of formal logic (Allen and Newell: "Human Problem Solving"). Formal logic consists of finite elements and logical operations on those elements, e.g. if a<b then c. Computers are machines which process numbers according to the rules of formal logic. To discuss whether computers can simulate human thinking is then to discuss whether human thinking and its meaning consist of finite elements and operations on those elements. Within cognitive science it is believed that the automaton simulating human thinking does not work yet, because it is not perfect, it is not made all encompassing. If only all instances were taken

care of, if only the analysis could be sufficiently fine-grained in the right places, it could work on its own.

The other position works with identifying specific aspects of human thinking, which cannot necessarily be formalized, so that they may be modelled in a computer. Embodiment and situatedness are concepts to circumscribe these specific traits. In the present chapter a central aspect of human thinking is determined as its ability to identify what kind of object this particular thing is. This is seen as achieved by human beings according meaning to situations in which they act by making ends meet. Furthermore formalisms are understood as tools, which do not possess meaning, but are used and accorded meaning by human beings in their activity. This position is an elaboration of Critical Psychology (cf. Tolman and Maiers (1991) and Holzkamp (1983)).

Thus, in the present chapter these two positions are confronted, and some arguments will be given to the effect that human thinking is determined by content and cannot be formalized. Such arguments are of course not meant to deny formalisms their fertility. The advent of the computer, all the kinds of use - also unexpected - to which it has been applied, the profound change of the organization of social activity it has caused, must all be taken as evidence of the fertility of the application of formal analysis to human activity. However, in the end the feritility of formal analysis is not a proof of its validity as a model of human activity, not a proof that it governs human activity itself. The chapter will accordingly aim at encircling a domain of analysis of human activity, in which formalisms can be of no avail, in order to help the proper domain of formal analysis to stand out more clearly. It argues that each domain should be given due respect according to its characteristics, and attempts to sketch out good reasons for this position. The present position is then part of the change of importance of formal analysis in human sciences, as heralded by Garfinkel's criticism of the notion of rule based behavior. In the fifties and sixties it was a dominant claim that a theoretical analysis should end up in formal statements, a theory in the humanities could only be considered a proper theory if it was "dressed in a formal tuxedo" to use an expression by Leigh Star. The present chapter does not posit a counter claim that only artistic rags will do, the aim is to determine the conditions for the proper application of formal analysis, to differentiate the process of human activity and its formal aspects, and thereby to identify the proper scientific methods for each domain.

First the formal approach will be determined and some of those characteristics will be accentuated which stops it from being a valid instrument with which to grasp the process of human activity. Second, some of those aspects of human activity will be determined, which place it out of reach of formal analysis. Lastly some of the points discussed will be demonstrated in the work activity of a group of control room operators in a city district-heating system.

### *Cognitive science as abstract and formal*

In their classic "Human Problem Solving" (1972) Newell and Simon characterize their own conception as emerging from a powerful and growing "Zeitgeist", having its origins around the turn of the century (ibid, 72, p. 878) and coming together just before and after the World War II. The Zeitgeist congealed from the formalization of logic and mathematics of Whitehead and Russell, Shannon's information theory, Wiener's cybernetics based on servomechanism theory and control theory. Thus Newell and Simon point to those developments in formal sciences and engineering, which made the computers and automatic plants of today possible, and hence they base their understanding of human beings on technological developments. As they see it, the fundamental contribution of formal logic was that the manipulation of symbols "could be described in terms of specific, concrete processes quite as readily as could the manipulation of pine boards in a carpenter shop. The formalization of logic showed that symbols can be copied, compared, rearranged, and concatenated with just as much definiteness of process as boards can be sawed, planned, measured and glued" (ibid, 72, p. 877).

To base one's understanding of human beings on control processes utilised in technological progress is not necessarily problematic in itself. In the industry the formalisms were planned, measured, sawed and glued so that plant productions were regulated and controlled in anticipated ways. This feature made the formalizations advocated in Bruner's "A Study of Thinking" from 1956, and in Miller, Gallanter and Pribram's "Plans and the Structure of Behavior" - which was published in 1960 and was inspired by the approach of Newell and Simon - appear workable in the behavioral scientist's shop. A conscious control of behavior could be understood as processes which were open to the same kind of scientific control procedures as behavior and the construction of industrial plants. Consciousness was not anymore a volatile phenomenon studied by vitalists, control structures were a ram which made the study of consciousness possible at the behavioral departments of primarily American universities. All the same, it is still an issue, whether the formalisms grasp the central aspects of subjectivity. In order to discuss this we must get more into the formal paradigm.

Now, it would not be very convincing to claim that man is like a computer or like the automatic control functions of an industrial plant. "Then it becomes relevant to discover whether man is all bits on the inside" (Newell and Simon, (72) p. 5). But one can state that there is a theoretical identity between computers and man, they are both instances of the same abstract Information Processing System. According to Newell and Simon, to proceed in this way makes it possible to disregard the material side of the computer, its fast arithmetic, and its simply ordered memory, and of man and his physiological mechanisms. The abtraction allows us to study the precise symbolic process, the implementation of which will be restricted by material considerations, whether the process is implemented in man or machine.

Thus on the level of the abstract Information Processing System, the performance of human problem solving is investigated as symbolic behavior. Some aspects of human behavior is omitted, however. Learning is seen as changes in the performance of the individual, and it is claimed that as long as the theory of performance in human problem solving is not well understood, it is better to abstain from the study of learning (Newell and Simon, (72), p. 7). Furthermore, contrary to computers human beings possess a fully developed perceptual system. But in perception one can find gestalt phenomena, whose nature is not sequential and has not yet been determined. Because the theory of symbolic behavior works with sequential processes, also perception has been omitted. The study of human problem solving may thus be characterized as a formal theory of how problems are solved, discounting perception, learning, and behavior.

Let us investigate this abstract theory a little, which emerged from the construction of control structures in automatic machines and then was applied to human beings. We may ask in what way the formal theory of sequential symbolic behavior would determine how an operator reacts to alarms in an automated hydraulic system. To the knowledge of the present author the answer has not been worked out in detail, but we can make a sketch of the direction such an investigation would take. According to the delimitation of Newell and Simon we must disregard perception, learning and development, and therefore we must consider an abstract case of recognition, which is pure routine. If everyday life were different from their conception - that is, if you could learn from even the most drowsy routine - Newell and Simon would not be able to detect it, having eliminated learning from the theory and relegated it to other kinds of investigation.

What we win by excluding anything new or changing in the operator's recognition - or in any other aspects of his activity - is an ability to formalize the operator's routine. We become able to identify formal symbols, which can be processed in an information processing system, and which denote alarms, pumps, vents etc. in the plant. To make our formalization work properly we must identify all the symbols relevant to the system of the plant. Out of the elementary operations in the information processing system - those of copying, comparing, rearranging, and concatenating - we must construct the complete set of more specific operations on the symbols relevant to the functioning of the plant: acknowledging alarms, turning pumps on and off, opening and closing vents etc. As the behavior of the operator is conditoned, we must set-up the conditions proper to each operation, conditions for turning pumps on or off, for opening or closing vents. Each condition and operation is called a production, and the productions may be put together in production systems, small episodes like: Turn on the pump when all valves are open and the pressure is too low and monitor the pump until the pressure is at the standard level of the plant, this being the goal level. All the production systems relevant to the operation of the plant are included in a closed problem space, containing all the possible states of the system, and all the possible productions to be performed on the states and all the possible goals of the plant. The problem solving in the information processing system of the operator is then determined in the following way. The plant is in one state, e.g. an alarm turns on when pressure is too low, he knows the relevant goal state for this alarm, e.g. attaining the standard level pressure, and he must now identify the set of productions with which he can proceed from the alarm state to the goal state. A fundamental procedure with which to move from the initial state to the solution is a search hierarchy: on the initial state each possible production is applied, and the new state is analysed in terms relevant to obtaining the goal. The best production is chosen, a further state is obtained by applying yet another production etc.

The concepts of symbol, operation, production, production system, problem space and search hierarchy have become the common lore of cognitive scientists. They were originally developed through the analysis of small problems, like how to open a safe with ten turn knobs, each having ten possible positions. The problem can also be used to illustrate another key concept in cognitive science, which pointed to its further development. The systematic search dictates setting all knobs at the first position, then turning the first knob through all its positions, then setting the second knob on its second position, again turning the first knob through all its positions etc, until the knobs were in the position allowing the safe to be opened. If now the click of each knob was recognizably faint when it entered the correct position, the search would be greatly reduced. This is an example of a heuristic search, in which knowledge about the particular safe shortens considerably the search for the correct position of the knobs. Everyday experience tells us that the heuristic search mostly resembles the way human beings work with problems. This consideration is especially valid for our operator, he would not perform a systematic search of all the possible production rules applicable to the present state of the plant, he would do something resembling a mixture of a heuristic and systematic search, based on his acquired knowledge of the workings of the plant. The change from general procedures in problem solving to heuristic searches based on knowledge of the problem space was a key development in cognitive science in the seventies.

To acknowledge the importance of heuristic search makes the importance of learning evident. Originally, way back in the fifties when Newell and Simon defined their new science of information processing, they were scientifically strict by delimiting their approach from learning and perception. As demonstrated above the formal theories they applied transformed problem solving to formal operations in an axiomatic system, where all the elements for the solution of the problem are given before the solution is embarked upon. The formalisms can only be applied after the problem has been posed (cf Seidel, "Denken" 1976). By excluding perception, learning and development, in which processes one would expect the problem to be encoded, or better to be posed, Newell and Simon were hence acting in accordance with their theoretical approach, not necessarily in accordance with the necessities of reality. To introduce heuristics is to introduce the fruits of learning without attacking the problem of understanding learning. In this way Newell and Simon could continue their investigations into formal procedures, and leave the study of learning to somebody else. Only in cases where it is requried by the theoretical approach, is it self evident that performance must be studied without learning. One might as well on the basis of another conception claim that since everything a human being is able to perform is learned and relearned, one must study learning as performance.

The pressure for issues of learning, arising from the work with heuristics and the therein contained work with expert systems forced cognitive science to take up issues of learning and perception. The late Newell followed this trend with the AI programming system SOAR, which purports to be a general system to build expert systems able to learn (Waldrop (88)). Simon claims that problems in perception have been solved with the techniques of neural networks (Vera and Simon (93)).

The need for a theory of learning and perception does not however change the preconditions of formal theories, it is still true that formal theories can only be applied to closed problem spaces where all elements and operations are determined in advance. A formal description of how the operator responds to alarms must still be based on the closed set of representations for alarms, acknowledging alarms etc. present to him when he responds, as stated above. I take this to mean that performing the operations of a formal system in a problem space we may be able to combine the present elements in as many ways as allowed by the rules for permutation, but we will never be able to abstract a new kind of symbol or operation learned from our operations, or from a formally operating perceptual system. This conclusion is based on a well known discussion in philosophy, a main direction of which will only be hinted at in the present chapter:

- *In an abstract formal system the abstraction process is presupposed.* It is Locke's idea of concept formation, which became one of the roots of formal logic. Katherine Nelson ((1974),

p. 270) explains: To Locke "it is by a process of abstraction that concepts are formed; we observe a number of particular objects and abstract from them those features that are common to several of them. Concepts are formed when objects are classified. Not only must we notice similarities to form a general idea, but we must also set aside particular differences, which are not relevant to the concept in question." The argument has two steps, first we note common features and set aside particular differences in a set of objects, then we classify the objects according to their common features. The classification is normally said to constitute the concept. In "Substance and Function" Cassirer argues: "The concept, however, is not deduced thereby, but presupposed; for when we ascribe to a manifold an order and connection of elements, we have already presupposed the concept, if not in its complete form, yet in its fundamental function" ("Substance and Function", 53, p. 17). Cassirer argues that the classification presupposes the abstracted features, and that the concept is inherently constituted by the abstracted features, which the classification simply confirms. The classification is the formal process, the abstraction lies before it and sets up the concept. This circumstance parallels our earlier statement that the posing of a problem comes before its formal statement. It was the reason that Newell and Simon in the fifties disregarded perception and learning, which we connect with the abstraction process.

- *Formal statements are only valid after the concept has been established.* But could it then be possible to explain the abstraction process itself whether in perception or in learning through a formal system? This question is immediately selfdefying. The reason is that in perception and learning the objects appear as the unity of the particular and universal. Logical statements, however, deal with universals and not with specific objects (cf Passmore on Herbarth, p. 159f). This must mean that as long as the operator of our example has not found out that the specific object in front of him is an alarm, he cannot use formal statements. To put it sharply, logic will not help him decide whether the blinking light is an alarm, reflections of a moving object or whatever. According to the formal description he may reason about his assumptions, and the reasoning may guide him, but the reasoning presupposes preformed concepts to work with and thus the reasoning helps him choose among pre-established conceptual alternatives. Hence you cannot use conditional statements to establish or identify the universal aspects of this particular thing! There must be other kinds of necessities involved in perception and learning. These other necessities must be able to work in an open space, meaning that they must allow for the possibility of acknowledging that the object confronting the operator was not an alarm of this kind, but maybe of that kind or maybe something quite else whose identity must be ascertained.

According to this line of argument abstraction, perception, concept formation, learning, and human development, then, cannot be explained by formal systems. Furthermore, mathematics cannot be identified with the formalistic school of Whitehead and Russell, there are other mathematical schools contesting that formalisms constitute mathematics (cf Davis and Hersch (90)). Formal systems are tools with which to systematize elements already formed and belonging to a closed space. Within the terms of the formal paradigm and its application on thinking, we have come upon serious problems. To me, the nature of the problems offers reasons of sufficient strength to transcend the paradigm. It becomes the task to identify how human beings dig out meaning of a situation. We saw that Newell and Simon stated that the formal, mechanical operations of copying, comparing, rearranging, and concatenating are just as definite as the processes of sawing, planning, measuring and gluing pine boards. This statement we may take to demonstrate the tool character of formalisms. When formalisms are tools, we must go back one step and study the use of tools. We must investigate the carpenter's shop, the computer scientist's shop, the social activity of the subjects in the shops. We must determine central aspects of human subjectivity.

*Human activity as embodied and situated*

In the discussion of Newell and Simon we noted that symbolic behavior was considered an abstract theory on a level above computers as well as human beings. To allow the formal approach to be applied the problem space was closed, all symbols, operations and states belonging to the specific problem to be solved were enclosed in this space. On the one hand this procedure would be defended by Newell and Simon on the grounds that the abstract level included the essentials of the problem solving process. On the other hand we can say that intrinsic aspects of the object of study have been locked out. To isolate a theoretical domain on its own is the characteristic feature of essentialism, where the abstracted form is given precedence over content, where the abstract formalisms are located in a realm of their own parallel to concrete reality, and where it hence becomes impossible to connect the two domains (cf. Axel, (92)). The problems of essentialism follow us as long as we stick to formal, abstract theories. We saw how perception, learning and development were separated from performance in order to allow for formalizations. When cognitive science does take on the task of theorizing about learning, it is viewed as acquiring existing knowledge, learning is always understood in the past tense. We recognize that to cognitive science existing knowledge can be contained in a closed problem space in which the flow of knowledge from node to node can be studied. This excludes invention and reinvention of knowledge, which are difficult problems to cognitive science (Lave (93) p. 12). Thus, in order to mold content - learning - according to form - formal control theory - central aspects of reality escape cognitive science.

To avoid losing central aspects of our subject, we must let our theory of human behavior, of human activity, be molded by its subject matter. This means that we cannot extract it out of its realm, we must emerge ourselves in the material process. To step back to see formalisms used as tools in the computer scientist's shop and thus to study concrete human subjectivity, means to enter material human activity. To step back, moreover, means to include ourselves as participants in the social process investigated. We investigators are human beings ourselves, we must be guided by our own participation in the processes. Our participation is our human method - our ethno-method - with which we explore human activity. The differentiations we make must be relevant to participants, including ourselves. We must begin with the object we confront when stepping back, with the social activity of human subjects in the shop and its meanings. This approach can be generally characterized as working with concrete, real activity and with embodied and situated meanings.

In our case, to study concrete, real activity means to ask ourselves how the operator comes to identify what is in front of him as an alarm, - to ask how he recognizes this particular thing in front of him as an alarm, as having universal aspects. If now we claim that we must study how the operator sees the particular thing in front of him we defy ourselves: we are only able to identify it through universals: e.g. "particular" and "thing" are universals of language presupposing a very general level of discussion. On the other hand we have claimed that we cannot presuppose universals, that would mean to relegate their development out of the field of study. To study concrete, real activity thus includes studying the object of activity as the dialectical unity of the particular and the universal. It means to study how the particularities of the object is determined through its universalities and how the universalities through the particularities, how the two opposites develop each other in human social activity. Concrete, real activity unites the human being and the situation, constitutes an active organism-environment relationship. What gives meaning to the human being - what is relevant to it - makes it act. A first broad identification of meanings is their relevancy for acting, and meanings as part of the active organism-environment relationship are embodied as well as situated.

The meanings of social activity are embodied. The embodied aspect is a unity of a species specific and biographical perspective in human activity. Even though the term embodiedness is not used within Critical Psychology, we may explicate the species specific aspects of human activity with categories from Critical Psychology. To Critical Psychology the social nature of human beings implies that they satisfy their needs through socially produced objects (cf. Tolman and Maiers (1991), p. 12-15). Therefore, even though specific societies restrict the development of some individuals more than others, such a differentiation in social opportunities is seen as a historically conditioned aspect of society. The fundamental aspect of society is the fact that it provides human beings with objects to consume for the satisfaction of their needs, and this provision is a result of productive human activity. Now, the embodied aspects manifest themselves in the organization of human activity, its immediate as well as mediated aspects. The human beings as bodies in social time and space must arrange their activities in more or less regular and interwoven rounds: repeated participations in different social activities and their coordination (cf Dreier (94, pp. 72-74), Holzkamp (95)). Some of the rounds take care of immediate needs, sleep, food, social contact, others make arrangements around them, provide shelter, food, etc., yet other activities enter into more mediated and interwoven connections, participation in societal productive activities or their arrangements etc. We may take this to mean that generally the embodied aspect of meanings concerns a species specific arrangement of activity rounds based on an individual history of situated changes and developments. When we confront a concrete human being, the meanings it acts upon within sets of acts and their arrangements may therefore also be understood as an expression of the unity of the species specific and biographical perspectives in its activity.

The meanings of social activity are situated. This implies that they change according to the relevancies of the situation. The relevancies of the situation change according to the activity of the subject and to situational aspects here and now, other locations and other times, that is to general and specific aspects of the situation. To cope with situational changes, the individual must develop. Thus it can be said that situated activity always involves changes in knowledge and action (Lave (93), p. 5), meaning is a part of and a product of social history. Furthermore, the circumstance that meaning is situated implies that each participant in activity with each his perspective has its angle on the meanings of the situation. This has also implications for the meaning of tools, and is related to the concept of boundary object (Star and Griesemer, 1989). Boundary objects are common objects in an institutional setting, where each group of participants organize their specific rounds according to those aspects of the boundary objects which are relevant for activities in their site.

Furthermore, to step back to see formalisms as tools in the computer scientist's shop and thus to study human activity means to study human subjectivity, to investigate purposeful human activity in the shop. It is important to determine the uses of the tool sets, the purposes they serve and the anticipations and organisations they set up. Within the trend of investigating embodied situated activity Critical Psychology is conspicuous for having developed a category of the subject (Holzkamp (1983), Tolman and Maiers (1991)). It has already been stated that studying human activity as embodied and situated is to think developmentally. The inherent intent of such a project is to grasp human beings as active participants in their own development dependent on the social circumstances. The category of subject is meant to grasp these aspects. It is many sided and systematically developed within Critical Psychology, here it can only be sketched. Subjectivity is seen as having developed phylogenetically from the need for exploratory activity in mamals. Animals explore unknown aspects in their biosphere in order to master them. Along with the development of human social nature the need for exploratory activity evolved into a need to explore and cooperatively master unknown aspects of the social situation of the human being, be they objects, meanings, social processes having impact on its life, social processes it partakes in, or whatever. The need is called productive need. The exploration unfolds through ordinary activity when the conditions make it meaningful to the subject, and as an exploring participant in social processes the subject changes itself by changing changed circumstances. The productive need is thus the origin of human active development, and since any activity, even the most distracted routine, contains possibilities for development, the productive needs must be considered to be involved in any activity to a greater or lesser extent. To think developmentally is to think in possibilities, accordingly Critical Psychology opens up for actions not being totally determined by social conditions, but appearing as possibilities for action under certain conditions. It is stated, that when a human being acts, it makes use of the conditions of its social position, of their meaning for its action possibilities. The category of action potence is a focal point for the category of subjectivity, our determinations of productive needs, action possibilities and conditions merge in it. A human being is said to have action potence, if the social conditions open up the possibility for a human being to have the ability to participate in the social regulation and development of its life conditions. Here ability means subjective potentials in relation to those of the situation. Action potence is seen as a species specific human need. Its need character becomes evident in for example the fear of being exposed to adverse social conditions. It is common in social science to find conceptions where the social beings are either seen as totally socially determined or as totally free-wheeling, as if they were able to change their life at will. The category of subject is developed to grasp the circumstance that human beings are active *and* socially determined. The fact that they are beings socially evolved means that what happens to them and what they become cannot happen without them being active. Human beings relate to, act in and thereby change their social conditions. Any act is a reciprocal change of circumstances and subjects, the geographical and organizational extent of development being also dependent on the conditions of the act.

The subject makes use of its action conditions. The conditions are not exploited one at a time, but all the conditions and their interwoven relations and contradictions in a situation constitute one complexqualitative evaluation of the situation, on which the subject acts. However, even though all meaningful aspects of the situation form part of the evaluation of relevancies, the subject focusses on some, differentiates, selects or unfold some as the most pertinent on the background of the situation. This implies that meaning is not additive, nor abstractable from the situation, it is a situated totality. That is, meaning cannot be pieced together into a closed problem space as we attempted when discussing in what way the formal theory of Newell and Simon would determine how an operator reacts to alarms. On the contrary, the operator estimates the configuration of alarms according to his knowledge of the plant, its general state of disrepair, of how it was regulated by the operator on duty before him, on how much trouble he can delve into just now, etc, etc. He made use of all these conditions in his reaction, you may ask him and he will explain. But he did not reflect on each of them and then acted. He acted on the complexqualitative evaluation, and then reflected when you asked. He could go on giving aspects and reasons for his action for as long as you cared to ask (cf. Garfinkel (67) p. 24ff). There is no closure, and all the same he made an evaluation of the total situation and acted on a pattern of considerations in the situation. Had he reflected, it may have let him apprehend future events, and his reflection on his acts may make him learn why things happened, and imply the reorganization of future complexqualitative evaluations. But reflection presupposes that the person has experience from activity to reflect on. Furthermore, he is not only acting on immediate considerations as the set of alarms, etc., but also on mediated ones, as on what happened to the plant on the previous duty, on the general state of disrepair of the plant, where his evaluation of the general state is also determined by what he generally expects about repair states in his society, etc. Situated meaning is socially mediated (Dreier (93) p. 113).

Now, it has been stated that situated meaning is historical and changing according to the relevancies of the situation, and that meanings are accordingly organized specifically on each location in an institution, in a society. From such a location situated meaning reaches towards other locations. Additionally it has been stated that meanings are the meanings of conditions for action possibilities. All this implies that meanings must be understood from the perspective of the subject, though they are not subjective in the sense of being arbitrary or free-spinning. Each meaning has its material conditions and material consequences, has its relations to other times and places. Bound up with the subjective perspective meanings are based on interests to achieve certain anticipated events. The distribution of conditions and resources opens up for configurations of more or less comprehensive, more or less restrictive interests. The distribution is a central element in the formation of the different perspectives on a situation. Among the different perspectives there may be conflicting interests about participation in the social regulation and development of the conditions and resources. This implies conflictual negotiations of the state of the system. Like meanings the conflicting interests are mediated. A conflict between mr White and mr Blue in a control room is not only an immediate conflict between persons, nor a mediated conflict between only professional groups, but also between classes. As participants we have no privileged position from which we can judge who is right. The general ambiguity of conflict processes does not allow for an unequivocal definition of the initial problem. Individual points of view on the problem will not totally coincide, and no individual contradiction could be defined more closely than simply a contradiction (cf. Dreier, (91), p. 202).

According to the relative positions and scope of interests of the participants in conflict, deadlocks or development are created. Deadlocks may be tense or relaxed, development may be step by step or a fundamental reorganization. Conflicts may come into deadlocks for many reasons: the distribution of resources may make a set of restrictive interests possible so that the actions of some block the interests of others. The reciprocal loss of control in conflicts narrows the view of participants additionally. In such cases the conflicts become easily personalized (Dreier, (91), p. 203). When conflicts open for development, the scope of the relevant interests are more comprehensive. One way such a scope can be patterned can be identified in the following case. Christof Ohm (89) has written a report on a participatory planning of a new computer system in a botanical garden. The botanists with a university degree defined the institution as one which should serve the scientific classification of plants, while the gardeners without a university degree saw the institution as one which should serve the cultivation of rare and not well known plants. Ohm mentions that this type of conflict seems to be inherent in the organization of botanical gardens, and mentions that at a certain point in time it lay behind the suicide of a director of a botanical garden. The introduction of a computer system for the registration of plants created an opportunity for changes. On the basis of discussions with the professional groups a common project was outlined. The extinction of many plants in nature was made the background for setting up the task of storing seeds from plants for future use while entering into a database their classification as well as information on their growth and cultivation. Thus a new computer system was an opportunity to expand the two specific interests and thus move towards a more comprehensive one.

On the basis of the presented categories we can now here explore a little further how meanings are established. We will give a hint of how the process of identifying meanings works, the process Cassirer argued to be presupposed in formal systems. As meanings are embodied and situated totalities, we cannot say that they are abstracted - pulled out - from a situation, we have said that they are focussed figures on a situational background. Thus all possibly meaningful aspects of the situation may form part of the evaluation of relevancies, on the basis of which the subject focusses on a meaningful formation of the situation. The main sides of activity involved in our discussion will be its productive, consumptive and distributive facets and its aspects of time, space and matter. As meanings are social, they are used - or consumed - but as they change with the situation, they are simultaneously used and re-produced each time anew. As meanings are situated, they are concrete and particular, as they are recognizable from situation to situation, ~~they are universal - or distributed.~~ Meanings are thus determined as the unity of the universal and the particular, of consumption and production in activity.

When social objects - processes, routines or tools - are consumed or used in activity, they are seen as the unity of the universal and particular aspects of meaning. Regulating or investigating the plant in which I work, and which has been designed by contractors with an anonymous operator in mind, I will make a particular reproduction of its general use on the basis of my previous experience. Dependent on the circumstances and my relations to them, my reproduction will modify the universal theme I find in the plant, the modification spreading from the easily overlooked to the conspicuous, easily remembered way of use.

When I observe your particular way of regulating the plant, I notice the contrast between what you do and what I would have done. When I see how you do it, I may wonder, what makes you do it that way. Dependent on the circumstances and my relation to them based upon previous experience, I may investigate the reasons more or less thoroughly, and deepen my knowledge of the particular circumstances in this case, thereby grasping the universal aspects of the situation better. In other words, the greater my experience, the better I grasp at the same time the universal and particular aspects of the situation.

My regulation of the plant, and my investigation of your way of doing it is part of the general social distribution of that kind of plants: The plant or its components must be incorporated in a widespread social practice so that we can find its meaning by identifying differences and similarities, particularities and universalities in different uses. There are some plants like this one and we hear what kind of problems operators of the other plants run into. Our group works each day with this plant, regulates it routinely under different circumstances. I regulate the pump and other professional groups repair them, construct them, buy them. Thus we all routinely work with components in the plant for complementary purposes, in different locations, sometimes for the purpose we believe the component is meant for, other times not, and we may for different reasons contest each other's use of the components. In the midst of the conflicts and reciprocal contestations each of my regular uses of these components acquires an obviousness to each of us, which makes it look as if the meaning of the plant and its components were carried by them. However, if I discover an artefact, a tool or a language, whose use nobody knows of, I may only recover its meaning, if I can relate it more or less directly to artefacts, whose use is known. The tool acquires its meaning through the kinds of practice related to the one it was meant for, and the meaning cannot be understood only from the form of the tool. The tool is a condition of life for me, and through comparisons between our practices its form becomes meaningful to me by opening new action possibilities, which I may explore further on my own.

When the contractors produced or designed the plant, they gave it a particular form according to their anticipation of its general use. The meaning they found in that kind of plants made them form it in this way When the operators began to regulate the plant, they may for good reasons the contractors did not know, and has no need to know, use it in ways not anticipated. The contractors cannot claim that the operators have used it wrongly, even though the use was not included in their general apprehension. Such phenomena demonstrate that tools get their meaning through their social use, and there is no crucial difference between the processes of according the tool with meaning when it is used in the general and common way or in a unique way. The general use the designer anticipated is not immanent in the tool. It is not written on the forehead of a chair that one can sit on it, use it as a ladder, as a weapon, as fire-wood if it is made of wood etc. But when I use a tool in the general and common way, I can say that I use it as intended and be right.

Meanings have here been determined as the meaning of conditions for action possibilities, and thus as based on interests to achieve ends. To be interested in achieving a specific situation is to value it, which is the result of an emotional evaluation of the present and future state of the situation and the subject. To evaluate a future state of a situation is to anticipate what may happen and to strive for one of the possibilities: We are not able to know exactly what the future holds for us, we may have a general idea, we may have a hunch, a more or less vague perception of what may come, which makes us explore possibilities. I strive to achieve something which I perceive vaguely. I strive differently according to my anticipation, and my endeavour shapes my anticipation: to have a hunch in explorative activity is a basic phenomenon, which forces us to admit the existence of cognitive functions in emotions. We cannot say that emotions determine cognition, nor can we say that cognition determines meaning, but we must acknowledge their interrelatedness. This makes us see that we cannot subtract emotion and be left with objective meaning as the remainder. Emotion and cognition as a unity form situated meaning. This also implies that we cannot talk abstractedly about either emotion or cognition, when we discuss cognitive aspects of meanings, we are also implying their emotional aspects et vice versa. The hunch, the open idea, ready to be reorganized according to relevancies in praxis which it guides and is guided by, is that objective phenomenon which we take as a guideline to understand even the most stable perceptions in human consciousness. This must mean that a perception in consciousness may always be developed further, and that therefore the very likely possibility exists that we may in principle at any time do the right thing for the wrong reasons.

Thus, within the re-production of meaning emotions and cognitions are reciprocally determining each other in a process playing on the dialectical unity of the particular and the universal, of necessity and coincidence, and progressing from the arbitrary beginning to the unfolded general meaning. This is implicated when I act and think, and when I think acts. In principle it is a process which in relation to the object can take its beginning anywhere, stop anywhere. With good reasons its beginning, end, and direction is determined by conditions in the situation, my previous experience, and my evaluation. Beginning anywhere means beginning with some aspect of praxis, e.g. either notions, or perceptions, or vague feelings. It cannot mean that abstract universals are presumed at the starting point, but anywhere concrete meaning in concrete activity can unfold. With a term picked from Jean Lave (1988), we could call the process for gap closing, a process of changing circumstances according to anticipations and anticipations according to circumstances until what unfolds is acceptable as what is strived for.

Even if it is claimed that meaning resides in consciousness, it must be made absolutely clear that meaning is social and dynamic, meaning is the coordinating rythm of social dance. Meaning does not come from within, from archetypical symbols in my hereditary constitution or other conceptions like that. Nor is it inherent in things. But tools have significance for me, I accord them with meaning in the situations of my social activity, in keeping with my way of using them.

This, then, is a conception of situated meaning. Meaning is as stable as the conditions for activity, changes according to activity and wanes with the conditions of activity. As stated, this does not imply that meaning is immediate and only concerns the situation here and now, but it implies that the focus of an organized system of meaning is determined by the organization of kinds of situations, their anticipations and tools. I may still have an idea what this alarm means, even if I have not reacted to it for years, but my concrete reaction to it with all its shortcuts, remedies and smartness comes to me through repeated reaction in the rounds of everyday work situations.

The conception implies that the establishing of situated meaning can best be investigated in everyday life. Work situations are one part of human activity, where all the manysided aspects of a situation coalesce to accord it with meaning. This process can be identified in the negotiation of errors in the following exploration of some operators working in a district heating system.

# AN EMPIRICAL EXPLORATION OF TOOL USE WITH LOCALIZED MEANINGS

## *The plant*

We will look at a district heating system - which I will call the "Company" - from the point of view of its operators. What is said about the localization and funtioning of the "Company" in the community is to be understood as the perspective coming into view through a confrontation between a researcher and a group of operators. The task will be to demonstrate that the problem-based and localized understanding of the operators is emerging as the result of according the plant with meaning in its social connections. The plant as a tool comprises ways of working, which left to themselves would make them wander beyond social meaningfulness. This ongoing process is a central part of the work conditions of the operators. They must bend the ongoing activities by relating to the social needs, demands, and anticipations they are exposed to in their workplace. It will also be important to understand the broader perspectives they talk about as getting their meaning from the daily operation of the network.

The "Company" must be considered as a societal response of the eighties to the oil crisis in the seventies. The response is multifaceted, there is no single goal, no unequivocal intent, to use a term from Bourdieu, the response is orchestrated with no conductor. Among the aspects of the response, the ecological and economical ones are in the foreground. Each aspect is complex and laden with potential conflicts.

This goes right into the core of the physical process of the plant: From the perspective of the power plants, the heating system is a cooleant agent. The water under high pressure in the pipes carries heat away from the plants. The water runs through a number of heat exchangers, which cools the water of the district heating system, and the cooled water returns to remove yet another round of heat. From the perspective of the consumers, be they municipalities or households, the district heating system through the heat exchangers delivers heat, relatively cheap compared to other available resources. As a cooleant agent, the system must be at disposal according to the production of electricity. As a heating agent, the system must be at disposal according to weather conditions. Many times the conditions will support each other, e.g. during the winter it is cold and dark, therefore the need for heat and electricity are both enhanced, the 24 hour rythm of the two needs is also a close match. But even in winter, some days are colder than others, although each of those days can be as clouded as the other, etc. The operators say that in the beginning of the operation of the network, old power plants supplied the heat. Prior to the construction of the net these plants had had the control over the level of production of electricity as well as heat. This made the operators of the power plants reluctant to respond to the needs of the "Company", and created a lot of tension. The newer plants started up with the "Company" already present, therefore the operators of those plants easily accomodated for the needs of the "Company".

This story of a development contains aspects of a regularly appearing pattern in the explanations of the operators: as a start they describe a situation, which is unappealing because some need is not met and you get a lot of trouble, discord and conflict between work groups of the net. Then they tell you about the arrival of a new rule or component, either of which solves some problems. If you specifically ask, you will hear that it also creates others, and are reassured that as an answer to the present state of discord and conflict a new set of rules or yet a new component is set-up, either of which creates order and a smoothe operation. If there are still disagreements it is a matter of yet another round in greater detail. Thus the vanishing point of their stories is an end state, which they laughingly talk about as unachievable, and which resembles the night shift: the graph giving the trend is a nice, smooth curve, and the operator can lean back in the big arm chair and watch everything with no need of doing anything. Their stories are thus in compliance with the formal approach: it is possible to implement the automation of the plant, so that nothing needs to be done. But if one persists and asks whether conflicts between the cooling of the plant and the heating of the city are really settled, or are still a source for action, one can get a spectrum of answers. Some will tell you that the contradiction still pops up in the anticipation of rare situations. For example in an emergency situation the need for electricity must be met before the need for heating. Also, operators of an electrical power plant are not allowed to strike, but operators of a heating plant are. Others will tell you, that the conflict between heating homes and cooling power plants will constantly pop up in the acquisition of different components, and give a recent acquisition as an example. You will also hear about rules, which are constantly contested and which are set-up so that the priority of power production is ensured. Thus, on the one hand, you are presented with an official story in compliance with the general ideology of an automated work place: the plant will nearly run by itself, if only you can disregard some small annoyances. But if you persist and scratch the surface, you can collect a set of examples, illustrating conflicts permeating the process of the plant, and having different appearances in the everyday work functions.

The "Company" was established to save money, and it is organized according to the way power production has been organized in Denmark for many years, a procedure which has peculiar resonances in the basic ideological prescription of the eighties: Even though the "Company" cannot go bankrupt or be taken over by a competitor, it is driven as a private enterprise and must show profits. Cost efficiency is in the mind of everyone

The "Company" is the result of the cooperation of municipalities at different levels at their organization. It is not unusual among the operators to interprete each action of the authorities according to "whom does it benefit". In the net of a certain part of town the water runs at lower temperatures than other parts. At the same time there is a limit to the amount of water, which can run through that specific net. This means that the "Company" cannot meet demands with cheap heat from its main net. In that case the municipality is allowed to start up an expensive power plant at the expense of the "Company". Because the "Company" has the monopoly of selling and buying heat, it must buy the more expensive heat from the power plant and sell it to the municipality which owns the plant and runs the net. This in the opinion of the operators can only mean that citizens from other municipalities will have to pay for the heat in this part of town.

Within the organization the operators can be identified according to their tasks and the tasks of the work group with whom they have the closest relations, the engineers. The widespread use of computers in the eighties has made it possible to automate the regulation of the district heating system on a level not seen before. In a control room the operator on duty

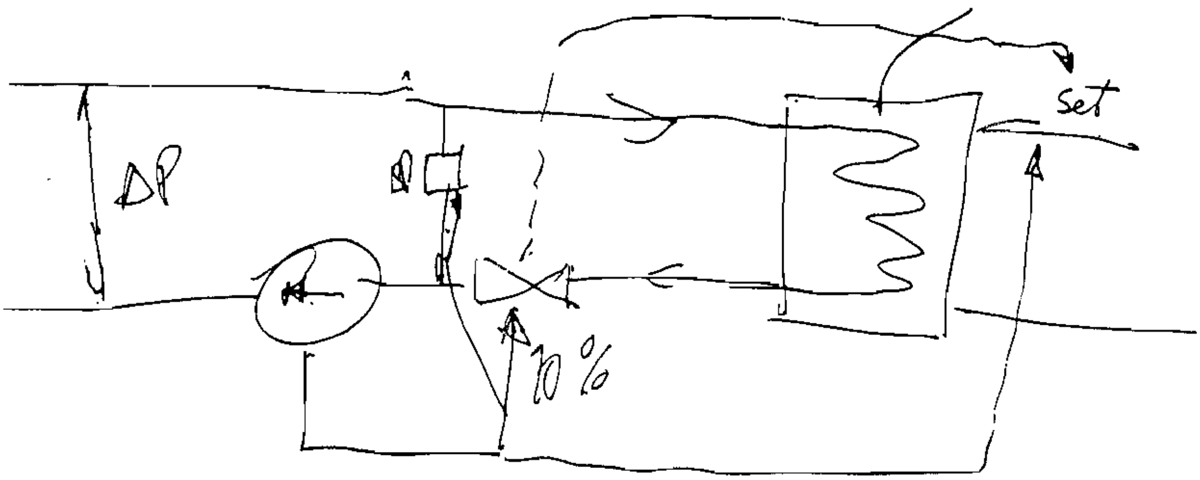


Figure 1. Diagram drawn by operator, showing main components in the control system of the heat exchanger. Pump, valve, heat exchanger, set point, pipes and cables drawn. Delta p, pressure difference between pipes to and from heat exchanger indicated.

sits at a console with seven computer screens and some keyboards for entering commands. Here he monitors and modifies the regulation of the network. As a consequence their workload has been eased in some aspects, and the designers foresaw a new one, boredom and emptiness. Therefore they followed a trend in high tech work places in Scandinavia to combine work functions. In the past few decades before the advent of the computerized plant these functions were divided as a matter of fact between specific workgroups. Now the operators of the "Company" perform as well the regulation of the plant as the maintainance of some aspects of it. They are also involved in the "ripening" of the plant, and in the planning and evaluation of the regulation.

*calibrating pumps and valves or reconstructing the plant?*

But these work functions are not easily distinguished. They are constantly changing, and what at one time looks like calibrating will at another time appear as mending a faulty component. The following example on work on the heat exchangers demonstrates the change of meanings according to the perceived goals.

The heat exchanger is a complex piece of equipment, which can most easily be identified by four of its main components (See figure one). First there is the heat exchanger itself, where heat is exchanged through metal plates between the water of the "Company", the primary side of the heat exchanger as seen from the "Company", and the water of the consumer, the secondary side. On the primary side hot water enters the exchanger, gives off heat to the secondary side, and cooled water then leaves the exchanger on the return side of the primary side. Immediately after the exchanger it passes through a valve and then a pump. These components regulate the amount of water passing through the primary side, determined by the temperature of the water, which leaves the exchanger on the secondary side. Here a regulating device is located, which measures the temperature of the water and compares it to a set-point. If the temperature is lower than the setpoint, a command is issued to the valve on the primary side to open more up. More water will pour through the exchanger, and the temperature on the secondary side will increase above the setpoint, a command is issued to close down a certain amount, and now less water will pass through on the primary side. This will go on for a while, and the oscillations will become less and less, and in the end the secondary side will get a stable supply of water at a set temperature. To this is added a further refinement. The regulating valve on the primary side will cause the least disturbance of the pressure in the network, if its opening is within a specific range. If the changes in the amount of water are so large that the opening of the valve is outside this range, then - after some time has passed and the change thereby has proven stable - the state of the pump is changed automatically in such a way that the valve will be within its opening range and the temperature on the secondary side still meets the set-point.

Now, the interplay of pumps and valves within the network as a whole creates pressure waves, which the designers were not able to calculate before the construction of the system. Therefore they made it the task of the operators to identify the opening range of the valves, the amount of opening asked for by the regulating device on the secondary side, and the steps in effect the pumps must take when changing the opening of the valves. A part of the construction of the system was thus transferred by the construction engineers to the operators.

This calibration occupied the operators for four or five months after the initiation of the system. Out of this work emerged two strategies of regulation, each advocated by its originator. One strategy was to let the valves stay as open as possible. This would cause the least loss of pressure, and therefore economize the effect used in the pumps. It also meant that the pumps would accomplish a greater part of the regulation. The other strategy was to let the valve regulate the small changes, and the pump the bigger ones. This would ensure a more stable delivery to the consumer on the secondary side. There would, however, be a slight loss in pump economy, as the pump would have to work for a short time under adverse conditions. But the operator advocating this strategy also had a solution to this slight impediment. He said that the regulating device on the secondary side should also be changed so that it could send a command directly to the pump, if the change in heat was greater than a specified value and lasted for at least a specified time. In this way one could avoid the two step regulation of longer lasting large changes in temperature. But the operator could not make the managers pay the expenses for such a change in the working of the regulating device.

Since the inception of the strategies their originators each worked according to their preferred strategy. When arriving at work, they tuned the system according to their strategy. Being on duty after one of the two advocates the newcomers did not change the setpoints, but watched their behavior, and tested them. Some apparently did not, however, align in the discussions, while others felt the urge to alter the settings, if the system was not stable during their shift. The constant altering of the settings proved to be a source of irritation. The operators had tried to agree on a common policy on some meetings, but had not achieved agreement, and the conflict had gone stale. I was told, that you could not really discuss the matter anymore. It was common lore in the control room to consider the divergence as personal differences, maybe one could even say a matter of personal style or taste.

Now, at the time of observation some problems occurred in a heat exchanger station belonging to a municipality. The engineers working with it contacted the operators in order to get some help. The operator, who advocated the strategy of stable supply, made the contact,

S. W. ...

cation network handles a command as an inconvenience due to specific features of the system. He may see many reasons for the inconvenience, limitations of present technology, of resources put into the project, of the quality of the specifications. They are all related to his task as a designer. Furthermore, the inconvience is not an error, if the mode of operation is within specifications agreed upon. The operation engineers inspect the system and must account for incidences in the system within the organization. Therefore they consider the mode of operation an error due to its possible consequences, and get annoyed with such an error delivered with a system, for which they payed so much. The operators consider the mode of operation as a silly characteristic of the system not worth mentioning and easily circumvented, but which it would be nice to be without. Furthermore these are not fixed and determined positions. The operation engineers looked up the specifications and found ground for action, they made a case of it, and are now negotiating with the contractor how to handle the situation. The outcome of the negotiations will become conditions to which each group must relate, in order to accord them with meaning.

*Testing a pump.*

Each work group thus accord the process in the system with meaning in keeping with their anticipation of goals, and what counts as errors are part of this production of meaning. The redefinition of what is an error can also be found in the everyday regulation of the plant.

One cool winterday an operator got a call from a pump station, which contains pumps able to regulate the pressure in the system, and pumps which are called fixed pumps, because they cannot regulate, but work on a fixed level. One of the fixed pumps had been serviced, and now the service people wanted to check it. Due to the weather the pump station assisted the power plant in regulating the pressure, the regulating pump was on. As the regulating pump

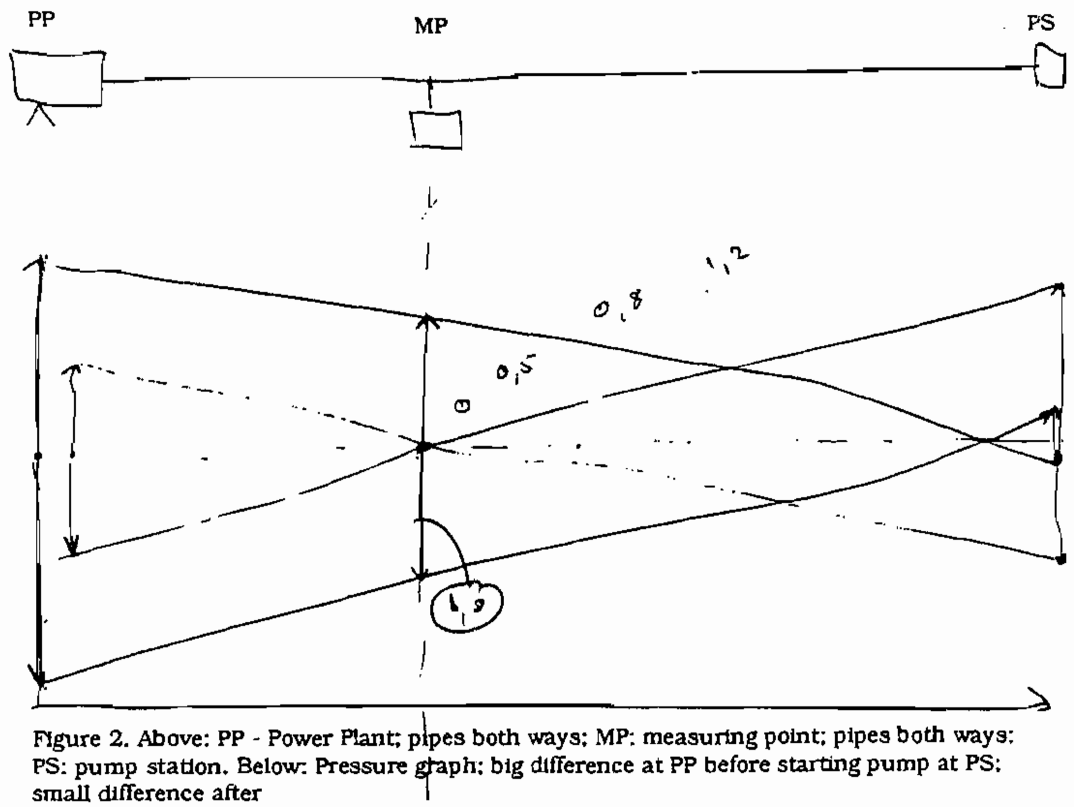


Figure 2. Above: PP - Power Plant; pipes both ways; MP: measuring point; pipes both ways; PS: pump station. Below: Pressure graph; big difference at PP before starting pump at PS; small difference after

was working the operator identified his task as changing the workload to the fixed pump, and he thought he would have to do it manually. He would start the fixed pump in its basin, and stepwise he would have to open the valve manually, so that the pump gradually overtook the workload, and the regulating one would automatically recede. Manually to open a valve the right amount is not easy. You are only told how many percent the valve disc has turned, and there is no simple relation between percentage opennes and amount of water able to pass through the valve. Furthermore, there is a delay in the feedback, you cannot in real time see the opening of the valve while you issue the command, and as you only know how long it takes to open the valve completely, you must judge how great a percentage openness is required and the time it takes to get there. But the task had to be done, he issued the opening command while counting slowly to twenty, the amount of time he thought was needed to open the valve to the required position. But, alas, the pressure went far beyond any anticipated level (see figur two). This also meant that automatic safety measure to protect the system made the pumps at the power plant stop regulating. This was not anticipated, now the two pumps at the pump station were both working, maintaining the pressure of the system. But looking at the situation, the operator discovered he had what he wanted: the fixed pump working. Thus there was no need to go for the situation where the fixed pump had overtaken the work load from the regulating one. He would just have to stabilize the present situation, and then little by little give the work of maintaining the pressure back to the pumps at the power plant. Thus correction of errors is never pursued relentlessly, but is only maintained so far as the functioning is understood as an error. The operator first changed circumstances according to anticipations then he changed anticipations according to circumstances, what unfolded in front of him was accepted as what they were striving for, he made ends meet. We may also say that gap closing or other consequences of the ambiquity of the tool stopped the error correction in the middle of a jump so to speak, as soon as the contextbound meaning of the tool in a concrete work activity has changed.

## CONCLUSION

That meaning is negotiated does not mean that it is not at times self evident. And the other way round the fact that meaning is self evident under certain circumstances does not mean that it cannot change under other circumstances. In everyday life it will be a not contested error if the water slipped out of the tubes into the city streets, but one could imagine situations (e.g. war) where this was a most wanted effect by some people. The point made in this article is to point to those processes, which establish the self evident true meaning, and which would also under other circumstances establish the opposite true meaning as self evident. This is not relativity, if anything it is absolute relativity: meanings have conditions and consequences, meanings mean something.

The cases presented have hopefully demonstrated good reasons for exploring concrete everyday practice: Formalism in everyday practice is treated as a tool. It is getting its meaning from the anticipations in everyday practice, and it is bent and reorganized according to these. This conception has implications for what can become computerized, and what cannot. They are tentatively sketched out here, to be further elaborated:

Human beings working in an organization must be viewed as producing formalized procedures and tools. The stability of the formalized procedures, their robustness, will vary according to many aspects of the organizational practice. Formalized procedures set up to regulate physical systems must be modified over time according to changes in the way the system is used as a tool, in the way components are used in the system, and according to the introduction or development of new components. Sometimes the formalized procedures will need only slight modifications even after extensive changes in the physical system, other times the formalized procedures must be thoroughly rewritten due to small, but significant changes. The formal procedures produced to regulate the flow of tasks or the decisions in a bureaucratic organization, may, dependent on the task at hand, be relatively open to interpretation. Thus formalisms for date stamping of letters and journals, produced and used for matters of accountability, might relatively easily become computerized - dependent on the action of the workers they can be set up as a well defined and finite set of procedures on a specified set of elements. But the formalisms for much casework are harder to objectify in computers, here the interpretational or gap closing aspect of the use of formalisms has a less controllable function, because it is much more an expression of the dynamic development of social life. The formalisms of case work cannot be determined definitively by being specified in minute detail, they come about as the result of localized conflict resolution in social organizations. You cannot determine the pension of Mrs Smith on formal procedures relying on among other things a minutely specified description of her invalidity, what she gets will be the result of social conflict ridden negotiation among the involved parties.

The possibility and ease of computerization is thus dependent on the relationship between the interpreting, meaning producing, and gap closing aspect of human action and the produced formalistic tools. The good reasons to study the concrete everyday practice are to be able to reach sensible decisions about computerization on the basis of the relationship between on the one hand the work functions producing meanings and on the other hand formal procedures. Where the meaning producing aspects can be controlled in such a way that the formal procedures can meaningfully be considered as a closed, well defined set of procedures stable over time, the procedures can be computerized. In these cases it is also important to establish a round of work routines which open up for the possibilities of developing challenging, rich, situated experience, on the basis of which the regulation and monitoring can be performed efficiently. Only then can technology be implemented as a proper enhancement of human powers.

## *List of literature*


Axel, Erik: "One Developmental Line in European Activity Theories." The Quarterly Newsletter of LCHC, vol:14, Nr.1, pp. 8 - 17, Jan (1992).

Bruner, Jerome S., Goodnow, Jaqueline J., Austin, George A.: "A Study of Thinking" Wiley (1956).

Cassirer, Ernst (1923): "Substance and Function & Einsteins Theory of Relativity" Dover Publication Inc, New York (1953).

1907-1939", The Sociological Quarterly, vol 28, Nr 2, pp 147-169 (1989)

Suchman, Lucy: "Plans and Situated Actions: The Problem of Human-Machine Communication" Cambridge University Press, Cambridge (1987)

James R. Taylor, Geoffrey Gurd, and Thierry Bardini: "The Worldviews of Cooperative Work" in this volume (1996)

Tolman, Charles W., Maiers, Wolfgang: "Critical Psychology, Contributions to an Historical Science of the Subject" Cambridge University Press, Cambridge (1991).

Vera, Alonso H. and Simon, Herbert A.: "Situated Action: A Symbolic Interpretation", Cognitive Science, vol. 17, pp. 7-48 (1993)

Waldrop, M. Mitchell: "Toward a Unified Theory of Cognition", Science, vol 241, pp 27-29 (1988).

---

Erik Axel

February 28th 1996

Copenhagen 4th March 1996

S. 20
mangler.

To the participants in the Critical Psychology Seminar in Farum, Friday 22nd March 1996.

Here follows a background paper for my presentation "Regulation and Conduct of Life". The paper is "soon" to appear in a book from Lawrence Erlbaum Associates.

The paper may hopefully serve as an introduction to my variant of a position within Critical Psychology. It also presents a sketch of results from my participatory observation in a district heating system in Copenhagen.

At the seminar I will shortly present my project and its background. Next I will outline a conception of regulation on the basis of the observations made. Lastly I will compare the conception with the concept "conduct of life", as it is identified in Klaus Holzkamp's "Alltägliche Lebensführung als Subjectwissenschaftliches Grundkonzept".

Erik Axel