# Holistic and participative (re)design : a method for more integral designing flexible and productive systems contemporary Dutch sociotechnical developments

# 12. Holistic and Participative (Re)Design: A Method for More Integral Designing Flexible ànd Productive Systems Contemporary Dutch Sociotechnical Developments

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## Introduction

Socio-Technical Systems Design (STSD) is again at parting of ways. Some forty years elapsed since its conception at the London Tavistock Institute (Trist and Bamforth, 1951; Trist and Murray, 1991). The classical STSD views and change methodologies, well-documented in the literature, are becoming more and more extinct. Conceptual inadequacies, restrictive emphasis on the work group level and expert-led application scenarios gradually have been identified as the major weaknesses of the original approach (Van der Zwaan, 1975; Emery, M., 1989; De Sitter et al., 1990). Four decades later our models and methods are much more elaborated. Rapid technological and cultural change continuously have called for further adjustments and regional developments of the sociotechnical inheritance. With more solidly anchored systems concepts, multi-level design options and participative change procedures we are facing the nineties. Both in North America, Australia and Europe new and innovative STSD approaches have been emerging, mainly on a local level.
This chapter is about contemporary STSD modelling in The Netherlands. It reports on developments of 'The Approach to Flexible Productive Systems (AFPS)', a practical Dutch sociotechnical systems variant which recently has evolved towards a multi-level method integrating task design (Van Eijnatten et al., 1986) and organization design (De Sitter et al., 1986). After discussing some relevant literature, the core of the chapter consists of a method for integral organizational (re)design, based on an analytical interface model (Van Eijnatten et al., 1988) and design-oriented methodology (Van Strien, 1986; Den Hertog and Van Assen, 1988). A small case illustration shows how the method is working.

## STSD Paradigm: some Essentials and (Pre)Judgments

STSD is an organization renewal paradigm aimed at supporting more integrated analysis and co-design of manufacturing process and work organization. It stresses the importance of 'joint optimization' or integration of those two vital aspects of production systems. Central to STSD is its method. Self-management and self-design are its ultimate goals.
STSD paradigm, which is based on action research, has gone through a number of phases, as is reported in the literature (Trist, 1981; Emery, M., 1989; Van Eijnatten, 1990/1991). During the pioneering phase (1950-1960) the semi-autonomous work group was discovered in British coal mines (Trist and Bamforth, 1951; Trist et al., 1963).

More elaborated concepts and expert methods have been tested in the period of Classical STSD (1960-1975), showing some demonstration experiments in Scandinavia (Emery and Thorsrud, 1964/1969/1975), work structuring experiments in The Netherlands (Van Beinum, 1963; Van Beinum et al., 1968; Allegro, 1973; Den Hertog, 1977), and sociotechnical consultancy practices in North America (Pasmore et al., 1982). From Australia participative design first came to the fore (Emery and Emery, 1974/1975/1976; Emery, M., 1982/1989), giving birth to the phase of Modern STSD (1972-1989). Contemporary STSD is a mixture of classical concepts, local theories and participative methodologies. In Scandinavia currently a new phase is emerging, stressing democratic dialogue and large scale change (Van Beinum, 1986; Gustavsen, 1985/1988; Engelstad, 1990).

In the literature STSD most often is associated with the early Tavistock pioneering work. Several authors have been criticizing the initial conceptualisations which indeed suffer from the growing pains of systems thinking in the fifties and sixties.
The conceptual roots of traditional STSD paradigm lay in biology, cybernetics and neurophysiology (Litterer, 1963; Herbst, 1974; Lilienfeld, 1978). Although epoch-making insights like the open-system conception, steady state and equifinality (Von Bertalanffy, 1950), the law of Requisite Variety (Ashby, 1958) and learning in random networks (Beurle, 1962) have had considerable impact on STSD scholars, an adequate translation and incorporation of these new concepts in early STSD models is problematic. In his commentary to the historical review by Trist (1981) Hackman (1981) has pointed to the elusive character of STSDs basic notions. According to Van der Zwaan (1975) in general definition of concepts is poor. Also, the system-theoretical model hasn't been worked out properly. For instance, the vital concept of 'steady state' is not much elaborated. A main point of theoretical critique is that traditional STSD has not reached a satisfying level of maturity. Conceptual clarity as well as coherence is criticized especially. Unfortunately, there is some absurdity, even logical inconsistency in specifying coupled but independently based social and technical systems which have to be jointly optimized (Emery, 1959/1963). The brilliant idea of integral design, which lay behind this, initially could not be sufficiently worked out theoretically because the 'aspect-system' as a logical construct was not known at the time.
Sociotechnical design principles mainly have been borrowed from 'natural occurring field experiments'. Although Cherns (1976/1987) did try twice to summarize those principles, the resulting theory never has become a very coherent one. According to Kuipers and Rutte (1987) the principles haven't been clearly attributed to different kinds of organizational structure (production, control, preparation), while design application order has been totally neglected. Also the scope of traditional STSD theory has been judged as too narrow. In addition, conventional STSD is not as integral as it claims to be. According to Van der Zwaan (1975) traditional STSD has occupied itself almost exclusively with psychological needs, resulting in unacceptable reductionism with respect to the social aspect of the system. Having reviewed 30 years of STSD, Pasmore et al. (1982) concluded that the contribution of conventional STSD paradigm to technological innovation is very limited. According to Hackman (1981) surprisingly limited attention is given to systematical multi-level evaluation of change attempts. More recently, one of the best designed outcome evaluation studies on autonomous group

functioning (Wall et al., 1986) failed to show significant long-term effects on work motivation and performance whatsoever.
Criticizing complacency in traditional STSD, Pava (1986) complains that 'methodologically, little has been developed beyond the conventional "nine step method" forged by the pioneering efforts of Emery (1959/1977) and of Davis and Canter (1956) based on early change projects' (p. 202). Indeed Hill (1971), Cummings (1976) and Cummings and Srivastva (1977) haven't made any substantial additions. In fact, they only have been reprinting the working drafts of the Tavistock's analytical models (Foster, 1967). Pasmore and Sherwood (1978) reprinted the same text with Emery and Trist as authors.
The basic problem with conventional STSD method is the lack of an explicit design orientation. Analyzing activities are dominating design activities. Because in the last decade the complexity of organization design activities has been multiplied, there is a great need for new participative STSD method that encounters the action planning stage in a more appropriate way. From a methodological point of view Van der Zwaan (1975) argued that - because of an ill-developed analytical model - in practice there is real risk in confusing system levels. In the same line he found it difficult in conventional STSD paradigm to differentiate the analytical model from the action model. In a methodological critique of fifty-eight selected work experiments Cummings et al. (1977) show that the majority of studies is suffering from weaknesses concerning internal and external validity. Most selected studies score badly on minimum quality criteria of experimental design.

In the literature there seems to be only slow progress in system-theoretical, methodological and conceptual debates concerning what is generally known as core STSD. Probably one or more of the following circumstances are accountable for this.

. STSD key publications have been highly dispersed in heterogeneous volumes and in exotic international journals, while a number of conceptual papers never reached these media at all. Prolonged difficulties in obtaining such documents have urged authors to copy older or non-original sources, resulting in inaccurate or incomplete discussions of the subject matters.

. STSD literature is hardly organized with respect to the paradigmatic generations. Each author implicitly represents his/her country with its own idiosyncratic time schedule of STSD phases and specific mixture of conceptual developments. STSD lacks an universal approach.

. STSD paradigm is mainly a strategy. Originally it has been developed as a method, not as a theory. STSD method can produce a whole array of concrete, highly situation-specific, end results which are not always reported as STSD-inspired endeavours.

. STSD has been strongly based on (a narrow version of) the open-systems concept. Early design principles lacked appropriate conceptual profoundness. As said before, part of the problem inevitably had to do with the severe immaturity of systems thinking in the fifties and sixties. It is not before the seventies start, that more basic solutions are put forward. Paradoxically these new insights have not been picked up in STSD literature. In the same

period of time STSD paradigm shifted gradually from an expert approach to participative process. Because of this, further development of more specific and accurate structural design concepts faded and moved more and more into the background.

It seems that after 40 years the interest of the international academic world in STSD as a paradigm has vanished. But on a more local level, for instance in Holland, the sociotechnical inspiration is still very much alive. Although most problems concerning methodology and system theory have been solved in the last two decades, international diffusion is hampered by the fact that a majority of studies is stated in the own national language.

## Dutch Contributions to STSD

Although the visibility in the international literature is minimal, the contribution of Dutch researchers to the conceptual renewal of STSD has been quite significant, as we shall illustrate.

- With respect to system-theoretical aspects, there have been two major developments. First, at the time that Ackoff and Emery (1972) published 'On purposeful systems', De Sitter (1973) presented an up to date system-theoretical paradigm of social interaction, in which there is a systematical thorough definition of systems concepts. Second, In 't Veld (1978) developed an elaborated analytical model of a system in steady state with equifinality, which also have made it possible to systematically differentiate between succeeding systems levels in an ordered way. Both contributions can be characterized as 'empty cartridge' approaches, constituting some neutral system-theoretical framework on which a modern STSD view can be more firmly based.
- With respect to methodological aspects there has been one significant Dutch contribution. In an attempt to support the process of giving full scientific status to the action model, Van Strien (1975) proposed the 'regulative cycle of diagnostic and consultative thinking'. This cycle contains five phases: identification of the problem, diagnosis, action planning, intervention and evaluation. The unique aspect here is not the action cycle as such, but the epistemological and methodological treatment of action research as an equal alternative to the traditional scientific method (Van Strien, 1986). Central in it is the 'theory of practice'. According to Van Strien (1975) 'the view of science as a system of statements is making place for a view of science as a set of conceptual and methodological tools in approaching reality' (p. 601). Modern STSD-interventions can be methodologically treated as theories of practice.
- With respect to design aspects, in Holland in the last decade modern STSD paradigm widened towards a management science approach, covering more relevant systems aspects (production, control, information), including different levels of aggregation (micro, meso and macro level in the organization and its relevant environment) and at the same time combining design content (integration of tasks in self-controlled organizational units) and process (training for self-design, organizational learning).

Dutch STSD Paradigm

Contemporary Dutch STSD can best be characterized as a mixture of up to date systems concepts and an integrated whole of various design aspects and management science techniques, applied in a participative design context. The modern Dutch STSD variant covers all necessary ingredients: basic socio-technical systems theory including level-independent concepts (Van Assen, 1980; De Sitter, 1982/1989; Van Assen and Van Eijnatten, 1983; Van Eijnatten and Otten, 1985; De Sitter et al., 1986; Van Amelsvoort, 1989); elaborated action methodology (Van Strien, 1986; Den Hertog and Van Assen, 1988; Van Eijnatten and Hoevenaars, 1989); tailor-made research instruments (Van Eijnatten, 1985/1986/1987a; Pot et al., 1989a/b); and dedicated participative design strategies (Buyse and Van Eijnatten, 1987; Den Hertog and Danklaar, 1989). Dutch STSD uses a multi-level strategy, carefully combining task design (quality of work) with organization design (quality of organization). Semi-autonomous functioning has been generalized to departments, product lines and business units. The Dutch Journal 'Gedrag en Organisatie' (Behavior and Organization) eventually published a special issue on Dutch STSD in 1989. An English language monograph on the 'Dutch Variant' is also available (De Sitter et al., 1990).

## New STSD Method

An Analytical Model for More Integral Organizational (Re)Design

In this chapter we actually are concentrating on the issue of (re)design implementation logic. A multi-level model for more integral organizational (re)design is proposed, containing a mixture of (re)design ends, (re)design means and (re)design processes (see figure 1). Central in the model is the so called '(re)design interface' in which means, ends and processes are tied together to lead up to the factual (re)design intervention. The model specifies three main entries to this (re)design interface: environmental, knowledgal and methodological.

Figure 1 about here

- The environmental entry is producing market requirements and functional claims to guide design ends for the (re) design intervention. These claims are normative in character.
- The knowledgal entry specifies theories, practices and conceptual organizational paradigms to deliver design means for the (re)design intervention. These content-theories are supportive in character.
- The methodological entry consists of action planning procedures and participative methods/ techniques for (re)designing, in order to support the process of (re)design intervention.

Modern Dutch STSD method - here it is stressed again - is a mixture of content and process: it contains both rules and procedures based on structural paradigms sprung from several key disciplines (including management science, industrial engineering and accountancy), and

(re)design strategies based on participative methods and techniques within a regulative action cycle framework.

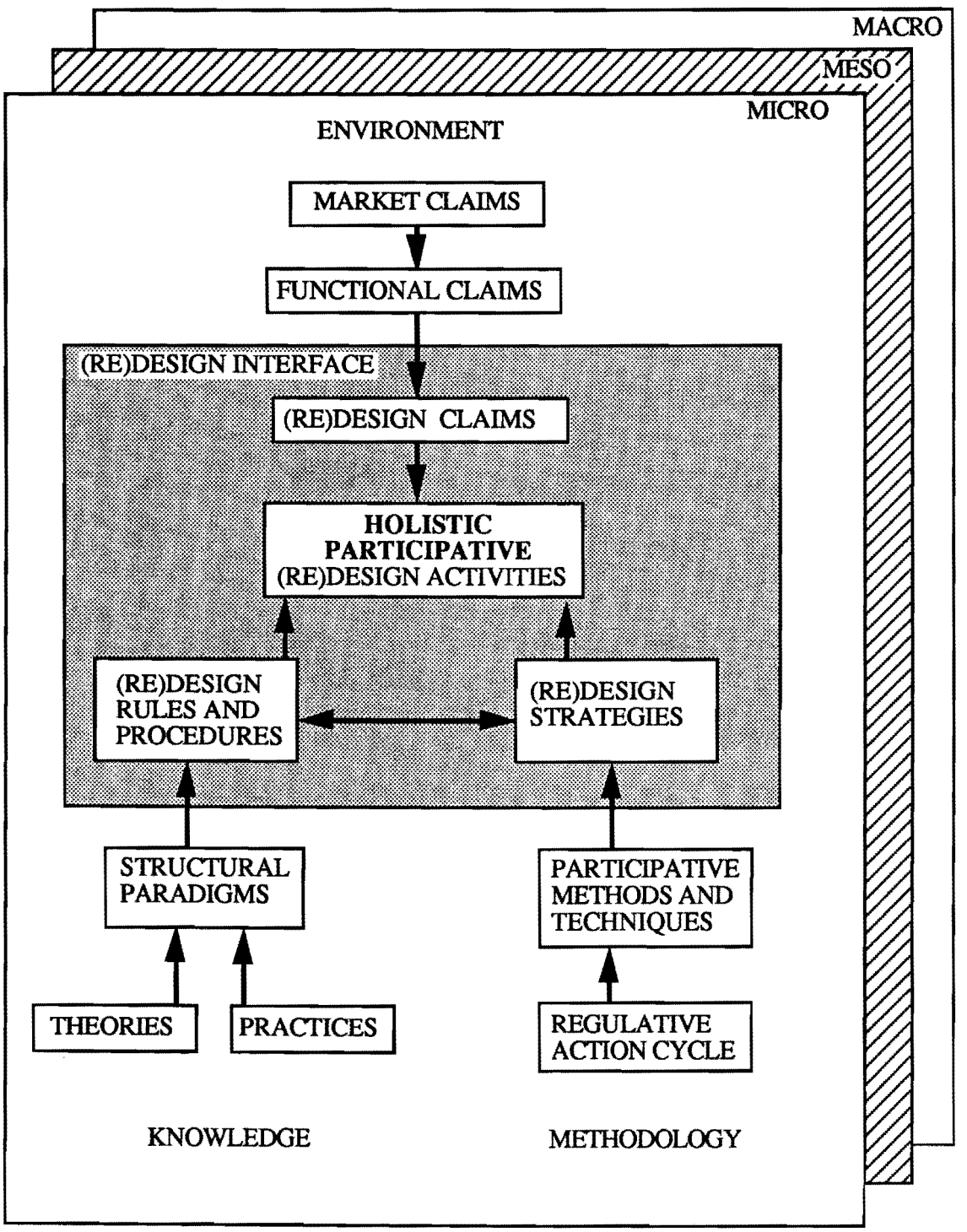


Figure 1: An analytical model for more integral organizational redesign.
After: Van Eijnatten et al. (1988).

What is 'really new' in contemporary Dutch STSD method is the re-introduction of a proper balance of up to date structural system paradigm with participative process paradigm, explicitly

stressing both content and process on the same advanced level. The resulting holistic participative (re)design activities are guided by the normative multiple environmental claims, which have been analyzed and given a concrete form to.
The model stresses the multi-level quality of organization (re)design: the interface problem must be simultaneously dealed with at macro, meso and micro level, in order to count for the actual complexity of the (re)design intervention.
Leaving the environmental and knowledgal entry, we will elaborate the methodological entry in this chapter in the first place.

## A Tentative Proposal for a More Integral Organizational (Re)Design Method

Because of earlier mentioned deficiencies in traditional STSD-method, a new method for integral organizational (re)design is proposed. To guarantee a more explicit design orientation, the new STSD method follows the five methodological steps of Van Strien's regulative cycle. Each of those steps will be divided into smaller portions in such a way, that the new method contains a total of 16 steps (see figure 2). The new method not only emphasizes the micro level, but also incorporates the meso and macro level to guarantee an integrative approach. It also is explicitly participative in character: a (re)design team of organizational members is trained to do the self-design.

Figure 2 about here

### A) Identification of the Problem

#### 1) Global Strategical Analysis

The first step contains a global strategical analysis of the system at hand on a macro level. In this stage it is important that the system boundaries are widely chosen, preferably on the level of what Kotler (1988) has called 'strategic business unit' (p. 39). Basically a strategic business unit is a single business or collection of related businesses that can be planned separately and, in principle, can stand alone from the rest of the company. It has its own competitors which it is trying to equal or surpass. For the selected strategic business unit a global analysis has to be done with respect to environmental demands, and the consequences of these for the (re)design of the system. It is important in this step to actually start specifying the environmental demands in terms of market claims with respect to controllability, flexibility and quality of work. In the succeeding phases of the regulative cycle these functional claims serve as design objectives.

#### 2) Global System Analysis

The second step is a global system analysis of the business unit on a meso or departmental level, starting with a pure description and ending with an estimation of the current achievement in already specified design objectives. The purpose of the description is to provide insiders as well as outsiders with a global picture of the system containing matters as layout,

organizational structure, main inputs, transformations and outputs. An estimation of the current achievement in design objectives can be made by analyzing if and how much the system conforms to the requirements of the design objectives as specified in the previous step.

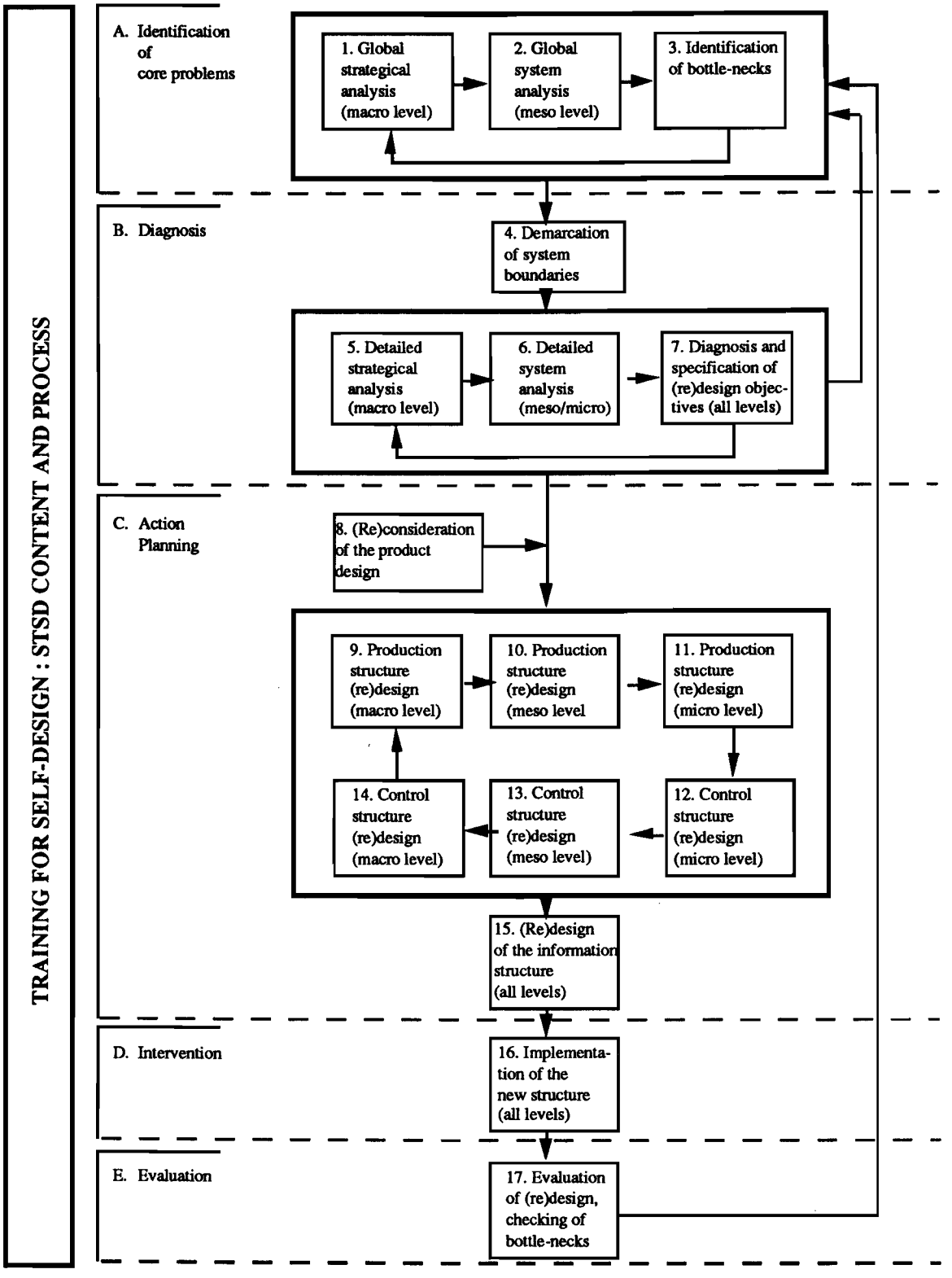


Figure 2: A tentative proposal for a more integral organizational (re)design method.

3) Identification of Bottle-Necks

Contrasting the design objectives of step 1 with the current state of affairs in step 2, results in an inventory of bottle-necks. Herewith phase A of the regulative cycle is completed, i.e. the problems are identified.

B) Diagnosis

4) Narrowing the System's Boundaries

To start the diagnostic phase, the system's boundaries are definitely demarcated. Accurately demarcating the boundaries is an important step. A too wide boundary results in unnecessary extra work. A too narrow boundary results in incorrect design choices. The boundaries should be chosen thus, that the (re)design can provide a solution for all bottle-necks. Often this will imply that the originally chosen system has to be (re)designed entirely.

5) Detailed Strategical Analysis

Step 1 is repeated in detail for the demarcated system. The parts of the organization which were possibly deleted from the original system, are now considered to be additional parts of the environment. Environmental demands and the design objectives belonging to them are to be recorded as detailed and as specific as possible.

6) Detailed System Analysis

Now step 2 is repeated in detail for the demarcated system. A complete inventory has to be made of material and information inputs, transformations and outputs. It has to be established how materials and informations flow through the organization. All decision tasks have to be specified within the context of regulation loops. An inventory has to be made of all norms and of all supportive tasks. With the help of all these data it has to be established who performs what tasks. Finally a detailed description has to be made of layout, organizational structure and units, and product design.

7) Diagnosis and Specification of (Re)Design Objectives

The data collected in step 6 are used to determine the exact causes of the bottle-necks specified in step 3. At this point the semi-autonomous (re)design team has very detailed knowledge of the environmental demands (step 5) and of the causes of current problems. These insights in the system can be used to detail the (re)design objectives even further. With this full description of the (re)design objectives the diagnostic phase is completed.

C) Action Planning

8) Reconsideration of the Product Design

A good and efficiently constructed product is of vital importance. In this step it is tried to reduce the number of parts and components of the product and to minimize the number of manufacturing steps, or to prepare for easier making (design for production).

9-11) Planning the (Re)Design of the Production Structure

The (re)design of the production structure has to be done on all levels, planned in a top-down order. To start the planning of the action process, firstly the macro level has to be (re)designed (step 9). Next the production structure on the meso level is prepared for (re)construction (step 10). Finally the micro level production organization is (re)structured (step 11). In general the (re)design team will parallellize on the macro level, segmentize on the meso level and build in operational flexibility on the micro level.

12-14) Planning the (Re)Design of the Decision and Control Structure

The (re)design of the decision and control structure is also done on all levels, but in reversed order (bottom-up)! Starting on the micro level (step 12), the planning of the (re)design is continued on the meso level (step 13). The (re)design of the decision and control structure is completed on the macro level (step 14). In general the (re)design team will allocate respective decision power as close to the point where the problems originate.

15) Planning the (Re)Design of the Information Structure

The (re)design of the information structure should not be started before the planning of the new production and control structure satisfactorily have been finished. How this can be done, is still the subject of study (Van Eijnatten and Loeffen, 1990). With this step the action planning phase is completed.

D) Intervention

16) Implementing the Plans

This step has many facets. From a sociotechnical point of view this step contains the actual building up of the planned production and decision i.e. control structures and information systems, in close cooperation with users and specialists.

E) Evaluation

17) Checking of Bottle-Necks

After implementing the new system, an evaluation has to take place in terms of the (re)design objectives. If discrepancies are found, adjustments have to be made by starting a new regulative cycle.

A training program to master modern STSD concepts, rules and procedures supports the (re) design team in the same way as used to be done in the participative design tradition. Training of process and content matter is seen as an essential condition for effective self-(re)design and organizational learning (De Sitter et al., 1990).

## Case Illustration

To illustrate (the first three phases of) the method, a fictitious but as realistic as possible simulated model redesign is presented. The actual stage (desk chair production) is borrowed from a redesign exercise which arised in the context of a STSD training course (Van Amelsvoort and Vermeulen, 1988). The case originally has been developed by Van Amelsvoort and Vossen (1981). The stated problem is a cautious abstraction of the setting of a real-life project. The actual design solution has been taken from a case study report of a student design team (Adams et al., 1988).

The redesign planning case is about a small desk chair factory producing several kinds of chairs in a rural production location employing some 130 workers, mainly local personnel. The original management team, members of the same family, recently has been replaced following an amalgamation with a large office furniture manufacturer. The desk chair plant financially has been very unsuccessful in the past decade. The new management team wants to make a fresh start and calls for an integral organizational renewal project. A company redesign team has been formed as a 'deep slice' (Emery and Emery, 1974), containing members of all levels of the chair manufacturing plant. The redesign team has been thoroughly trained for self-design by an authorized external STSD training agency.

- A global strategical analysis (phase A, step 1), carried out with some advisory help of a senior consultant of the training agency revealed that the chair production organization was confronted with rapidly changing product demands, like the customer's wish for more product varieties, higher and more constant product quality, lower prices and faster delivery times. Also the labour market had changed. Higher educated employees presented themselves asking for more challenging jobs with "whole" tasks, including all kinds of self-control and decentralized decision making.
  This multitude of environmental claims has been operationalized by the redesign team in three basic functional requirements: higher flexibility in products and production process, higher controllability of the production process, and better quality of work. Flexible production

process would mean that the production departments are able to produce several product varieties without taking too much time to change from one product variant to another. Controllable production process would mean that the production departments have the capacity to control for variations in inputs, transformations and outputs. Quality of work would mean that employees are offered work structures in which flexible allocation of individual tasks is possible in order to control the process and to act according to one's own discretion.

The specification of the more concrete redesign claims by the redesign team can be highlighted as follows. For our illustrative case a flexibility redesign claim was among other things minimal throughput and delivery times for all product variants. A controllability redesign claim was among other things a minimal number of hierarchical levels and small units with appropriate decision facilities. A quality of work redesign claim was among other things integration of non-decision and decision tasks and loose coupling of people and machines.

- After having translated the functional claims in more concrete redesign objectives for the organization, the redesign team continued with a global system analysis, which revealed a description of the existing design situation (phase A, step 2). The production process of desk chairs occurs in three shifts during a 5 days week cycle. Basic transformations are carried out in separate departments for sawing, bending, cleaning, welding, finishing, painting, varnishing, drying, assembling and packing. Some 75 workers are concerned with those basic transformations. Stocks of 3 days work function as a buffer between the functional departments. Some 55 employees take charge of other functions: maintenance, planning and scheduling, buying, quality control, selling, marketing, developing new products and production methods, efficiency improvement, finance and administration, information services, personnel management and physical distribution. Each staff member/department makes decisions about only one aspect of the production organization. The organization chart shows 6 hierarchical layers, ranging from chief executive officer to the shopfloor workers themselves.

  The functioning of the desk chair production organization has been very disappointing. At the time the chair market was expanding, sales fell back with some 10 percent. Its market share dropped from 11 to 6 percent; cost prices rose with more than 30 percent. About 10 percent of last year's production showed quality deficiencies, while only 25 percent of the production orders could actually be delivered within two weeks time. Most client orders had been delivered later, with extremes coming up to more than five weeks after due date.

  Also personnel figures scored badly: absenteeism has reached the astronomical level of some 11 percent of total working time, while only 5 percent is judged as normal for this type of industry. A couple of interviews with production personnel revealed the employees were showing not a spark of pride for the job they had to perform. Needless to say, the plant eventually turned into serious trouble: year after year production suffered more severe losses. An amalgamation offer could no longer be resisted.
- Summarizing the global system analysis carried out by the redesign team revealed serious drawbacks on all specified claims. Main bottle-necks (phase A, step 3) were among other things: too long feedback loops, too many hierarchical levels, too long throughput and

delivery times, too close coupling of people and machines, and complete separation of decision and non-decision tasks. The symptoms just described are indeed blocking the realisation of a desirable future, put forward in the redesign requirements document of the redesign team, which has been very much welcomed by the new executive management team. The diagnostic phase is entered.

- A reexamination of the selection of the system boundaries (phase B, step 4) did not result in any alterations. The chair production plant as a whole was selected for reorganisation purposes.
- A detailed strategical analyses (phase B, step 5) gave the redesign team some additional insights in structural and functional deficiencies, as perceived for instance by customers. Additional information on the position of the firm in the office furniture chair market revealed that contemporary profit chances in upholstered chairs were far better than chances are in plastic desk chairs. Other discussion with former customers ultimately showed the firm's image suffered most because of unreliable delivery times and absolutely unpractical standard delivery quantities of six chairs.
- During the detailed system analysis (phase B, step 6) the causes of insufficient flexibility, controllability and quality of work were exactly pinpointed. The desk chair product apparently was build up out of some 19 parts. This observation prompted a closer look at the appropriateness of the design for production. The factory layout also asked for reconsideration. Control requirements unnecessarily had been enlarged by creating small functional departments in separate rooms. The appointed organization of technical process drastically hinders the getting of a clear picture of order status and is dramatically enlarging order throughput times.
  With respect to ineffective control the following causes have been detected: exactly identified missing or too long feedforward, feedback and boundary transaction loops, exactly identified missing or outdated norms, too much distance between performing employees and staff members, no decision power on the shopfloor, and too complex layout. All product varieties had the same inconveniently arranged material flow, and finally boundaries of units were judged as a-logical: allocation of dependent employees had been done to different groups and allocation of independent employees has been done to the same group.
  The rather strict separation of decision and non-decision tasks had led to a situation in which manufacturing employees were made dependent on staff members who work only in day shift. Particularly in evening and night shifts this situation became problematic because quality and order scheduling problems have to be tackled by the uninformed supervisors. This bottle-neck added to the further rising of quality problems and of throughput times.
- Ending the diagnostic phase (phase B, step 7) the redesign team concluded that the way in which product and production process structure originally had been designed, called for some extra control requirements. Smart redesign should make it possible to reduce those. Concerning process redesign, order flow could be simplified by logical grouping. Concerning product redesign, design for production could lessen the total number of parts, while abandonment of the unsalable plastic variants could further lower control requirements. Of course this strategical decision should be certified by the top-management team.

On the other hand the redesign team came up with a number of ideas concerning the means of control. These means would be reallocated in such a way that all kinds of disturbances can be intercepted and controlled as close to its source as possible. Actual means of control can be enlarged by introducing an information supply system on the shop floor, or by allocating more decision power to lower organizational levels. The redesign team developed and accepted the idea that by better balancing means of control to control requirements, a better functioning organization results.

- The action planning phase started with a reconsideration of product design (phase C, step 8). Although the modular design was appropriate for all product variants, minor constructional changes could simplify assemblage to a considerable extent. Bolts and nuts could be replaced by a clever design of click mechanisms. This innovation resulted in a reduction of 8 out of 19 parts!
- The action planning for the production process structure at a macro (or plant) level (phase C, step 9) resulted in no changes at all. On this level the organization of the technical processes was judged as appropriate. The factual re-organization started at a meso (or departmental) level (phase C, step 10). The redesign team divided the system in 2 main segments: a components department and an assemblage/packaging department. Within the latter, the team created 2 parallel flows: one for wooden chairs and the other for upholstered chairs. The reorganization of the production process structure was finished on a micro (or shopfloor) level (phase C, step 11) by tuning the individual tasks to the production means. Machines were grouped together in such a way that units were formed, combining several transformations, which let disappear the buffers in the components production. Individual tasks were grouped together in such a way that production units could function relatively autonomous and independent from each other. For instance one unit is planned to make black and grey frames, while another unit produces brown and white ones.
- The planning of the decision and control structure redesign started on a micro (or shopfloor) level (phase C, step 12) by allocating operational flexibility in each process segment or unit. As much decision power as possible was allocated to this lowest organizational level, aimed to guarantee that workers within each segment flexibly could solve as much occurring production variances as possible. For example, for the 'black & grey unit' in the components department, this redesign measure resulted in 'whole tasks', where employees not only were producing black an grey frames, but also were controlling the amount of stock and were deciding when to make new ones. They also were planned to be equipped with simple repair-tools in order to tackle small machine breakdowns, and were made responsible for the quality of the frames. Clear targets will be assigned to them with respect to the level of product quality and the quantity they have to reach. At the same time they were equipped with financial budgets, which should not be exceeded. All employees are planned to get a tailor-made training program.
- The planning of the decision and control structure redesign on a meso (or departmental) level (phase C, step 13) resulted in an organization hierarchy with only four respective levels. Also the more allocation of employees to staff functions could be reduced, while distinct staff departments could be grouped together.

- The planning of the decision and control structure redesign on a macro (or plant) level (phase C, step 14) resulted in allocating explicitly strategical decision power in the top level of the chair production business unit. The executive management team should have one eye directed into the market and the other one focussed on the plant itself.
- It was made sure that the reorganization proposal included a plan for up to date technical redesign of the information system (phase C, step 15), so that necessary information would reach those employees who had the decision power to act on that information.
- The redesign plan has been successfully implemented by the team in close collaboration of the workers involved (phase D, step 16).

Table 1 about here

- In table 1 some key attributes of the old and new structure are compared. It is predicted that the new system will function better on all sorts of outcomes (phase E, step 17). Evidence from similar real project evaluation studies is encouraging (Den Hertog et al., 1991).

Table 1. A comparison of some key attributes of the old and new structure of the desk chair firm.

| key attributes | old situation | new situation |
|---|---|---|
| number of product parts | 19 | 11 |
| type of process flow organization (production structure) | one flow for all orders (complex flow) | partly parallellized and segmented flow (simple flow) |
| buffer stocks between process steps | yes, many between each step | no, hardly any |
| type of work organization | functional structure | product structure |
| number of personnel | 75 direct<br>55 indirect | 90 direct<br>40 indirect |
| allocation of decision tasks (control structure) | no decision tasks allocated at the shopfloor level | quality and quantity decision tasks at the shopfloor |
| number of hierarchical levels | 6 | 4 |
| supply of information (information structure) | no information supply to the shopfloor | own information system at the shopfloor |

## Discussion

The proposed method for Modern STSD primarily has been developed as a practical tool, which can be used in (re)design projects. As said before, it is an intricate part of the Dutch STSD package, which also contains elaborated structural systems concepts, (re)design principles advocating more integration of aspects, and procedures supporting participative self-(re)design process.

At first sight the proposed method looks very much the same as it famous predecessors like the admired and abused 'nine step method' (Foster, 1967; Emery and Trist, 1978). But at a closer look there are some striking differences.

- The proposed method for Modern STSD clearly has an iterative character (see figure 2). This is true for the cycle as a whole, as for the constituting phases. Therefore, in practice each project can have an unique intrigate pattern of specific iterations of 'successive' steps and phases. In each stage already available techniques and instruments can be used and may improve the efficiency of the distinguished steps. We list some of them briefly for illustration purposes. System Analysis (SA) can support the problem identification and diagnostic phase. A Dutch steady state system model (In 't Veld, 1978; Van Eijnatten, 1987b) governs the descriptive and evaluative process on all the levels of aggregation (macro, meso, micro). Socio-Technical Process Analysis (STPA) and Socio-Technical Task Analysis (STTA) can be used for task analysis at the micro level during diagnosis and evaluation (Van Eijnatten, 1985/1986). Recently alternative Dutch task analysis instrumentation has been become available (Pot et al., 1989a/b). Stream Analysis (Porras, 1987) may be of great help in identifying core problems during the diagnostic phase as well as in planning the (re)design actions and tracking the interventions in the action planning and intervention phase. Very useful in the action planning stage is TIED analysis (Schumacher, 1975/1979/1983; Van Amelsvoort, 1987). This (re)design technique governs segmentation of production flows, while controlling for machine interaction, process interaction and interferences. A similar technique to plan the parallellization of factory/manufacturing flows is Group Technology (Burbidge, 1975/1979; Agurén and Egren, 1980). Production Flow Analysis (Burbidge, 1975; De Witte, 1980) can be used to recognize routes of production flows in the planning phase. We want to stress here the importance of technical (re)design of the production process. Therefore technical analysis once again has become vital in Modern STSD. Of course, also the whole array of OD techniques are good supporters of the diagnostic, action planning and intervention stages in the regulative design-oriented cycle, from process consultation (Harvey and Brown, 1988) to user participation and quality cycle techniques (Juran, 1978; Dewar, 1980) such as Pareto Analysis, Ishikawa's 'fishbone' and Brainstorming. Also Soft Systems Methodology (Checkland, 1979a/b/1990a/b) can be used by all parties to organize and manage the process in each stage of the regulative cycle.
- The proposed method for Modern STSD basically promotes controllable organizations and democratic work structures as the same time. Although for traditional sociotechnologists there is something of a paradox in that statement, we cannot exaggerate on this here. Suffice

it to say that Dutch STSD is trying to find a proper balance between variety increasing measures like segmentation of flows constituting 'whole tasks' and variety decreasing measures like inputs selection by means of parallellization of process flow. The argument is discussed in more detail in De Sitter et al. (1990).

- The proposed method for Modern STSD is basically supporting a multi-level approach. The parallellization of flows is advocated on the next higher level than segmentation is carried out. Also a strategical analysis of the system at a macro level is actually stimulated to discover the environmental demands of the very near future. In this context of course there is acknowledgement of the Search Conference (Emery, M., 1989) as a network approach for creating desirable futures under turbulent field conditions. In Holland a STSD (re)design tradition is gaining ground in which technological, social and organizational innovation are going hand in hand. A series of more integral organizational renewal projects is being carried out along the theoretical and method(olog)ical lines of The Approach to Flexible Productive Systems (AFPS).
- The proposed method for Modern STSD is not necessarily linear in nature. The 'successive' steps do not insistently represent a prescribed time order. They also can be used as a checklist to manage aspects interconnections. The order of steps first of all are indicative of available degrees of freedom for change. For instance, a change in production structure necessarily will urge forward changes in control and information structure, while a change in information structure is not expected to affect the production and control structure at all (see figure 2). The steps stress dependencies in the (re)design process.
- The proposed method for Modern STSD is of course highly political in nature. Although it must be stimulated that the different parties are using it as a connecting and integrative device, insufficient control of that process easily can result in coalition formation. Also there will be some sort of paradoxical self-selection process going on among firms with respect to adoption. Because the method basically supports a democratic approach, organizations who want adopting it already feel sympathy or have invested in the type of change which Modern STSD intents to accomplish.

In this chapter we have presented organizational (re)design methodology which explicitly advocates restructuring of construction at different levels of aggregation. The method to some extent supports 'manageable change and innovation', within the context of the integral organizational renewal of the total firm. The method is based on a sociotechnical inspired perspective, which guaranties a better focus on the interactions between individual, group and organization in a highly automated work environment.

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