

Juha Pihlaja

LEARNING IN AND FOR PRODUCTION

An Activity-Theoretical Study of the Historical Development
of Distributed Systems of Generalizing

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Contents

1	The need to understand the nature of learning in and for production	1
1.1	Learning in and for production as a historically changing phenomenon	1
1.2	The structure of the study	5
2	Historical changes in theories of organizational learning	7
2.1	Four representative theories	7
2.2	Organizational learning as change in theories of action and values.....	9
2.3	Organizational learning as a change of routines.....	15
2.4	Organizational learning as the creation of new knowledge	21
2.5	Organizational learning as the development of communities of practice..	26
2.6	The inadequacy of organizational learning theories in understanding the current change in learning in and for production.....	32
3	Learning in theories of the historical development of production	37
3.1	Three theories explaining historical change.....	37
3.2	Freeman and Louçã's theory of techno-economic paradigms	38
3.3	Paul Adler's analysis of the historical evolution of management doctrines	51
3.4	Victor and Boynton's developmental model of work types	56
3.5	Observations on the three historically oriented theories	62
4	Toward historical-genetic method for studying learning in and for production	67
4.1	The general as a principle of development.....	67
4.2	Learning as the cultural process of adopting, applying and producing generalizations	70
4.3	Transforming generalizations that are fixed in the human activity system	79
4.4	Historical types of generalizations.....	84
4.5	The results of the analysis thus far	92

5	Taylor's experiments as the origin of generalizing in mass production.....	95
5.1	Taylor's works and experiments.....	95
5.2	The sources of Taylor-type generalizing.....	96
5.3	Experimental change in the way of handling pig iron.....	102
5.4	The written standard as a carrier of generalization	107
5.5	The vision of the planning-office system	110
5.6	The actions of generalizing in Taylor's system	111
5.7	Standardizing work methods as a distributed system of generalizing	114
5.8	Assessing change in generalizing.....	122
6	Trist and Bamforth's study as the origin of the socio-technical form of generalizing	123
6.1	Socio-Technical Systems Design as an umbrella framework for developing production	123
6.2	The content and position of Trist and Bamforth's study.....	125
6.3	Problems in the implementation of mass production as reflections of contradictions in the activity system	137
6.4	The conceptual development towards dualism	142
6.5	The basic STSD model as abstract-empirical generalizing.....	144
6.6	The spreading of socio-technical generalizing	146
6.7	Assessing change in generalizing.....	149
7	Post-war experiments in Toyota as the origin of generalizing in flexible mass production.....	151
7.1	The rise of flexible mass production.....	151
7.2	The Toyota Production System	152
7.3	Toyoda's innovations during the pre-war era.....	154
7.4	The contradictions in production and their first solutions.....	157
7.5	Building a system of generalizing to support the small-batch mass- production system	160
7.6	Assessing change in generalizing.....	169
8	The concept of a distributed system of generalizing.....	171
8.1	Elements of the system	171
8.2	Three systems for generating production-relevant generalizations	172
8.3	The development of a new system of generalizing as expansive learning ..	179
8.4	The need and possibility to master the historical transformation in forms of production	180

9	”Learning activity” as a historically new form of generalizing	183
9.1	Expansive learning actions	183
9.2	Developmental Work Research – an intervention methodology for supporting learning activity	185
9.3	The Change Laboratory as a specific application of developmental methodology	187
10	Triggering ”learning activity” in Finland Post Ltd. using the Change Laboratory.....	191
10.1	The starting point	191
10.2	The overall progress of the project	196
10.3	Expansive learning actions in the Change Laboratories.....	198
10.4	Assessing the experiment.....	227
11	Summary and discussion of the results of the study	233
	References	237

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Abstract

The current shift from industrial mass production to new forms of ICT-supported production has questioned established principles and structures of learning in and for production. The purpose of this study was to explore the current change in production-related learning and to find concepts to describe it. This was achieved by analyzing the logic behind the main forms of learning in and for production that preceded the ICT revolution. The limitations of these forms in the current situation were considered and a new principle was developed. It was assumed that forms of learning in and for production were tightly connected to the historical development of forms of production and should therefore be studied historically.

The study explored the extent to which the main theories of organizational learning on the one hand, and theories of the historical development of production on the other, could explain the historical change in learning in and for production. The analysis showed that theories of organizational learning did not provide adequate concepts for explaining the historical changes in learning, while those concerning the historical development of forms production did explain the context of the current change in learning in and for production. Moreover, they supported the idea of historical change in learning but they did not provide concepts for describing more specifically the changes taking place in the learning processes.

A genetic method involving finding the initial abstraction of the phenomenon was used to conceptualize the change of learning in and for production. On the basis of previous research carried out in the tradition of cultural-historical activity theory, the adoption, application and development of generalized operations objectified in tools and concepts were taken as this initial abstraction.

Interpreting learning as the production of production-relevant generalizations highlighted the importance of analyzing the historically varying artifacts used in production and production control. Three variants of mass production developed during the long wave of economic development based on the motorization of the economy (1941-1990): the Fordist-Taylorist model, the socio-technical model and the model of flexible mass production. Methodologically, the research focused on analyzing the development of the first installations of these forms of learning in and for mass production as the "ancestors" of the three families of later applications of the same principle.

It was found out that the basic form, or the "ancestor", of learning in mass production was the new distributed system of optimizing the methods for performing repeated tasks. This type of generalizing was based on the varying ways individuals were performing the same task. In Taylor's system, specialized planning officers analyzed this variation with the help of time-and-motion studies, and objectified the result in a new type of artifact, the work standard, which comprised the "one best method" to perform the task. The generalized operations embedded in the standard were thus results of a process of empirical generalization.

The analysis revealed four dominant forms of learning in and for production that preceded the ICT revolution: craft-type learning based on perceptual-functional generalizing, in which the generalized operations were mainly preserved as social practices and forms of implements used in the work, and three variants of distributed systems of generalizing in and for mass production, all of which were based on the division of labor in producing production-relevant generalizations, and the use of representations as a means of preserving the generalizations. The analysis showed that all these distributed processes of generalizing were based on abstract-empirical methods of generalization, which in turn were based on a comparison of the cases. The object of generalization in Taylor's system was a task. Socio-Technical Systems Design and the flexible manufacturing system expanded this object and changed the interaction between the parties from unilateral control to peaceful coexistence in the socio-technical system, and further to creative dialogue in flexible mass production.

A developmental experiment was carried out in order to further understanding of the kind of learning in and for production needed in ICT-supported operations a developmental experiment was carried out. The Change Laboratory method was used to prompt and support a collaborative process of theoretical-genetic generalization in the form of expansive learning activity. This kind of learning involves the practitioners in a process of expansive re-conceptualization and remediation of activities through questioning current practices and inquiring into the systemic causes of problems in the daily activity. The experimental application of the Change Laboratory in Finnish Post Ltd. demonstrated that, with the help of an ex-

ternal interventionist, the post carriers were able to institute a theoretical-genetic process of generalization concerning the principle of their activity that produced a viable new model of postal delivery in turn. On the other hand, the new form of learning did not become a stabilized practice, but succumbed to the strong infrastructure of the mass-production-type distributed system of generalizing in the organization. There was thus a remarkable move first toward theoretical-genetic generalizing and then reverting back to abstract-empirical generalizing. This contradiction could be seen as a methodological challenge for further research on learning in and for production as well as for its practical development.

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1 The need to understand the nature of learning in and for production

1.1 Learning in and for production as a historically changing phenomenon

It was only yesterday that we began to pitch our camp in this country of laboratories and power stations that we took possession of this new, this still unfinished, house we live in. Everything round us is new and different – our concerns, our working habits, our relations with one another. Our very psychology has been shaken to its foundations, to its most secret recesses. Our notions of separation, absence, distance, return, are reflections of a new set of realities, though the words themselves remain unchanged. To grasp the meaning of the world of today we use a language created to express the world of yesterday. The life of the past seems to us nearer our true natures, but only for the reason that it is nearer our language. (Saint Exupery, 1941, p. 70)

Antoiné de Saint Exupery is describing the fast and pervasive nature of the change that was brought about through technological invention and the mechanization of production about sixty years ago. That change seems to have features similar to the information-technological revolution of today. Although people are similarly confused about the change, its nature is different.

One reason behind the pervasive change described in the quotation was the closer interaction between science and production that started in the early 20th century. New science-based production branches emerged, but science was also applied in the traditional areas. The first industrial research laboratories were established. New applied research fields appeared between basic research and practical engineering (Berner, 1981, 105–114) and new forms of mediating activities developed between production and scientific research (Nowotny, Scott, & Gibbons, 2001; Freeman & Louca, 2001).

Another reason behind the change was standardization. Industrial plants that were in the vanguard of progress began to standardize their products, their modes of action, and their tools. In the new era of mass production progressive standardization and rationalization became the most important means of survival for companies in the competition. Organizations – usually large plants with thousands of workers – learned through successive cycles of rationalization and standardization the most effective ways to produce standard products.

Today, in the emerging information society, companies that use and produce information and communications technology (ICT) are in the vanguard of economic progress. Centralized plants that were the typical units of mass production have been replaced by dispersed global networks of production organizations (Castells, 2000). "Knowledge workers"¹ have taken the place of industrial workers. Surviving in the current competitive climate depends more and more on companies' abilities to produce new knowledge and innovative products and services. The competition is all about continuously designing and producing new generations of products (Peters, 1992, p. 315).

The rise of information and communication technologies is currently changing production structures in all branches of the economy. Companies manufacturing software products, chips, computers, and the like have, in a short time, become the dominating sector, crucial to the economic development of society. ICT is being applied increasingly in all societal organizations but the ICT revolution has probably not yet reached its peak. The structures of the emerging forms of production and economic activity are still embryonic.

Mastering global production networks and the challenges of increasing collaboration and knowledge creation call for new methods of developing work, as well as new forms of learning. The ongoing transformation of production has raised discussion about the nature of learning in organizations, as well as about the methods of development and consultancy needed to master the new forms of production (Adler & Cole, 1994; Kyrö & Enquist, 1997; Tienari, 1999). Researchers have tried to find new, more adequate ways of conceptualizing, explaining, and promoting collaborative learning. (Agyris & Schön, 1996; Dierkes, Berthoin et al., 2001; Nonaka-Takeuchi, 1995; Easterby-Smith, 1997; Lave & Wenger, 1991; Powell, 1996; Toiviainen, 2003)

The importance attached to organizational learning in management discourse is a good indicator of the increasing challenges of collective learning created by

¹ Drucker (1994) points out that, at the end of the 1900s, knowledge workers made up a third of the workforce of the United States – a greater proportion than industrial workers ever comprised in the country.

the new competition in the information society. Peter Senge's ideas of the five disciplines of the "Learning Organization", for instance, were very popular among business managers in the early 1990s. According to this doctrine, managers should analyze the processes and problems of their organizations using systems thinking. They should learn to think of the causal textures in their organizations as circular rather than linear cause-and-effect relationships.

The idea of the learning organization became so popular in business-management circles that it was hard to find any well-known company that did not aspire to be a "learning organization" in the late 90s (Gherhardi, Nicolini & Odella 1999, p. 103). The wealth of publications on organizational learning (Crossan & Guatto, 1996) also reflects the growing need for theoretical understanding and practical mastering of the processes of collective learning. Theories of organizational learning have nevertheless been criticized for not meeting the challenges of enhancing the mastery of learning in organizations. Huber (1991) criticizes the research for its inability to create guidelines for increasing its effectiveness and other researchers (Jones, 1995; Tsang, 1997) have since expressed concerns about the lack of practical value in the results of the increasing amount of research that is being carried out.

It seems that production, learning and developmental work are at present converging in a new way: "While you perform knowledge work, you learn. And you must learn minute by minute to perform knowledge work effectively." (Tapscott, 1996, p. 198). As early as in 1988, Shoshana Zuboff pointed out that learning had become a dominant feature of daily work:

Learning is the new form of labor. It is no longer a separate activity that occurs either before one enters the workplace or in remote classroom settings (...)
Learning is the heart of productive activity. (Zuboff, 1988, p. 395)

The rapid increase in the use of consultants could also be seen as a sign of the qualitative change in the learning challenges firms encounter, although some of the increase in the number of independent consultants is probably due to the outsourcing of developmental activities. In fact, helping organizations to learn and change has become big business (Toivonen, 2004). The use of management consultants has increased dramatically since 1980, notably in North America.² A similar growth trend, although not so strong, is also to be seen in Europe. The estimated world market for these services was 25,000 million dollars in 1992 (Kyrö & Enquist, 1997, p. 11).

² In 1994, there were 137, 000 management consultants in the United States alone. (Kyrö & Enquist, 1997, p. 11)

From its very beginning, the main task of management consulting has been to apply scientific knowledge in business (Kyrö & Enquist, 1997, p. 12). Consultants were applying technical and economic knowledge until the end of the 1970 when the value of knowledge in other disciplines especially in social sciences began to be appreciated. Consultants are increasingly being invited to help in carrying out major transformations of firms' activities rather than to give advice on operative matters. Tienari (1999, p. 174) notes that consulting firms are now emphasizing integrated change programs rather than fashionable management doctrines or "fads". Consulting is turning away from the recommendation of incremental improvements towards the implementation of programs of rapid strategic change that combine expertise from many doctrines. Although management consultants typically discuss the transformations they are helping to carry out in terms strategic change rather than of learning, it is obvious that collective learning is a necessary prerequisite for the success of such transformations.

Experiences of change programs are not encouraging, however. Porras and Robertson (1983) carried out a meta-analysis of a large number of studies on change. They discovered that fewer than 40% of them produced positive changes in the dependent variable of interest. Beer, Eisenstat, and Spector (1990, p. 159) found that, in one third of the cases they studied in-depth, a major resource-intensive change effort actually made the situation worse. They argued that most top-down change programs, which were still the dominant form of change efforts in the 1980s, did not work because they were guided by faulty conceptions of change and learning.

Two developments seem to dominate the recent discussion on organizational learning and change management. First, the traditional forms of individual training and learning do not meet the new challenges because production, developmental work, and learning are converging. Second, the challenges of learning and development are connected to the ongoing ICT revolution.

In order to secure continuous mastery of their activities and their learning, actors in firms have to carry out various actions of learning such as analyzing and solving problems of production, as well as designing and implementing improvements. These actions are often taken in relatively well-established ways according to a stable division of labor and using established methods. Their patterns could be characterized as *institutionalized forms of learning in and for production*.³ Insti-

³ I use the term "learning in and for production" for the distributed and collaborative ways of learning that enable collective mastery and development of a productive activity. "Work-based learning" is for my purposes too limited as it focuses attention to individual's learning. "Organizational learning" refers to collective learning, but takes an institution rather than a productive activity as the unit of analysis.

tutionalization is understood here as the formation of relatively enduring social structures composed of regulative, normative, and cultural-cognitive elements that are closely intertwined (Scott, 2001, p. 48). Institutions are transferred to new generations by various types of carriers, such as symbolic systems, relational systems, routines, and artifacts. As Latour has (1991) pointed out, the development of technological artifacts is essential in the stabilization of forms of action.

My thesis is that institutionalized forms of learning in and for production are closely related to the prevailing form of production. *In this study, I maintain that the revolution in information and communications technology not only affects the amount, content and type of learning necessary for mastering production, but also makes the old institutional forms of learning obsolete as production models change.* Consequently, new types of learning actions and new institutional forms of learning in and for production are needed, and are also currently emerging.

In order to understand institutional forms of learning in and for production, we have to study them as historically changing phenomena. The purpose of this study is to create conceptual tools for understanding the nature of the ongoing historical transformation of learning in and for production. More specifically, the study purports to answer the following three research questions.

1. How can the ongoing qualitative transformation of the content and the institutional forms of learning in and for production be conceptualized and located historically?
2. What were the principles and general structures of the dominant forms of learning in and for production preceding the ICT revolution?
3. What is the major limitation of these principles of learning in and for production that are typical of mass production in current situation and how can this limitation be overcome?

1.2 The structure of the study

This study is a theoretically oriented search for concepts to describe the principles and structures of change in the institutionalized forms of learning in and for production. It comprises both a historical analysis and an empirical experiment. Below, I explain the purpose and methodological premises of the analyses presented in each of chapters that follow.

I will begin Chapter 2 by evaluating the contribution of the four most influential theories of organizational learning to the understanding of the ongoing change in the institutionalized forms of learning in and for production. After that, I will

present three historical theories that explain the historical developments in forms of production in Chapter 3, and analyze how these theories relate to the change of learning in and for production. Using the results of the analyses in chapters 2 and 3 I will construct an activity-theoretical framework for analyzing the development of learning in and for production in Chapter 4. This framework is based on the idea of viewing learning as *appropriation, development and the use of practice-relevant generalizations that are objectified in artifacts that mediate actors' interaction with the object of the activity*.

Using the concepts developed in Chapter 4, I will then analyze the logic and structure of three prevalent forms of learning in and for production by studying how they were created. First, in Chapter 5, I will consider the system developed by F.W. Taylor as a prototypical form of the *distributed system of generalizing* applied in mass production. Socio-Technical Systems Design is thereafter analyzed in Chapter 6 in an attempt to create an alternative system of generalizing in conditions of mass production. Third, Chapter 7 considers continuous improvement in processes as the distributed system of generalizing in flexible manufacturing. Chapter 8 summarizes the results of the historical analysis.

In Chapters 9–11 I will assess the limitations of the system of generalizing that is typical of mass production. The Change Laboratory method, which represents a different type of generalizing, was used as an intervention method in the developmental experiment of the study. Chapter 9 gives the theoretical background of the Change Laboratory, and Chapter 10 reports and assesses the contradictions that arose when the method was used in practice in an effort to develop postmen's work in Finnish Post Limited in 1996. Chapter 11 summarizes the results of the study.

2 Historical changes in theories of organizational learning

2.1 Four representative theories

In this chapter I will analyze the contributions of the four most influential theories of organizational learning⁴ to the understanding of the historical change in institutional forms of workplace learning. The main question concerns the kind of conceptual tools that the theories provide.

Chris Argyris and Donald Schön (1978; 1996) are probably the researchers who first systematically used the concept of organizational learning. Argyris' background is in psychology. His early research focused on the unintended consequences of formal organizational structures and on individuals' chances of changing those consequences. Schön's background is in philosophy, especially Deweyan pragmatism. He has studied organizational learning and knowledge in practice and in the reflective practice of professionals. These two researchers have been collaborating since the early seventies and have written three books together. Their theory of organizational learning fruitfully combines their different points of view about learning and action in that they see it as a process in which the governing values that direct the action are changed.

Richard Cyert, James March and Herbert Simon consider organizational learning from the perspective of decision-making. They are well-known representatives of "the Carnegie behaviorists", who are interested in describing how individuals and organizations act and make decisions in the real world. They have developed the concept of "bounded rationality" to depict the way organizational actors act when facing and dealing with "the uncertainties and ambiguities of life". Richard

⁴ I assume that these four theories are of general significance. Although Zuboff expresses exceptional views regarding the adequacy of learning in and for production she does not introduce any particular theory of learning. The learning-organization theory introduced by Senge is not actually a theory of learning either, but is rather an application of systems thinking to management.

Cyert has studied behavioral economics, economics in general, decision theory and management. James March, the principal developer of the approach, is known for conceiving of the behavioral theory of firm, and for his contributions to organization theory. According to the Carnegie behaviorists, organizations learn from the ways in which individuals experiment, draw inferences and code lessons of history into the established routines of the organization. They see organizational learning as the *refinement of organizational routines*.

Argyris and Schön and the "Carnegie behaviorists" developed their theories in the 1960s. Nonaka and Takeuchi's (1995) theory of knowledge creation is more recent. Ikujiro Nonaka is a Professor and Hirotaka Takeuchi is Dean of the Graduate School of International Corporate Strategy at Hitotsubashi University in Tokyo. Nonaka has had a long career in management, social science and business research, while Takeuchi is especially interested in knowledge management and conducts research on the characteristics of innovative activities in Japanese companies. Nonaka's and Takeuchi's widespread theory focuses on knowledge creation in organizations, and especially in the development of products. This is not about organizational learning, but rather concerns the process by which corporate organizations create competitively valuable knowledge. It relies on Michael Polany's distinction between tacit and explicit knowledge. Knowledge creation is also a process of organizational learning: organizations learn by *creating new knowledge*.

Jean Lave and Etienne Wenger analyze organizational learning in terms of "communities of practice". Their theory was first published in the book: "*Situated Learning: Legitimate peripheral participation*" (1991), and later developed in separate works (Lave, 1993, 1997; Wenger, 1998). Jean Lave is a social anthropologist and much of her work has focused on the "re-conceiving" of learning, learners, and educational institutions in terms of social practice. Etienne Wenger did his Ph.D. on artificial intelligence. According to their theory, learning always involves individuals' gradually deepening participation in a community of practice. Consequently, organizational learning comes to be seen as the process of sustaining the interconnected communities of practice that make an organization effective.

In this chapter I will present the main concepts and the lines of reasoning of these theories using the following five questions as my analytical tools.

1. What is organizational learning according to the theory?
2. What triggers organizational learning?
3. What are the main forms of organizational learning?
4. How does the theory conceptualize the relationship between individual and collective learning?
5. How does the theory conceptualize the relationship between organizational learning and historical change in the form of production?

2.2 Organizational learning as change in theories of action and values

Argyris and Schön depict their approach to organizational learning as normative and practice-oriented. Their purpose is to describe the patterns of behavior that threaten organizational learning, and also to provide concepts for changing those patterns. The research method is inductive: the authors typically present data and analyses of particular classroom interventions, and make generalizations in the form of propositions.

According to Argyris and Schön (1996, p. 8), organizational actions are decisions and acts that individuals take and carry out on behalf of an organization. An observable action that is new to an organization is the most decisive test that, in that particular instance, organizational learning has occurred.

The authors conceptualize organizations as *agencies* that make decisions, delegate authority and monitor membership. Manufacturing plants, schools, churches and government bureaus are examples of such agencies. Formal organizations are collective vehicles for the regular performance of recurrent tasks. The members' behavior is, in crucial respects, governed by rules that are grounded in the society's legal system and are, to some degree, explicit. Informal organizations, on the other hand operate without a formal plan or an identified leader. They work out their situation-specific tasks through talk and gestures on the spot, at the site and with the available materials. Complex bureaucracies comprising detailed roles, rules, tasks procedures and hierarchies are cooperative systems that are governed by the constitutional principles of organizational policy (*ibid.*, pp. 10–11).

Individuals in organizations are not passive recipients, but active inquirers of these principles. Following Dewey's ideas, Argyris and Schön maintain that an inquiry proceeds from doubt to the resolution of doubt in a process that intertwines thought and action. Doubt arises from an experience of a problematic situation, triggered by a mismatch between the expected results of an action and what is actually achieved. Such a mismatch blocks the flow of spontaneous activity and gives rise to thought and further action aimed at re-establishing that flow.

The results of organizational inquiry may change individuals' thinking and the way they design organizational actions. They design their actions on the basis of their theories of action. Such theories may take two different forms, both of which are learned early in childhood and later supported by features of societal and organizational culture (*ibid.*, 1996, pp.75–76). An "*espoused theory of action*" refers to the theory of action that an individual advances in order to explain or justify his or her pattern of activity. "*Theory-in-use*", on the other hand, is implicit in a certain pattern of action. The researcher constructs it by observing action and identifying recurrent patterns (*ibid.*, 1996, p. 13).

Each member of an organization constructs his or her own individual representation of the theory-in-use of the whole organization, but the individual actor's view is always incomplete. He/she strives continually to complete his/her picture of the organization's theory-in-use by redescribing it continuously in his/her relations with other members. According to Argyris and Schön, the organization is like an organism in which each of the cells contains a particular, partial, changing image of itself in relation to the whole (ibid., 1996, pp. 15–16).

Because organizations are large and complex, their members cannot rely only on face-to-face contacts. Individuals need external references to guide their private adjustments. Artifacts such as physical objects, tools, products and working materials diagrams, drawings, photographs, buildings, files, and records describe existing patterns of activity and serve as guides for future action. Organizational learning changes the images in the mind, and also in the maps, memories, and programs of the organizational environment. Argyris and Schön crystallize their view of what organizational learning is in the following.

Organizational learning occurs when individuals within an organization experience a problematic situation and inquire into it on the organization's behalf. They experience a surprising mismatch between expected and actual results of action and respond to that mismatch through a process of thought and further action that leads them to modify their images of organization or their understandings of organizational phenomena and to restructure their activities so as to bring outcomes and expectations into line, thereby changing organizational theory-in-use. In order to become organizational, the learning that results from organizational inquiry must become embedded in the images of organization held in the members' minds and/or in the epistemological artifacts (the maps, memories, and programs) embedded in the organizational environment. (Argyris & Schön, 1996, p 16)

Argyris and Schön identify three types of organizational learning. *Single-loop learning* is the product of organizational inquiry that changes strategies of action or the assumptions underlying the strategies in ways that leave these assumptions, the governing values, unchanged. Single-loop learning is typically sufficient where organizations have to continually detect and correct errors. *Double-loop learning* is the product of inquiry through which the organization changes the values behind its theory-in-use, as well as its strategies and assumptions (ibid., pp. 20–21). The third type of organizational learning is a specific type of double-loop learning that is closely linked to the conditions under which individuals interact in organizational inquiry. The authors call it *organizational deuterolearning* and it refers to the organization's capacity to learn how to learn.

Argyris and Schön believe that in situations of mismatch between action strategy and outcome all people utilize similar theories-in-use in the final analysis. They call these common theories-in-use Model I and Model II. When human be-

ings deal with issues that are embarrassing and threatening, they strive to satisfy through their actions the governing values of Model I in four ways: defining their goals and trying to achieve them, maximizing winning and minimizing losing, minimizing the generation or expression of negative feelings, and being rational. Almost all, over 99 percent, of the people Argyris and Schön studied used this general model. The action strategies that the participants adopted in order to satisfy these governing values consisted of designing and managing the environment unilaterally, owning and controlling the task, protecting themselves unilaterally, and also protecting each other from being hurt. This suggests that members of an organization act defensively and that its behavioral world⁵ consists of defensive interpersonal relationships. The individuals lean on defensive norms such as mistrust, lack of risk, conformity, external commitment and diplomacy and only test their theories of action privately, and not at all publicly.

The governing values behind Model II include valid information, free and informed choice, and internal commitment. Every significant action is evaluated in terms of the degree to which it helps the individuals involved in the activity to generate valid and useful information and to share problems in a way that leads to productive inquiry. The related action strategies involve sharing power with anyone who has competence and who is authorized to make decisions concerning the implementation of the action in question. The definition of the task and control over the environment are also shared with all relevant actors. Individuals do not compete to make decisions for others, to achieve one-upmanship, or to outshine others for the purposes of self-gratification. Their degree of defensiveness within groups and among groups will tend to decrease as they function as agents of organizational learning. The assumptions and norms at the heart of organizational theory-in-use may surface, be publicly confronted, tested, and restructured. In the behavioral worlds of Model II, the social virtues taught early on in the individuals' life, such as helping, supporting and respecting others, strength, honesty, and integrity, are more developed than in Model I (*ibid.*, pp. 117–121).

According to Argyris and Schön, individuals using Model I or II create a corresponding organizational learning system (O-I or O-II). These systems are made up of structures, such as channels of communication, information systems, the spatial environment, procedures and routines, which enable a certain kind of organizational inquiry. Individual theories-in-use help people to create and maintain a certain kind of learning system and the system, in turn, contributes to the reinforcing and restructuring of individual theories-in-use. The crucial question

⁵ By the term behavioral world Argyris and Schön mean the qualities, meanings, and feelings that express the degree of win/lose in games between members within an organization.

of organizational learning according to the theory is the shift from Model I to Model II, which will lead to a new kind of learning system (*ibid.*, p. 29).

O-I learning systems involve a web of feedback loops that inhibit organizational learning. A conversation intended to be constructive can, given Model-I action strategies, lead to defensive reactions despite the participant's positive intentions and attempts to correct the error. Such a mismatch between outcomes and expectations reinforces and escalates the defensiveness. Argyris and Schön call this pattern of action strategies the primary inhibitory loops. The loop comes out during face-to-face discussions. Defensive and dysfunctional responses are triggered within such a loop, and information that tends to obscure error is produced. Not being able to discuss important issues is a typical example. A primary inhibiting loop may escalate into a secondary inhibiting loop the main components of which are organizational defensive routines. These are actions and policies that are intended to protect individuals from experiencing or an organization as a whole from identifying embarrassment or threat (*ibid.*, 1996, p. 99–100). The defensive routines create areas of undiscussable topics, but the very undiscussability also becomes undiscussable. The members of the organization are in a double-bind situation⁶: "If we do not discuss the defensive routines, then the routines will continue to proliferate. But if we do discuss them, we are likely to get into trouble" (*ibid.*, 1996, p. 101).

Thus the challenge is to create an organizational learning system, O-II, that is based on Model II theory-in-use. The force driving double-loop learning is the discrepancy between theory-in-use and the espoused theory of organizational action. However, because people are programmed with Model I theories-in-use from childhood, the O-II learning system cannot evolve spontaneously. Double-loop learning has to be triggered using deliberately certain maps and rules in a process of open inquiry, in which practitioners are enabled to identify and discuss their defensive reasoning.

The intervention method that Argyris and Schön developed focuses on primary and secondary loops that originally evolved as responses to threatening and embarrassing mismatch situations. The individually constructed theories-in-use that reflect these loops are an essential object of the intervention method. This is why the focus in the interventions is on the change in the individual's cognitive structures and mental models – not on the learning systems.

The aim of the intervention is to start the process of open inquiry in the organization, in which the action researcher promotes the learning processes. Argyris

⁶ The authors use the concept created by Gregory Bateson

and Schön claim that a classroom situation provides a more robust test of the features of their theory than questionnaires and interviews because the participants are able to provide the instructor with behavioral data that can be used to test the theory of organizational learning. Because the participants are dealing with their defensive routines, they begin to feel stuck. This feeling leads them to struggle to learn new skills, and also to explore their core values.

The data used during the interventions typically consists of transcripts of discussions, and recordings that are made during work meetings or intervention sessions. The recorded data is picked up from interaction situations that tend to stimulate feelings of embarrassment or threat. Participants are asked to write down in one column of a sheet of paper their conversation concerning a problem they have in their work. They then record their thoughts and feelings that remained unexpressed during the conversation in the adjoining column. In Argyris' and Schön's view, what the interlocutors write provides directly observable data about their theories-in-use. The recorded thoughts – and feelings – give insight into the participants' self-censoring processes (ibid., 1996, pp. 77–78).

Argyris and Schön do not present any specific theory of intervention, but rather report illustrative case examples of interventions they have carried out in "a large electronics firm", and "in an industrial firm"⁷. The most comprehensive one was "in a leading consulting firm of senior executives" and was intended to help the whole organization to move from an O-I to an O-II learning system. In their case description they explain the design of the intervention⁸, the feedback process, the construction of an action map, the analysis of the discussions and the learning experiments. The objective of the whole process was to reveal the limitations of the learning systems and to create a new one.

The authors confess openly that the O-II learning system represents an ideal state "that may never be achieved" but only approximated. It tends not to become fixed and rigid because it continually questions the status quo (ibid., 1996, p. 112). Although they believe that the system is not fully developed in any real productive organization, they try to show its potential and beginnings by giving illustrative case stories from their interventions.

⁷ Argyris and Schön do not reveal the real names of the firms, not do they also describe the daily work the participants do.

⁸ The intervention (Argyris and Schön, 1996, 151) is designed around five goals: discovering 1) the degree to which the participants' theory-in-use is consistent with Model I, 2) the degree to which their use is consistent with defensive reasoning, 3) the designs they have in their heads, 4) the degree to which they discourage valid reflection on their actions, and 5) the defensive routines that exist in the organization. In order to reach these goals, the researchers also had to engage themselves in re-education.

They do not analyze the actual production activities of the organizations, but rather focus on discussions concerning certain mismatch situations in the past. There is a thorough study of organizational learning through discussions during classroom intervention sessions.

Argyris and Schön (ibid., p. 72) believe that organizations are in continual transaction with their changing internal and external environments. Organizational objectives, purposes, and norms are always potentially in conflict with each other. Changes take place and conflicts arise again and again, but learning is not connected to specific historical changes. The concept of the two learning systems that was originally developed by Schön does not refer to the analysis of any specific historical phase in the development of an organization either. In their view, the results of double-loop learning cannot be measured against predetermined criteria, and their theory incorporates no criteria or concepts for evaluating the development of an organization. Organizational learning can only be adequately analyzed within an intervention, and thus they do not study it before and after.

Below is a brief summary of the answers found in Argyris and Schön's theory to the questions presented at the beginning of this chapter.

1. What is organizational learning according to the theory?

Organizational learning is a change in the theory in use of organizational members as an outcome of an individual's inquiry into organizational actions on behalf of the organization. Double-loop learning includes the specific kind of inquiry that changes and the values behind the theory-in-use. This form of organizational learning is connected to the shift from learning system O-I to learning system O-II.

2. What triggers organizational learning?

Organizational learning is triggered by mismatch situations in which the outcome of an action does not meet expectations. O-I learning systems launch loops that inhibit learning. These loops can be transformed by means of intervention that helps individual members of an organization to identify their defensive reasoning and routines and to change the values governing their theories-in-use.

3. What, according to the theory, are the main forms of organizational learning?

Single-loop learning, double-loop learning and organizational deuterolearning, in other words learning to learn, are the main types of organizational learning.

4. How does the theory conceptualize the relationship between individual and collective learning?

The interaction between individual and collective learning depends on the theories-in-use of the individuals. Individuals engaged in learning system O-I cannot correct their theories-in-use collectively, but apply espoused theories that deviate from those in use. Because all individuals generally use similar theories-in-use, double-loop learning is only possible through planned classroom intervention that reveals and changes the governing values behind such theories.

5. How does the theory conceptualize the relationship between organizational learning and historical change in the form of production?

The authors do not discuss the content of organizational actions or the production carried out in the organization. They do not make any reference to historical development in general, or to the relationship between organizational learning and historical forms of production in particular. The concepts of single- and double-loop learning, and of the O-I and O-II learning systems, are conceived of as general and as independent of historical changes. They are *normative* concepts, which depict forms of organizational learning in any organization.

2.3 Organizational learning as a change of routines

Rules, aspirations, decision-making, and learning in organizations have been the objects of studies that are based on "the behavioral theory of the firm". The representatives of this approach, headed by James March, Richard Cyert, and Herbert Simon, have criticized the economic theories that presume that organizations behave rationally and that organizational action is based on explicit preferences, expectations about future outcomes, and choices based on expectations (March, 1988, pp. 2–3).

Cyert and March's book (1963; 2001) *A behavioral theory of the Firm* has become a classic in organization theory. It presents a theory of the business firm and the way in which it makes economic decisions. The theory takes the firm as its basic unit, the prediction of the firm's behavior as its objective, and the actual decision making as its basic research commitment (Cyert & March, 2001, p. 19).

March's main research interest over the years has been the pursuit of intelligence by individuals and organizations (Augier, 1999, p. 24):

Almost everything I've done is concerned one way or another with the pursuit of intelligence by individuals and organizations. Decision-making is one way in which individuals and organizations pursue intelligence; learning is another way – both learning from ones own experience and learning from others; variation and selection is another way. Theories of adaptation or action might be a broader term than theories of decision-making.

March and Cyert argue that they can analyze the processes of decision – making in the modern firm in terms of three groups of variables: organizational goals, organizational expectations and organizational choice. The organizational goals of a business firm are series of independent constraints imposed on it through a process of bargaining among potential coalition members and elaborated over time in response to short-run pressures. Goals arise in such a form because the firm is, in fact, a coalition of participants with disparate demands, changing foci of attention and a limited ability to attend to all organizational problems simultaneously (March & Cyert, 2001, p. 50). According to the theory, *organizational expectations* are the result of inferences drawn from available information. *Organizational choice* is made in response to a problem by using standard operating rules, which are procedures for solving the kind of problems that the firm has managed to solve in the past. As time passes by and experience changes through organizational search and learning, so do the standard operating procedures. The variables that affect choice are those that influence the definition of a problem within the organization, those that influence the standard decision rules and those that affect the order of consideration of alternatives (ibid., p.163).

The general starting point of decision-making is that the firm always has to operate "under uncertainty in an imperfect market" (ibid., p. 162). Uncertainty is a feature of the organizational decision-making with which the organization has to live. In the case of a business firm, there are uncertainties with respect to the behavior of the market, the suppliers, the attitudes of shareholders, and the behavior of competitors. The point is that organizations tend to avoid dealing with these uncertainties.

According to March (1998), organizations and their environment adapt to each other by means of several intertwined processes. Organizational learning means that they exhibit adaptive behavior over time. It has no particular starting point and there are no specific phenomena that trigger learning because learning is a sub-process of continuous decision-making (ibid., 1998, p. 176).

The behavioral theory of the firm (March, 1981; March, 1999) represents attempts to analyze how decisions actually come about in organizations as well as in individuals. Choices are made without much concern for preferences. Decision-making actions reflect images of behavior, and decision makers routinely ignore their own fully conscious preferences. They act not on the basis of subjective estimates of consequences and preferences, but on the basis of rules, routines, procedures, practices, identities, and roles. They follow traditions, hunches, cultural norms, and the advice or actions of others (March, 1999, p. 22). The processes of decision-making are more important than the outcomes: "Decision making is, in part, a performance designed to reassure decision makers and others that things are being done appropriately" (March, 1981, p. 232). This is the reason why orga-

nizational learning that deals with knowledge does not always lead to improvement in performance or to growth in organizational intelligence.

According to the behavioral theory of the firm, organizational learning is counted among organizational routines. Simon and March (1958, p. 142) define routines as a set of activities in which the making of choices has been simplified by the development of a fixed response to defined stimuli. "If search has been eliminated, but a choice remains in the form of a clearly defined and systematic computing routine, we will still say that activities are routinized". Routines are not automatic responses, but rather resemble grammars that allow flexible response patterns.

The generic term "routines" includes the forms, rules, procedures, conventions, strategies, and technologies around which organizations are constructed and through which they operate. It also includes the structure of beliefs, frameworks, paradigms, codes, cultures, and knowledge that buttress, elaborate, and contradict formal routines. Routines are independent of the individual actors who execute them and are capable of surviving considerable actor turnover (Levitt & March, 1988, p. 320).

Routines are transmitted to the organization and its members through socialization, education, imitation, professionalization, personnel movement, mergers, and acquisitions, and they are recorded in its collective memory "that is often coherent but sometimes jumbled, that often endures but is sometimes lost (ibid.).

Routines are based on interpretations of the past more than on anticipations of the future. Interpretations of earlier experiences provide more or less valid information about the organization's history. The "experiential lessons of history" are captured in routines in a way that makes the lessons accessible to organizations and individuals who have not themselves experienced the history. They occur through trials and errors and the conscious search for better solutions (ibid.).

By translating experience into rules and using these rules as a basis for action, an organization modifies its behavior in a coherent way. Within this framework, Levitt and March see organizational learning as "the encoding of inferences from history into routines that guide behavior". Organizational learning is, in this respect, the continuous refinement of rules and routines.

Although advocates of the behavioral theory of the firm have explained routines and rules as the basis of organizational learning, they have not been interested in how the routines in organizational practices evolve over time (Zhou, 1993). The definition of "routine" in the theory is so wide that it is difficult to operationalize it for empirical research.

Organizational learning, according to March, consists of two main, partly opposite processes: exploitation – the use and adaptation of knowledge already at hand (routinization, selection, risk aversion, execution) - and exploration – the

search for new knowledge (experimentation, variation, risk taking, search). An organization that engages only in exploitation will improve its knowledge in an increasingly obsolete technology or strategy while one that engages only in exploration will never gain any return from its discoveries. The achievement of an effective mixing of continuity and change is possible by developing intellectual and social structures that sustain a tension between the delights of exploration and the delights of exploitation (March, 1991, p. 87).

Intelligence, on the one hand, calls for a mix of these processes, but on the other hand learning also tends to eliminate one the another. Where success is difficult to achieve or sustain, it is easy for an organization to fall into the trap of changing strategies too rapidly to achieve competence in any one of them. This cycle of failure and experimentation produces an organization that under-invests in exploitation. The successes of exploration are systematically less certain, more distant in time, and more distant in space than the success of exploitation. Learning, which tends to be especially responsive to successes in the temporal and spatial neighbourhood of action, tends to favor exploitation and leads the organization to under-invest in exploration. Using the idea of these two modes of learning, March developed the argument that adaptive processes, by refining exploitation more rapidly than exploration, are likely to become effective in the short run but self destructive in the long run of organizational development.

Initially, March and Cyert assumed that the rules by which an organization adapts its self in the environment may be decision rules, attention rules, or goal-formulation rules. In the introduction of *The Pursuit of Organizational Intelligence* (1999), March identifies four types of rule development: 1) contractual, in which rules are chosen consciously by actors who have calculated the expected consequences of their actions; 2) experientially learned, when the organization modifies rules for action incrementally on the basis of environmental feedback; 3) imitative, when decision makers copy them from other organizations; and 4) the evolving collection of invariant rules.

March also discusses how organizations implement rules. In their first model of learning, Cyert and March assumed that the search for better solutions is stimulated as soon as existing programs no longer guarantee the achievement of the organization's goals, which are formulated as aspiration levels. This conceptualization proved to be limited because it neglected the link between individual and organizational learning. March and Olsen (1975) solved the problem by changing the unit of analysis from the organization to the individual. They presented a new model of the cycle of organizational learning.

In this model (see Figure 2.1), the cycle of adopting a new rule consists of four stages: (a) individual actions based on certain beliefs of the individual; (b) these individual actions lead to organizational actions that produce certain outcomes;

(c) these outcomes are interpreted as an environmental response, with success being distinguished from failure, and a link is drawn between actions and perceived outcomes; (d) this reasoning leads to new beliefs. March and Olsen also point out some barriers that can interrupt this cycle. These are indicated by boldface type and pairs of parallel bar lines in Figure 1 (March & Olsen, 1975, p. 158).

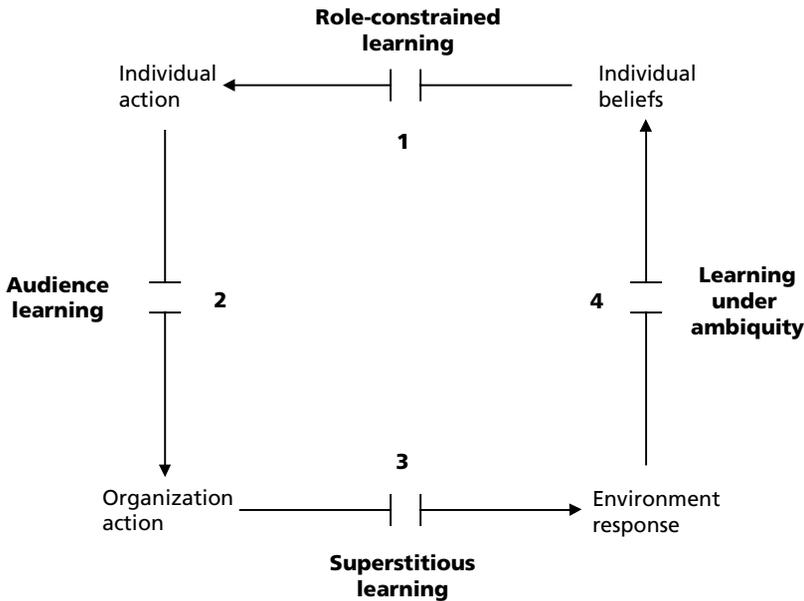


Figure 2.1 The cycle of organizational learning (March and Olsen, 1975, p. 158)

The first type of rupture occurs when individual members of a firm are prevented by certain organizational conditions from adapting their behavior to their beliefs. Prevailing role definitions or standard operational procedures, for example, may create these conditions (ibid.). "Role-constrained experiential learning" occurs when members of an organization are convinced that new actions have to be initiated because environmental conditions have changed but the individuals are not able to change their actions. "Audience experiential learning" occurs when individuals are able to change their own behavior but they are unable to affect the rule-guided actions of others (Rupture 2 in Figure 1). The third type of rupture in the learning cycle is caused by misinterpretation of the consequences of organizational actions. The members of the organization cannot accurately assess what effects the executed organizational actions will have on the environment and on the results. They tend to interpret data as justifying the actions taken in response to certain problems that were identified. "Learning under ambiguity" occurs when the changes in the environment cannot be correctly identified. The organizational

members are not able to make sense of the environment or to explain why certain changes happened (rupture 4 in Figure 1) (ibid.).

The creation and modification of the rules that make up this action cycle are, according to March and Olsen, the results of experimentation. They see organizational learning as consisting of three steps: variation through experimentation, selection based on inferences drawn from experiments and retention through the formulation of rules that produce successful actions and that can be passed on to the other members of the organization (ibid.). Rule creation is based on conscious experiments, while implementation is based on experience.

The answers to my questions below summarize the theory:

1. What is organizational learning?

Organizational learning is the continuous refinement of corporate routines; to be more exact, it is the "encoding of inferences from history into routines that guide behavior".

2. What triggers organizational learning?

Organizational learning and decision-making are continuous processes. They have no specific end or beginning. Dissatisfaction is more important from the point of view of learning than satisfaction, however.

3. What are the main forms of organizational learning?

The main types of organizational learning are exploration and exploitation. The knowledge at hand is learned through exploitation and the knowledge that has not yet been applied or created is learned through exploration. Organizational learning is based mainly on experience, but also on experiment.

4. How does the theory conceptualize the relationship between individual and collective learning?

The relationship between individual and collective learning is ambivalent in their theory. March and Levitt state that organizational learning is "more than individual learning". On the other hand, March and Olsen present a learning circle in which organizational learning is seen from the point of view of individual adaptation. Individual learning affects organizational learning when an individual can change the beliefs of other individuals or change the organizational routines.

5. How does the theory conceptualize the relationship between organizational learning and historical change in the form of production?

Although organizational routines change over time incrementally, the process of organizational learning is understood in this theory to be independent of the historical changes in the form of production.

2.4 Organizational learning as the creation of new knowledge

Nonaka and Takeuchi (1995) point out how important it is for modern organizations to create new products, new methods, and new organizational forms. What is more fundamental still, they think, is to understand how organizations create knowledge that makes such creations possible (Nonaka & Takeuchi, 1995, p. 50). Referring to Peter Drucker they point out that in the new economy knowledge has become the most important resource in competition between companies: the creation of new product innovations requires new knowledge. This change of emphasis makes the new society unique (*ibid.*, p. 6).

Traditional Western epistemology has focused on "truthfulness" as the essential attribute of knowledge. Nonaka and Takeuchi, however, consider knowledge to be the dynamic human process of justifying personal beliefs toward the truth (*ibid.*, p. 58) and new knowledge is created when existing knowledge is converted along two dimensions, the epistemological and the ontological (*ibid.*, p. 58).

In explaining the epistemological dimension they refer to the Michael Polanyi's distinction between tacit and explicit knowledge. They see tacit knowledge as personal and context-specific, and therefore hard to formalize and communicate. Explicit knowledge, on the other hand, refers to knowledge that is transmittable in formal, systematic language. Human beings acquire knowledge by actively creating and organizing their own experiences. Knowledge that can be expressed in words and numbers represents only the tip of the iceberg of the entire body of knowledge (*ibid.*, p. 60). Human beings create knowledge by involving themselves with objects, through self-involvement and commitment.

To know something is to create its image or pattern by tacitly integrating particulars. In order to understand the pattern as a meaningful whole, it is necessary to integrate one's body with the particulars. Thus indwelling breaks the traditional dichotomies between mind and body, reason and emotion, subject and object, and knower and known. Much of our knowledge is the fruit of our own purposeful endeavors in dealing with the world. (Nonaka & Takeuchi, 1995, p. 60)

The ontological dimension of knowledge creation consists of organizational processes that amplify the knowledge created by individuals and make it organizational. According to Nonaka and Takeuchi, the knowledge-creating entities may

be individual, group, organizational or inter organizational, but individuals are the key actors. They see an organization as a stable structure that supports individuals' actions and provides the context for them.

In a strict sense knowledge is created by individuals. An organization cannot create knowledge without individuals. The organization supports creative individuals or provides contexts for them to create knowledge." (Nonaka & Takeuchi, 1995, p. 59)

They also consider tacit knowledge and explicit knowledge complementary. By combining the two dimensions they created a matrix model of four modes of knowledge conversion: socialization, externalization, combination and internalization.

According to Nonaka and Takeuchi, the origin of the knowledge-creation process lies in organizational intention, which is defined as the organization's aspiration to reach its goals. They refer to Weick and Neisser, who argue that knowing occurs only in the context of purposeful activity, and that an organization's interpretation of environmental information has an element of the self-fulfilling prophecy because it has a strong will to actualize what it wants to become (ibid., p. 74). Learning, in this sense, is based on the adoption of a specific organizational strategy and goals. In practice, knowledge-creation processes start when managers have taken a decision about the development of a new product and give the assignment to a design team.

The role of middle managers is important in the knowledge-creation process. They are the people who remake reality, or engineer new knowledge, according to the company's vision. They become effective knowledge engineers if they are equipped with the topnotch capabilities of project coordination and management. Nonaka and Takeuchi suggest a new management model they call the middle-up-down model, in which the middle managers are at the very centre of the knowledge creation (ibid., p. 124).

The spiral of knowledge creation (ibid., pp. 62–70) begins with the conversion of the tacit knowledge of one group into the tacit knowledge of another group. This conversion is called *socialization*, which is the process of sharing experiences and creating shared mental models and technical skills. The key to acquiring tacit knowledge is experience: learning through observation, imitation, and practice. The next phase is the construction of explicit concepts by *externalizing* tacit knowledge. Knowledge explication is triggered by *dialogue or collective reflection*. An often-used method is to combine deduction and induction, or to use metaphors or analogies. The third phase is *combination*, which is a process of systematizing concepts into a knowledge system. Documents, meetings, telephone

conversations and computerized communication networks are used as media in combination. Reconfiguration of explicit knowledge by sorting, adding, combining, and categorizing leads to a new kind of explicit knowledge, which is eventually *internalized* and converted into tacit knowledge. When experiences are internalized in individuals' mental models and technical know-how through socialization, externalization and combination, they become valuable assets. This cycle of knowledge creation is repeated over and over again in complex processes such as the development of new products.

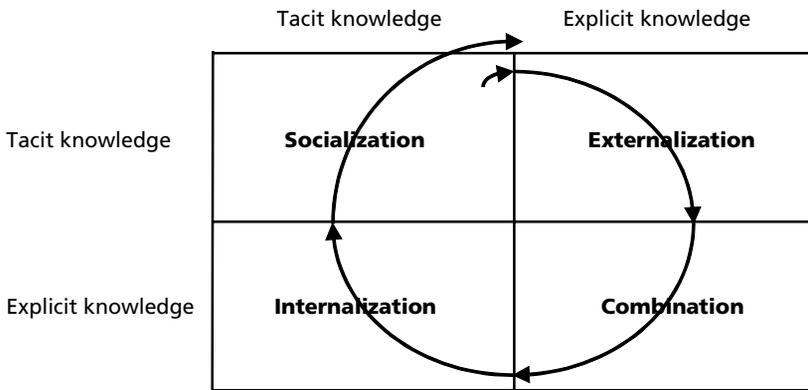


Figure 2.2 Four modes of knowledge conversion (Nonaka & Takeuchi, 1995, p. 62)

According to Nonaka and Takeuchi (1995, p. 70), organizational knowledge creation involves continuous and dynamic interaction between tacit and explicit knowledge. This interaction is shaped by shifts between different modes of knowledge conversion, which are in turn induced by several triggers. The socialization mode starts with building a "field" of interaction. Externalization is triggered by meaningful dialogue or collective reflection. The combination mode is triggered through collaboration with newly created knowledge. Learning by doing triggers the internalization.

Because the knowledge-creation spiral requires certain conditions in the organization Nonaka and Takeuchi (ibid., pp. 70–90) also introduce an integrated five-phase model incorporating the time dimension in their theoretical framework (Figure 3). The sequence of phases begins with socialization, in other words sharing tacit knowledge. The next phase, creating concepts, is the process of externalization in which tacit knowledge becomes explicit. The shared tacit mental models are now verbalized in words and phrases, and finally crystallized into explicit concepts. The third phase, justifying the concepts, involves determining whether the newly created concepts are truly worthwhile for the organization and

society. The fourth phase, building an archetype, means the conversion of the justified concept into something tangible and concrete, and the fifth phase involves the cross-leveling of knowledge. Organizational knowledge creation is a never-ending interactive and spiral process that upgrades itself continuously and occurs both intra-organizationally and inter-organizationally.

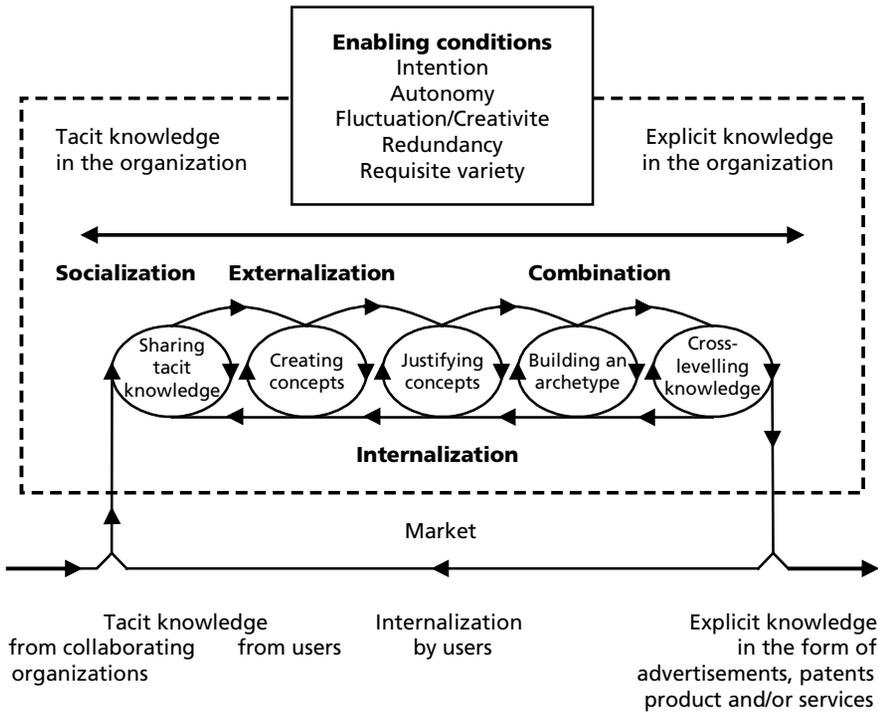


Figure 2.3 A five-phase model of the organizational knowledge-creation process (Nonaka & Takeuchi, 1995, p. 84)

Nonaka and Takeuchi suggest that two types of organizational structure were in oscillation during the 20th century: bureaucracy and task-force. Bureaucratic structures are highly formalized, specialized and centralized, and work effectively for routine operations. Task-force management, on the other hand, is flexible, adaptive, dynamic and participative, and is effective in carrying out well-defined tasks within a predefined time. In their view, as knowledge and innovation have become necessary to companies, a new organizational structure, a "hypertext organization", is needed. A Hypertext organization is a synthesis of the bureaucratic and task-force structures, and its purpose is to enable an organization to create knowledge. The efficiency and stability of the bureaucracy is combined with the

effectiveness and dynamism of the task-force organization. It also contains a third layer, the knowledge base, in which the knowledge generated in the two organizational structures is recategorized and conceptualized in relation to the firm's corporate vision, culture and technology (Nonaka & Takeuchi, 1995, p. 241). A hypertext structure is a necessary prerequisite for continuous knowledge creation.

Below is a summary of the five features of the theory in terms of the answers it gives to my questions.

1. What is organizational learning?

Organizational learning is the creation, justification, and cross levelling of new concepts.

2. What triggers organizational learning?

The theory does not explicate any driving force behind organizational learning. Learning begins when a manager gives an assignment to a design group. Knowledge creation is a result of adopting organizational goals, because the organization "has a strong will to self-actualize what it wants to become."

3. What, according to the theory, are the forms organizational learning?

The forms of learning are the processes of knowledge conversion: socialization, externalization, combination and internalization.

4. How does the theory conceptualize the relationship between individual and collective learning?

New knowledge is created first and foremost collectively by groups of designers. A Hypertext organization can support the knowledge-creation process.

5. How does the theory conceptualize the relationship between organizational learning and historical change in the form of production?

Nonaka's and Takeuchi's theory is an attempt to respond to the current historical change in the business environment, but it does not deal otherwise with historical changes in production. Learning is about creating new knowledge in order to design and produce new products for the market in which knowledge -creation has become an essential element of competition and profit making.

2.5 Organizational learning as the development of communities of practice

Lave and Wenger (1991) propose in their book "Legitimated Peripheral Learning" that learning involves a deepening process of participation in a community of practice. Wenger extends this framework in "Learning, identity, meaning" (1998) by using the term the *social perspective of learning*. This more general concept is a result of the further development of the concept of practice, and its connection to the analysis of the development of an individual's identity. Wenger proposes a framework for thinking about learning in terms of communities, their practices, the meanings they make possible, and the development of identities. He also explores the implications of their joint framework for the design of organizations and organizational learning.

The Lave and Wenger theory of "legitimate peripheral learning" was originally based on their ethnographical studies on the apprenticeships of midwives, tailors, quartermasters, and butchers, and on non-drinking alcoholics. They emphasized the fact that learning is situational and embedded in a practice: it is an integral part of a generative social practice in the lived-in world. They proposed the concept of legitimate peripheral participation as a general descriptor of human engagement in social practice that entails learning as an integral constituent (Lave & Wenger, 1991, p. 35).

Communities of practice are everywhere, according to the theory. Human beings are generally involved in a number of them – whether at work, in school, at home, or in civic and leisure interests. People are core members in some groups, in others more on the periphery. Learners inevitably participate in communities of practice, and the mastery of knowledge and skill requires newcomers to move toward full participation in the one in question. A person's intentions to learn are engaged and the meaning of learning is configured through the process of becoming a full participant in a socio-cultural practice. This social process includes the learning of knowledgeable skills (*ibid.*, p. 29). A community of practice is an intrinsic condition for the existence of knowledge, not least because it provides the interpretive support necessary for making sense of the cultural heritage. Thus participation in the cultural practice in which knowledge exists is an epistemological principle of learning (*ibid.*, 1991, p. 98).

Strictly speaking, the social perspective of learning is not a theory of organizational learning. However, Wenger's purpose is to show that placing the focus on participation has broad implications in terms of what it takes to understand and support learning. For individuals, it means that learning is a question of engaging in and contributing to the practices of their communities, while for communities it is a question of refining their practices and ensuring new generations of mem-

bers. *For organizations* it is a matter of sustaining the interconnected communities of practice through which the organization gains knowledge and thus becomes effective and valuable as an organization (Wenger, 1998, pp. 7–8).

Wenger maintains that learning is inseparable from practice. Although the characteristics of communities of practice vary, the people involved are brought together by what they have learned through their mutual engagement in common activities. A community of practice differs from a community of interest or a geographical community in that it involves a shared practice.

Being alive as human beings means that we are constantly engaged in the pursuit of enterprises of all kinds, from ensuring our physical survival to seeking the most lofty pleasures. As we define these enterprises and engage in their pursuit together, we interact with each other and with the world and we tune our relations with each other and with the world accordingly. In other words we learn.

Over time, this collective learning results in practices that reflect both the pursuit of our enterprises and the attendant social relations. These practices are thus the property of a kind of community created over time by the sustained pursuit of a shared enterprise. It makes sense, therefore to call these kinds of communities *communities of practice*. (Wenger, 1998, p. 45)

Wenger and Snyder (2000) describe more concretely how communities of practice differ from formal work groups, project teams, and formal networks. The purpose of a community of practice is to develop its members' capabilities: to build and exchange knowledge. The members select themselves and the community of practice holds together because the members have passion, commitment and identification with the group's expertise. Communities of practice are sustained as long as there is interest in maintaining the group. Wenger and Snyder (2000) also use examples of product-delivery consultants and line technicians to describe how they can exist entirely within a business unit, and how they can stretch across divisional boundaries.

Wenger (1998) characterizes the concept of practice from the viewpoint of doing, but not just doing in and of it self. He views doing in a historical and social context that gives meaning and structure to what participants do. Thus practice is always a social and cultural practice (1998, p. 47), and learning is first and foremost the human's ability to negotiate meanings. The notion of meaning refers to experience, while practice is about the meaning of experiences of everyday life. Human life involves the constant negotiation of meanings: people produce meanings that extend, redirect, dismiss, reinterpret, modify or confirm, or negotiate anew – the histories of meanings of which they are a part.

Negotiating meanings involves the whole person in a dynamic interplay between *participation* and *reification*. The term participation describes the social experience of living in the world in terms of membership in social enterprises. It is personal and social. It is a complex process that combines doing, talking, thinking, feeling and belonging. It includes the whole persons, including their bodies, minds, emotions and social relations. It can involve all kind of relations, conflictual as well as harmonious, intimate as well as political, competitive as well as cooperative. Participation shapes human experience and it also shapes communities: the transformative potential goes both ways. It is broader than mere engagement in practice. Officials are not officials only when they are working in their offices (*ibid.*, pp. 55–57).

Any community of practice produces abstractions, tools, symbols, stories, terms, and concepts that reify something of that practice in a congealed form. The notion of reification is used to convey the idea that what is in a concrete material object is not in itself a concrete, material object. It refers to the processes of giving form to human experience by producing objects that congeal this experience into "thingness". In so doing, people create points of focus around which the negotiation of meaning becomes organized. Writing down a law, creating a procedure and producing a tool are similar processes. A certain understanding is given a form. This form then becomes a focus for the negotiation of meaning, as people use the law to argue a point, use the procedure to know what to do, or use the tool to perform an action (*ibid.*, pp. 57–59).

Wenger points out that, as an analytical concept, community of practice is a limited category for describing the very large society of the global economy, and also smaller ones such as a company, factory or school. He views these kinds of social configurations as constellations of interconnected practices (*ibid.*, pp. 122–125), and in this sense he views organizations as constellations of interconnected communities of practice.

Wenger emphasizes the connection between practice and identity. The development of human identity, even in the context of a specific practice, is not just a matter that is internal to that practice, but also involves the participants' position and the position of their communities in broader social structures. He maintains that the characteristics of practice can be construed as the characterization of the identity that inherits its richness and complexity.

Non-participation is also a central aspect of the formation of individual identity. People not only produce their identities through the practices they engage in, they also define themselves through the practices they do not engage in (*ibid.*, p. 164). Being an outsider, or a peripheral participant, or being marginalized, may be forms of non-participation. In order to make sense of the formation of identity and learning he distinguishes three modes of belonging. Engagement means active

involvement in the mutual process of negotiation, imagination means creating images of the world and seeing connections through time and space by extrapolating from one's own experience, and alignment involves coordinating participants' energy and activities in order to fit within broader structures and to contribute to broader enterprises.

Wenger maintains that engagement, imagination, and alignment create relations of belonging that expand identity through space and time. Each of them requires a different kind of work, and each gives rise to various kinds of communities. The work of engagement is the work of forming communities of practice. It requires from the participants the ability to take part in meaningful activities and interactions in the production of sharable artifacts, in community-building conversations, and in the negotiation of new situations. The work of imagination requires the ability to disengage – to move back and look at our engagement through the eyes of an outsider. It demands some degree of playfulness. The work of alignment requires from the participants the ability to coordinate perspectives in order to direct energies to a common purpose. The challenge is to connect local efforts to broader styles and discourses in ways that allow learners to invest their energy in them (*ibid.*, pp. 183–188). He concludes that the notion of belonging is a basis for talking about learning, identity, and power in social terms at the same time.

Communities of practice do not take knowledge as an object: it is a living part of the practice even when it is documented. Knowledge is a matter of competence with respect to valued enterprises, such as singing in tune, fixing machines, and growing up as a girl or a boy. What is called general knowledge is not privileged with respect to other kinds of knowledge. The generality of any form of knowledge always lies in its power to renegotiate the meaning of the past and the future in constructing the meaning of present circumstances (*ibid.*, p. 4; Lave and Wenger, 1991, pp 33–34).

The community of practice acts as a locally negotiated regime of competence. Within such a regime, knowing can be defined as competent participation in the practice. To become even a peripheral member of a community of practice means doing some learning along the three dimension of competence: the ability to engage with other members of the community and respond to their actions (mutuality of engagement), the ability to understand the enterprise of a community of practice deeply enough and to take some responsibility (accountability of the enterprise), and the ability to make use of the repertoire of the practice to engage in it (negotiability of the repertoire) (*ibid.*, pp. 136–137).

Learning is not only a matter of competence, but also a matter of experiencing meaning. For learning to be possible in practice, there must be interaction between an experience of meaning and a regime of competence. Although experience and competence are both constituents of learning, they do not determine each other. Competence may drive experience and experience may drive compe-

tence. This two-way interaction is crucial to the evolution of practice. In it lies the potential for transforming both experience and competence, and thus for learning, individually and collectively. Wenger characterizes learning – taken to be the transformation of knowing – as a change in alignment between experience and competence, whichever of the two takes the lead in causing realignment at any given moment (*ibid.*, pp. 138–139).

Communities of practice provide a context not only for the learning of newcomers, but also for new insights to be transformed into knowledge. They are privileged loci for the acquisition of knowledge when they are contexts that can give newcomers access to competence, and also invite personal engagement. They may also be privileged loci for the creation of new knowledge when they serve as good contexts within which to explore radically new insights.

Wenger highlights the close interaction between competence and experience as a continuous source of learning: "If they settle down into a state of locked-in congruence, the learning slows down, and practice becomes stale" (*ibid.*, p. 214). He calls the communities of practice that can keep this tension alive *learning communities*, a concept to which he ascribes many meanings (*ibid.*, pp. 214–221):

- Learning communities will become places of identity to the extent that they make identity formation trajectories.
- Learning communities have a strong core but they let peripheral and core activities interact, because it is in the interactions that they are likely to find the new experiences and new forms of competence necessary to create new knowledge.
- Learning communities can combine modes of belonging .
- Learning community confronts structural issues of identification and negotiability both internally and externally.
- Learning community is fundamentally involved in social reconfiguration.

Wenger further emphasizes that learning cannot be designed. It belongs to the realm of experience and practice and moves on its own terms.

Learning changes who we are by changing our ability to participate, to belong, to negotiate meaning. And this ability is configured socially with respect to practices, communities and economics of meaning where it shapes our identities. (*ibid.*, p. 226)

Thus, communities of practice cannot be designed either. They cannot be legislated into existence or defined by decree. Practice itself is not amenable to design.

In other words, one can articulate patterns or define procedures, but neither the patterns nor the procedures produce the practice as it unfolds. One can design work processes but not work practices.

Although learning cannot be designed, Wenger thinks that it can be facilitated. The design from this perspective has to be a dialogue, a design from the *inside*, not from the *outside*. He rather talks about "architectures" for learning, which lay out basic questions and basic components that must be provided in any design for learning. He maintains that no community can fully design the learning of another, and no community can fully design its own learning. The design cannot clearly separate conception and realization, but must instead combine different forms of knowledge so that they inform each other.

Organizations can do what they do or learn what they learn only through their practices. Communities of practice differ from organizational entities along three dimensions: they negotiate their enterprise, arise evolve and dissolve according to their own learning, and shape their own boundaries.

Neither design nor teaching can cause learning. What ends up being learned may or may not be what was taught, or more generally what the institutional organization intended. Learning is an emergent, ongoing process, which may use teaching as one of its many structuring resources. In this regard, teachers and instructional materials become resources for learning in much more complex ways than through their pedagogical intention (ibid., p. 267).

1. According to the theory, what is organizational learning?

Wenger and Lave's social perspective on learning suggests that learning in and for organizations means that the communities of practice within them sustain and develop.

2. What triggers organizational learning?

The constant tension between competence and experience triggers learning. The authors conceptualize this in "Legitimate peripheral learning" as the contradiction between newcomer and old-timer within a community of practice.

3. What are the main forms of organizational learning?

Although the social theory of learning maintains that learning is a temporal process, it does not define specific forms, stages or phases. Learning has no specific end or beginning. It is continuously connected to the development of practices.

4. How does the theory conceptualize the relationship between individual and collective learning?

The very nature of learning is collective. Both individual and organizational learning are impossible without individuals' participation in communities of practice.

5. How does the theory conceptualize the relationship between organizational learning and historical change in the form of production?

Wenger and Lave do not recognize any historical changes in forms of learning. On the contrary their main argument is that the age-old form of apprenticeship is a general form that has to be sustained and facilitated. In other words, learning through peripheral participation has to be legitimated.

2.6 The inadequacy of organizational learning theories in understanding the current change in learning in and for production

My purpose in this chapter has been to analyze the kind of conceptual tools the four most influential theories of organizational learning provide for understanding the nature of current historical change in learning in and for production. The results of my analysis are summarized in Figure 4.

The following overall conclusions can be drawn from the analysis.

1. Theories of organizational learning conceptualize the phenomenon in completely different ways.
2. The theories do not address the question of historical changes in organizational learning.
3. The theories do not provide categories for conceptualizing the ongoing changes in production and in learning in and for production. They do, however, provide, abstract models and normative principles of learning: O-II learning systems, achieving a balance between exploration and exploitation, the learning community, and hypertext organization.

Learning in Organizations is conceptualized in the theories as a change of governing values, as refinement of routine, as sustaining the interconnected communities of practice, or as creating new knowledge. The driving force behind it is either not explicated at all or is seen quite differently, as are the forms of learning and the relation between individual and collective learning.

The differences between the theories are so profound that one could ask to what extent they are dealing with the same phenomena.

The common feature in all of them is their ahistorical and abstract nature. They search for universal mechanisms of organizational learning and abstract historical specificities. The other side of the universality aspect, however, seems to be a certain kind of limitedness. The theories seem to limit the concept of organizational learning to formal aspect its contents. The assumption is that the forms and contents are independent of each other, and that organizational learning processes are universal.

Table 2.1 The dimensions of the four theories of organizational learning

	Argyris & Schön	March & Levitt	Wenger & Lave	Nonaka & Takeuchi
What is organizational learning?	Inquiry that leads to changes in organizational theories-in-use and the values that govern them	Change of rules/ routines in a firm;	Sustaining interconnected communities of practice within an organization	The creation of new knowledge and concepts
What triggers organizational learning?	Mismatch between the expected and actual outcomes of an action	Not conceptualized: rather dissatisfaction than satisfaction	Tension between experience and competence	Management's decision to launch a design process
What are the main phases or forms of organizational learning?	Single-loop learning, double-loop learning, and organizational deuterolearning	Exploration and exploitation; Role-constrained learning, audience learning, superstitious learning, and learning under ambiguity	Not explicated	Phases of the knowledge-creation cycle: socialization, externalization, combination, internalization
How is the relation between individual and collective learning conceptualized?	Individuals inquire on behalf of the organization, which is a regulative agency	Ambiguous; individuals in a firm encode their interpretations of historical lessons into routines that guide the behavior of the firm	Both individual and organizational learning is based on individuals' participation in communities of practice	The creation of new knowledge is a collaborative process to which the individual participants contribute
How does the theory conceptualize the relationship between organizational learning and historical change in the form of production?	Not explicated; organizational learning is described in universal and ahistorical terms	Not explicated; decision-making and learning processes are universal, not specific to a historical period	Learning has been similar as long as communities of practices have existed	Not explicated, although the theory is substantiated by reference to the current change in the business environment

Prange (1999) criticized theories of organizational learning for not having been able to produce a coherent body of knowledge. Nevertheless, this could highlight the pluralistic character of reality and, contrary to common sense, imply that there exists outside of the actors a "real world" with its own unique qualities.

The problem is that there seems to be no common object in the research on organizational learning. Researchers who base their work on one theory or another do not necessarily study the same phenomenon. They do not share any categories for describing the object of their study. Because they consider the phenomena of organizational learning from quite different points of departure, they produce results that are incompatible and make comparison and discussion between the theories impossible. Holzkamp (1978) aptly described the same methodological problem in psychology.

Theoretical randomness (...) is not characterized by the existence of many different theories that are directed at different objects outlined from each other, but there exist many theories that are incompatible with their main concepts, theories that claim to have universal validity and that are directed every time at the same object as if they were competing with each other. It is not possible on the basis of any scientific criteria unambiguously to determine, what kinds of theories are acceptable and which are to be discarded.(...) Each of the theories, which compete with each other, claims validity in a certain area (however narrow an area it is) of reality universally, in other words, without restricting any validity requirements. The validity given under other conditions by other theories becomes so precluded. (Holzkamp 1978, p. 135, translated by JP)

Holzkamp (1978, p. 108) points out that given the lack of shared basic categories as opposed to the development of a science, there is an increase in the number of incompatible theories, a direction that he calls epistemological anarchism. He has developed a method, the purpose of which is to overcome this problem that he calls as the "*logical-historical method*". It incorporates logical, logical-historical and real-historical analysis.

The method does not mean implementing formal methodological canons into random content. The aim is rather to reveal real material developmental processes concerning the essence of an object in the developmental logic of its becoming. (Holzkamp, 1978, p. 108, translated by JP)

The four influential theories of organizational learning described above illuminate some aspects of the concept, but they do not provide concepts for analyzing historical changes in the logic of learning in and for production, nor in the devel-

opmental logic of these changes. I will turn in the next chapter three theories that deal with historical change in production in order to determine what explanatory resources they provide for understanding historical change of learning in and for production.

3 Learning in theories of the historical development of production

3.1 Three theories explaining historical change

In this chapter I will examine three theories that could shed light on historical change in the context of learning in and for production. The first one is set out in Freeman and Louçã's (2001) study on the relationship between technological innovation and the long cycles in the development of capitalism⁹. The authors analyze the interrelationships between developments in the economy, technology, and institutions. By explaining the dynamics of economic development and the changes in the forms of economic activity the theory provides a general societal context for understanding changes in learning in and for production. The second theory, Paul Adler's (2001) analysis of the historical transformation of managerial doctrines, provides the means for bridging the gap between general social development and production by describing changes in management doctrines.¹⁰ Thirdly Victor and Boynton's (1998) model of historical forms of work and the "the right path" in the development of production links the qualitative changes in production with changes in learning.

⁹ Freeman and Louçã's theory is important in the context of learning in and for production because they emphasize economics as a historical science and the need to analyze the qualitative difference between periods of capitalist development. They reject approaches that employ mechanistic and purely econometric methods and those that focus only on the 'trends' in aggregate GDP. They also criticize Regulation theorists (Boyer, 1988) and Social Structure Accumulation theorists (Gordon, 1986) for concentrating on the precise definition or evolution of economic periods rather than their nature and developmental connections.

¹⁰ Adler's study is based on Barley and Kunda's (1992) theory according to which rational and normative management rhetoric is associated with economic long-waves and technologies. Rational rhetoric dominates during periods of expansion, and the normative approach returns with the downturn. Abrahamsson (1997) confirmed this theory using bibliometric and economic data

3.2 Freeman and Louçã's theory of techno-economic paradigms

Long waves of economic growth

Freeman and Louçã argue that we are witnessing a deep technological revolution based on a cluster of innovations in information technology: the computer and software, microelectronics, the Internet, and the mobile telephone. Industries based on these innovations mushroomed in the United States in the 1990s and accounted for a major part of the growth in the entire economy (Freeman & Louçã, 2001, p. 301).

The pervasiveness of the current technological revolution in the economy and in society is comparable to the breakthrough of mass production after the Second World War. Since the institutional and social changes associated with this technological revolution are still unfolding, and are at a relatively early stage of development, it is not yet possible to describe the nature of the change. The fragile and unstable nature of the economy brought about by ongoing changes such as capital-market inflation, privatisation, and changes in stock-market ownership does not make forecasting easier. One thing seems clear, however. The new economy is based on the continuous production of innovations.

One of the most dynamic fields in organizational and institutional innovation is the financial market. The competition is ferocious: it is necessary to capture the savings in all their forms by multiplying new bank products, rearranging the systems of alliances and redefining the shape of the service. The capital market inflation is at the very centre of this drive for innovation, as it is both its cause and its consequence. Innovation requires more innovation, and the inflationary process requires more funds, and consequently further changes. (Freeman & Louçã, 2001, p. 302)

Freeman and Louçã argue, in their "reasoned economic history", that successive technological revolutions have caused dramatic changes in the economy and in the whole of society. Technological inventions play a crucial role in these transformations, but they also involve issues of social capability based on institutions that facilitate the international diffusion of technological knowledge and its national application.

Freeman and Louçã base their theory on Nikolai Kondratiev's observations concerning long waves of economic growth. They see these waves as a phenomenon typical of the capitalist mode of production with its upswing and downswing phases. They introduce new content to the study of long waves by analyzing the degree of "match" between the techno-economic and the socio-organizational elements of the economy: a good match explains the upswings and increasing mismatch the downswings.

Technological innovations hold center stage in the long waves of economic development. Nevertheless they are not isolated events, but are always and necessarily related to the availability of material, energy, components, skills, and infrastructure. The development of particular innovations is important, but the decisive factor in terms of economic development is the clustering of complementary innovations. Economic growth is driven by different clusters of technologies in different eras, and different institutional structures are needed to exploit and support these technologies.

The relationship between science and technology is an interactive one and new constellations of innovations depend on advances in both. Freeman and Louçã show how these new constellations of technology and social institutions emerge, spread and ultimately come to dominate society for a few decades before, after a period of several decades of great turbulence, giving way to a new constellation. They analyse the processes of technological, structural, and social change that give rise to long waves of economic development.

In each long wave, a set of innovations makes one or a few *core inputs* (iron, coal, steel, oil, electronic chips) into the economy, such as the cheap and universally available resources that give rise to a vast array of new combinations of production factors. The new innovations and branches of production arising from the core input become the major industries in each economic wave.

The new products utilizing these core inputs and some complementary inputs stimulate the rise of other new industries that become the ones to carry the growth in the upswing. The rapid growth and great market potential of "the carrier industries", provide a major impetus to the growth of the entire economy. The *carrier branches* of the five long waves were the cotton textile industry, the production of steam engines, railways, the production of electrical products, the automobile industry, and computer-software production. (Freeman & Louçã, 2001, p. 147)

A *new infrastructure* (from canals to information highways) has to be built to serve the needs of the new industries, and this stimulates and facilitates further the rapid growth of both the carrier branch and the major industry. Other branches of the economy (induced branches) are compelled to follow in the wake of the leading sectors, which included service stations, repair shops, garages and distributors in the case of automobiles, and later the development of mass tourism and "fast food" restaurants.

The structural transformation arising from these new industries, services, products and technologies is associated with a combination of organizational innovations and transformations in the social institutions that design, use, produce, and distribute them. New principles and rules for managing and organizing production using the new technology will gradually emerge and become the self-evident "common sense" of management. Freeman and Louçã (2001, p. 147)

call this new approach to management and organization a "*new techno-economic paradigm*". Once it has emerged and has demonstrated its effectiveness, it has a wider influence on society, affecting government and the general culture as well as business firms. The same new principles may also prove effective in the old industries. For example, mass and flow production techniques developed in the automobile and oil industries could also be applied in the food and the catering industry. Computer systems are used in practically all industries and services.

The technological revolutions, periods of upswing and downswing, and the major institutional changes in the five long waves of economic growth are presented in Table 3.1.

Table 3.1 A summary of the technological revolutions and the long waves of economic growth (Freeman & Louçã, 2001, p. 141)

Constellation of technical & organizational innovations	Examples of highly visible, technically successful & profitable innovations	"Carrier" branch & other leading branches of the economy	Core input & other key inputs	Transport & communication infrastructure	Managerial & Organizational changes	Approximate timing of the upswing * downswing
1. Water-powered mechanization of industry	Arkwright's Cromford Mill (1771) Henry Cort's Puddling' process (1784)	Cotton-spinning Waterwheels Bleach	Iron Raw cotton Coal	Canals Turnpike roads Sailing ships	Factory systems Entrepreneurs Partnerships	1780–1815 * 1815–1848
2. Steam-powered mechanization of industry and transport	Liverpool - Manchester Railway Brunels "Great Western" Atlantic steamship (1838)	Railways and railway equipment Steam engines Machine tools Alkali industry	Iron Coal	Railways Telegraph Steamships	Joint stock companies Subcontracting to responsible craft workers	1848–1873 * 1873–1895
3. Electrification of industry, transport, and the home	Garnagies Bessemer steel rail plant (1875) Edison's Pearl St. New York Electric Power station (1882)	Electrical equipment Heavy Engineering Heavy chemicals Steel products	Steel Copper Metal alloys	Steel railways Steel ships Telephone	Specialized professional management systems "Taylorism" Giant firms	1895 – 1918 * 1918–1940
4. Motorization of transport, civil economy and war	Ford's Highland Park Assembly line (1913) Burton process for cracking heavy oil (1913)	Automobiles Trucks Tractors, tanks Diesel engines Aircraft Refineries	Oil Gas Synthetic materials	Radio Motorways Airports Airlines	Mass production and consumption Fordism Hierarchies	1941–1973 * 1973–1990
5. Computerization of the entire economy	IBM 1401 and 360 series (1960s) Intel microprocessor (1972)	Computers Software Telecommunications equipment Biotechnology	Micro chip (integrated circuits)	Information Highways (Internet)	Networks; internal local, and global	1990–

Such a widespread process of structural and organizational change could hardly take place in a smooth and gradual way. The new techno-economic-paradigm is not easily accepted universally despite its evident superiority and profitability in many applications: the strong vested interests associated with the previous dominant paradigm, and the *regulatory regime* and the cultural norms associated with the institutions involved, are inhibitory factors.

Thus the downswing of the long wave is a period of great turbulence characterized by the rapid growth and high profitability of some new firms and industries, together, with slowing growth, declining trends and stagnation in others, and by political conflict over the appropriate regulatory regime. Monetary disorder, relatively high levels of unemployment, and tariff disputes are typical of these transitional periods of structural adjustment. The mismatch between the old institutional framework and the new constellation of technologies is resolved in various ways in different countries and different industries (*ibid.*, p. 148). The growth in new constellations may also be constrained in various ways by the old institutional and social framework, which is more resistant to change than the technology itself (*ibid.*, 2001, p. 151).

Freeman and Louçã show how rapid growth in the major industries that produces the "core inputs", and how the "*carrier branches*" act as exemplars for an entire historical period. They considered the emergence of new core inputs, major industries, and carrier branches recurrent phenomena, but the ways in which they affect society are unique. They emphasize the fact that every techno-economic paradigm leads to a specific way of managing and organizing production.

It seems fairly obvious that the diffusion of the constellation of major technical and organizational innovations through the economic and social system must cause profound changes in the structure as well as in the occupation and skill profiles and management systems. Moreover, precisely because each constellation is unique they will have very different effects in each technological revolution. (Freeman & Louçã, 2001, p. 338)

They also highlight the essential role of learning in economic growth: because the mechanisms of economic growth during each Kondratiev wave are unique, every technical revolution also creates historically unique challenges and opportunities for learning (*ibid.*, 2001, p. 338).

What have been changing are the ways of learning and accumulating knowledge and passing it on, interacting with changing ways of organizing production, and regulating economic activities and social behaviour. Learning by doing, even if it was once mainly learning by gathering and eating, has always

been with us. Learning by producing and using have been with us since the early use of tools of various kinds. Learning by interacting has always been with us. These are persistent human activities across all the civilizations. *What have changed are the modes of learning, and the ways in which different modes of learning interact with each other.* (Freeman & Louçã, 2001, p. 132, italics JP)

In the two following sections I will describe in more detail the technological revolutions and the qualitative transformation of the "techno-economic paradigms" of industrial production.

The paradigm change from water-powered mechanization to mass production

The innovations that created the first and second long waves of economic growth took place in Britain, and since then the new waves have started in the United States. The first constellation of technical and organizational innovation was based on the water-powered mechanization of industry. Iron and raw cotton were the core inputs of this wave. Cotton spinning with the new Jenny machine and many other innovations were supported by the building of canals and turnpike roads. New entrepreneurs from very different backgrounds, with Arkwright at the head of them, combined the innovations of the time by installing machinery in purpose-built premises. Similar constructions, called factories, spread in a short time all over Britain. The use of new innovations such as the waterwheel was demonstrated in technological experiments, and some scientific articles were written about those that were tried out in the factories. From the beginning of the first Kondratiev wave, called the First Industrial Revolution, entrepreneurs planned ideal factories together with scientists. The workers in the factories also played a key role in making innovations in cotton production.

Iron and coal were the core inputs of the second Kondratiev wave. Railways became a carrier branch in the steam-powered mechanization of industry. Trains and steam-powered ships began to replace the previous transport and communications structure. Railway companies were the first large companies ever.¹¹ The management systems that were developed during that time, which focused specifically on punctuality, functional specialization and hierarchies, were important in the next wave when huge organizations emerged in other industries too. As entrepreneurs increasingly used machines in their plants, the specific skills required to operate them also increased. The solution that management most commonly

¹¹ In Britain the explosion in the public use of railways even surprised the entrepreneurs.

adopted was to delegate the responsibility for managing production to skilled craft workers or foremen, often in the form of a subcontract for a group of workers and machines.¹²

The third long wave, from 1895 to 1940, was based on the electrification of industry and transport. Steel and copper were important raw materials in the manufacture of electrical products such as batteries, electric motors, generators, multi-core cables, illumination for public buildings, arc lights for streets, and telephones. The spread of telephones and typewriters began the process of office mechanization, characteristic of the development of bureaucracy in large firms. Electricity and chemistry were areas in which scientific research began to be directly and intimately related to industrial development. Machines for producing machines and heavy engineering also began to feature in the economy of that age.

In the two earlier waves, the average factory workforce consisted, on average, of about one hundred skilled machine operators. During the third wave, the factories became giants.¹³ The rise in fixed costs, associated with increasing capital intensity, put pressure on companies to sustain or improve profitability by using the physical capacity of their workers more fully and controlling the flow of materials and components. The management models of the industrial giants derived almost entirely from the railways – the carrier branch of the previous wave.¹⁴ By introducing the scientific management method to a growing class of professional managers, Frederic Taylor provided the rationale for a whole set of organizational innovations and new management institutions. The main organizational innovation of the third Kondratiev wave was the new management bureaucracy that was based on professionalization and specialization, which replaced the previous contract-based system.

¹² This devolution went so far in some English firms that the skilled workers identified with management to a considerable extent, and it was not unknown for some to arrive at work wearing top hats. Although this solution worked fairly well in many industries for many decades, it came under increasing strain towards the end of the century (Freeman & Louçã 2001, p. 215).

¹³ For example Krupp's factories employed 100 workers in 1848, 1,000 by 1857 and 8,000 in 1868.

¹⁴ Carnegie, an architect and manager of a giant firm, had previously worked for the railways. He introduced rigorous statistical cost systems, which were one of the earliest and most significant achievements of the new management style: cost sheets were his primary instruments of control and costs were his obsession. "Watch the costs and the profits will take care of themselves." He had very detailed cost data, which were used to control departments and foremen and to check the quality and mix of raw materials. They were also used to make improvements in processes and products, so that technical advance and cost cutting moved together hand in hand. Carnegie was a millionaire by 1880. Freeman & Louca's point is that economies of scale, technical and organizational innovation, productivity, and profitability were all interdependent.

The upswing of the third Kondratiev wave was followed by an especially hard and long crisis of structural adjustment in the downswing from 1918 to 1940, which was a period between two world wars. However, these international conflicts and sharp political struggles within countries were closely intertwined with the rise of new technologies based on oil which became the core input of the new techno-economic paradigm: mass production. The products of its carrier branches were automobiles, tanks, and aircraft.¹⁵

According to Freeman and Louçã, the downswing of a long wave is not just a period of slower growth in aggregate production, but also one of structural adjustment and the rise of a new constellation of technologies. The production of oil, aircraft and tanks, as well as of automobile and consumer durables, increased very rapidly during the downswing. The rise of the automobile industry in the United States aggravated still further the uneven development of the world economy as well as the internal structural problems within the United States.

The fourth Kondratiev wave was based mainly on the automobile industry as the carrier branch, and the oil industry as the producer of the core input. The period began back in the 1920s and 1930s, but high growth was possible only after the Second World War as the new social institutions that supported the use and spreading of the new technology were created. The most important new institutions were limited companies, and hire-purchase and unemployment-insurance organizations.

The availability of cheap and abundant petroleum made the motorization of the world economy possible in the twentieth century. Originally, the oil industry was developed first and foremost as a source of kerosene for lighting and heavy fuel oil for heating. A series of inventions and innovations were needed before gasoline could be separated in sufficiently large quantities of good enough quality and at low enough cost to provide it on the scale needed for the mass use of automobiles. In a hundred years, from 1860 to 1960, oil production rose from three million barrels to 7.7 billion barrels per year, and the price fell to very low levels.

The first internal combustion engines were developed in France and Germany in the 1860s and 1870s. After many trial inventions, the first truly mass-produced automobiles were developed by Henry Ford in Highland Park in Detroit between 1908-1914. Ford took advantage of Frederic Taylor's ideas but developed the doctrine further: discipline was strict in his factory and unions were banned.

¹⁵ The authors note that the Second World War was the first motorized war, with panzer divisions forming motorized infantry divisions: the decisive battle, in which the tanks were used, took place in Kursk in 1943.

The introduction of the moving assembly line in manufacturing the T-model Ford in 1913 was a culminating point in the development of the new techno-economic paradigm, mass production. It was only possible as a combination of the new inventions that Ford introduced: machines and presses that could cut, shape or stamp out each one of the components. Freeman and Louca quote Womack, Jones & Roos (1990), explicating how the new method changed the work on the shop floor radically.

The assembler on Ford's mass production line had only one task - to put two nuts on two bolts or perhaps to attach one wheel to each car. He didn't order parts, procure his tools, repair his equipment, inspect for quality, or even understand what the workers on either side of him were doing. Rather he kept his head down and thought about other things. The fact that he might not even speak the same language as his fellow assembler or foremen was irrelevant... the assembler required only a few minutes training. (Womack, Jones & Roos, 1990, p. 31)

It was inevitable in Ford's system that some of the produced parts were defective. A typical solution was not to improve the skills or add to the responsibilities of the production-line workers, but to have an inspection and "re-work" department at the end of the line.

The United States was the technological leader in the cluster of innovations that predominated in the fourth Kondratiev wave. It completely took over the world automobile industry in the 1920s.

The Model T was truly designed as a car for the masses. The reduction of the price of the car was an essential part of Ford's doctrine, contrary to other manufacturers who, according to Freeman and Louçã, sold their products at the highest prices in their respective industries. Ford's doctrine emphasized mass *consumption* to counterbalance mass production. The car was deliberately designed for ease of maintenance and ease of operation. It was very robust and could be used on rough roads. Ford assumed that many of his early customers would be farmers, with experience of farm machinery and some tools to hand (Freeman & Louçã, 2001, p. 276).

By 1935, over half of all American families owned an automobile and by 1989, 84 percent did so. Each wave of technical change had widened the range of consumer goods. The spreading of products changed consumer behavior radically. The increase in the purchasing power of a large number of people was greater than in any of the previous Kondratiev waves. The golden age of growth in the quarter century after the Second World War saw the biggest increase in GDP and in per capita consumption ever recorded.

The immense success of the mass-production paradigm made other American firms introduce the assembly line and many American-mass production plants were established in Europe in the post-war years. The Europeans were not merely imitators of American technology and management, however, they were also innovators. Mass services grew rapidly in most European countries, and later in Japan, in the long boom after the Second World War.

Technical innovations in the automobile industry were accompanied by organizational and managerial changes. The Taylorist-Fordist model dominated management for more than half a century, and it was only late in the twentieth century that this doctrine began to give way to a new style of management thinking and new forms of organization.

The automobile industry as the carrier branch of the economic growth with its major industry, infrastructure, and induced branches¹⁶ constituted a huge proportion of the total national output of the leading industrial countries by the 1960s, perhaps as much as a third of all production. Yet these industries and services barely existed before 1900. They represented a fundamental structural as well as technological revolution, and massive cultural change (Freeman & Louçã, 2001, p. 298). The shock of the 1973 oil crisis was all the greater when the very survival of this mass-production regime appeared to be threatened by the loss of its core input – oil. The rise in oil prices in the 1970s threatened the dominance of the United States in the world market. The main reason was not the blossoming of the European economy, but the meteoric rise of Japan's industry.

For half a century American and European producers had simply accepted defects and rejects as an inevitable cost of mass production, which they believed was greatly outweighed by the benefits of a vast output of cheap and fairly efficient machines. One of the main objectives of the Japanese producers who challenged the Fordist system after the Second World War was to make a drastic reduction in the number of defective parts or subsystems.

Freeman and Louçã point out that the main reason for that was the Japanese principle of "reverse engineering", which practically affected the R & D strategies of the major Japanese companies. Japanese management engineers and workers grew accustomed to thinking of the entire production process as a system, and of thinking in an integrated way about product and process design. This capability to redesign an entire production system has been identified as one of the major

¹⁶ These include the diesel engine and tractor industries, the aircraft industry and airlines, and all their component suppliers, the oil, petrochemical and synthetic to material industries, the highway and airport infrastructures with the supporting repair maintenance, and mass-distribution services.

sources of Japanese competitive success in industries as diverse as shipbuilding, automobiles, and colour television.

By 1989 Japan was producing more cars than the United States. The American producers were successful in imitating some key features of the Japanese producers and by the late 1990s the US industry had regained world leadership. Japanese firms also invested in their own plants in North America.

Mass-production principles were questioned in many ways during the down-swing period of the fourth wave in 1970-1990. The increasing number of strikes in the late 1960s was partly motivated by dissatisfaction with the form of work relations and the management style of mass production. The system was no longer the key to high economic growth. In the circumstances of low growth, mass unemployment and structural unemployment increased.

Some writers in the late 1970s also maintained that growth had slowed down because science and technology had reached their limits as a productional force, and their contribution to production would begin to decrease. This was not the case, however. Growth was not limited by technology. On the contrary, there was a growing need to change the limits that the institutional and social framework of the specific technological regime of mass production was placing on growth based on emerging new technologies. Scientists and technologists saw unlimited horizons, and promising innovations were developed in bio-technology, information technology and materials technology. The new paradigm of the age of information and communications technology was emerging.

Towards the computerization of the economy

The institutional and social changes associated with the ICT revolution, according to Freeman and Louçã, are at present at a relatively early stage of development. The carrier branches of this age are "obviously" computer and software industries, supported by telecommunications and the Internet.

The new ICT-based products represent a technically reliable and economically efficient mode of growth on a large scale, and this new technological constellation could take over as the chief engine of economic growth. The most influential of these new developments was the advent of the computer and the Internet. The stock of personal computers reached over 100 million in 1997 in the US, over 50 million in Europe, and 25 million in Japan. This scale of diffusion was only possible because of the huge price fall and improvements in design, performance and user-friendliness.

The core input of the new long wave came from microelectronics: chips. The manufacture of semi-conductors is a very complicated and difficult process requiring more than a hundred different steps of coating, baking and etching.

These steps are not well-understood and easily replicated on different equipment or in different facilities, and they impose demanding requirements for a particle free manufacturing environment. Product innovation depends on process innovation to a much greater extent than is true of automobiles... New equipment, with operating characteristics that are not well understood, is needed in order to manufacture a new product. The complexity of the manufacturing process also means that isolating and identifying the causes of the yield failures requires considerable time and effort. (Appleyard et al., 1996 p.5; Freeman and Louçã, 2001, p. 309)

The universal availability of computers as the carrier branch of the new techno-economic ICT paradigm, the introduction of local area networks, and rapid changes in product and process design eroded the old mass-production paradigm. Because of rapid and easy access to information, some layers of management became unnecessary and top-heavy. The new style of management became widespread and contrasted with the Fordist style in many respects. C. Perez outlined the elements of organizational change from mass production to ICT as follows (see Table 3.2).

Table 3.2 Changes in the techno-economic paradigm (Perez 1989; Freeman and Louçã, 2001, p. 325)

Fordist	ICT
Energy-intensive	Information-intensive
Design and engineering in drawing offices	Computer-aided designs
Sequential design and production	Concurrent engineering
Standardized	Customized
Rather stable product mix	Rapid changes
Dedicated plant and equipment	Flexible production systems
Automation	Systematisation
Single firm	Networks
Hierarchical structures	Flat horizontal structures
Departmental	Integrated
Product with service	Service with products
Centralization	Distributed intelligence
Specialized skills	Multiskilling
Government control and sometimes ownership	Government information, coordination and regulation
Planning	Vision

The contribution of Freeman and Louçã's theory to the understanding of the change in learning in and for production

Freeman and Louçã's theory strongly supports the thesis that learning in and for production changes historically. According to the theory we are currently witnessing

the transition from mass production to the "IT-based network economy". Although the transformation has not yet reached its mature phase, the emerging new paradigm has already led to changes in the forms of learning in and for production.

The theory suggests that the development of work includes both stable periods of established techno-economic paradigm and periods of qualitative transformation. The transformation from one paradigm to another goes through crises and takes a long time. We could assume that each techno-economic paradigm also comprises specific structures and dynamics of learning in and for production that correspond with the challenges set by the new constellation of technology and the new institutional forms.

Freeman and Louçã maintain that the institutions of the old paradigms do not completely disappear when new "carrier branch" emerges in the economy. This implies that different institutional forms of learning in and for production may prevail at the same time in working life.

However the theory does not provide concepts for analysing forms of learning in and for production in detail: the authors describe the various forms of learning during each Kondratiev wave and during the crises between them in general terms. Nevertheless it serves very well as a general background for understanding and analyzing the changes in the institutional structures and dynamics of learning in and for production.

3.3 Paul Adler's analysis of the historical evolution of management doctrines

The well-known organizational scientist Paul Adler reviewed the development of management doctrines and incorporated into a single narrative several contradictory but partially valid views of the long-term evolution of work organizations in the 20th century. He argues that the story has followed a zig-zag path between on one hand an emphasis on control on the one hand and on worker commitment to more collaborative interdependence on the other (see Figure 3.1). His analysis focuses on the United States and shows how the proponents of control and commitment tried to combine these opposing needs of management during the last century. He bases the periodization in his analysis on Kondratiev's theory of long waves.¹⁷

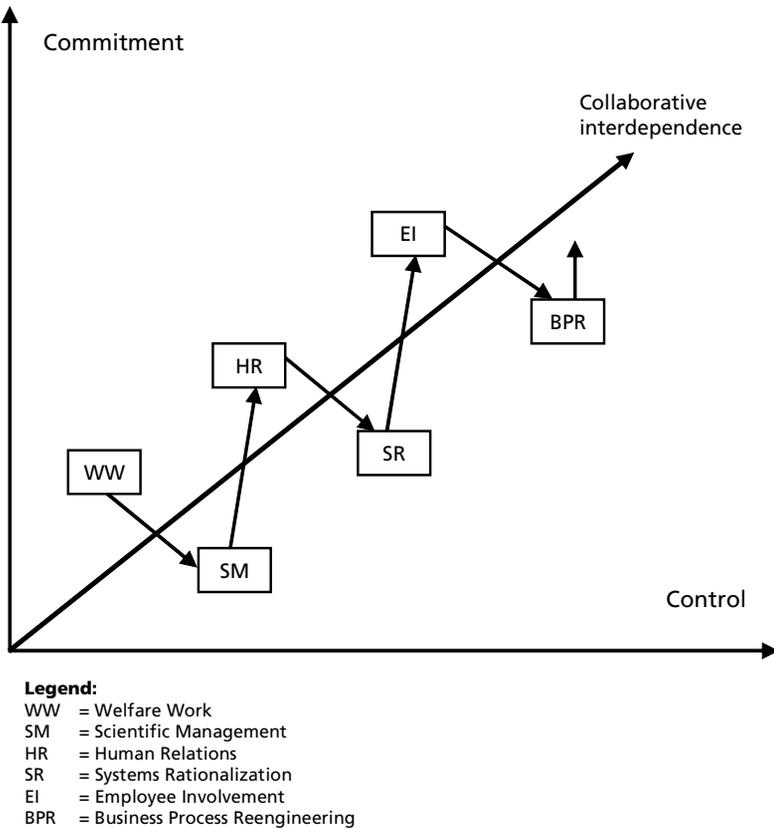


Figure 3.1 A trend toward collaborative interdependence (Adler 2001)

¹⁷ The general idea of Process Mapping, a tool used in both scientific management and STS was brought into non-routine operations in forms such as IDEF, CMM, ISO 9000, and clinical guidelines in medicine.

The United States was "catching up" Britain's technological lead in the downswing of 1873–1895 that Freeman and Louçã called the "steam powered mechanization of industry and transport". According to Adler, the first set of managerial innovations – *welfare work* – emerged during this period. Welfare work did not touch work organization directly, but rather aimed at shaping values, building basic skills, and improving physical health, and thereby promoting loyalty.

It used company schools, employee magazines, company churches, company cafeterias. While some of the specific practices of early welfare work subsequently disappeared, many others persisted and were developed further by the human relations. (Adler, 2001, p.12)

The upswing of the third wave in 1895–1918 that was based on the electrification of industry and transport gave rise to *Scientific Management* – a family of innovations designed to systematize management from the shop floor to the executive suite. It introduced techniques of production planning, work analysis, time standards, and piece rates. Using call centers as an example, Adler points out that similar work-study practices also prevailed fifty years later.

The deep depression that marked the age of the electrification downswing in 1918-1940 witnessed the emergence of the *Human Relations* school of thought.

It sought to broaden the role of the Personnel function and to infuse concern for employee commitment into the fabric of daily work. The associated innovations included ability testing for selecting employees, individual performance records, employee satisfaction surveys, coaching in supervisory skills, and the non-union employee representation plans. (Adler, 2001, p.13)

Instead of opposing each other, the proponents of Human Relations and of Scientific Management often joined forces in the design of formalized personnel-management systems. Gilbreth, among others, tried to construct a synthesis of Taylorism and Human Relations, with a focus on "active worker involvement" in scientifically grounded quality-improvement efforts.

Systems rationalization appeared at the beginning of the upswing of the "motorization age". It encompassed efforts to rationalize relatively non-routine activities through the introduction of formalized R&D budgeting and project-management approaches and the use of matrix structures. It combined operations research, management science, and strategic business units as a common corporate structure. It further refined business planning and built control systems on the basis of the Scientific Management legacy.

The beginning of the downswing of the "motorization wave", from 1973 on, witnessed a resurgence of interest in commitment in the form of *Employee In-*

volvement (EI), as expressed in the themes of quality, culture, and empowerment. This wave has often been positioned in opposition to the tradition of Scientific Management.

Socio-Technical Systems theory (STS), a common reference point, popularized the idea that the human costs of excessively standardized and fragmented work would eventually lead to losses in productivity and quality – and that this would occur not only in non-routine tasks, but even in routine work. Proponents advocated the adoption of forms of organization that would give work groups and individuals far greater autonomy in determining work methods and far less specialization in their job assignments (Adler 2001, p.14)

The general idea of *Process Mapping*, a tool used in both scientific management and STS was brought into non-routine operations in forms such as IDEF, CMM, ISO 9000, and clinical guidelines in medicine.

According to Adler, the emerging new Kondratiev upswing connected to the "computerization of the entire economy", which started in 1990, has seen the resurgence of control-oriented innovations, primarily under the banner of *Business Process Reengineering, outsourcing, and networks*.

The focus here was on radically rationalizing the scope and processes of work: downsize so as to focus on core competencies, and outsource the rest. A first phase of this cycle seemed deliberately scornful of the human dimension. Lay-offs and downsizing cuts were trumpeted as signs of reinvigorated management recommitment to shareholder value. (Adler, 2001, p.15)

Adler notes that BPR champions embraced STS ideas on how to configure jobs in the reengineered organization. In his view, Business Process Reengineering could be seen as a control-oriented doctrine. It consists of process analysis, the purpose of which is to eliminate parts of the production line (Hammer & Champy, 1993; Khoong, 1999). Knowledge Management is the latest management doctrine (Nonaka & Takeuchi, 1995; Brown & Duguid, 1992; Leonard-Barton, 1995). It focuses on the collective competences needed in knowledge-intensive production. The literature on knowledge management also comprises both Systems Rationalizing, which focuses on IT infrastructure, and a commitment focus on "Communities of Practice." It is clear that the new management doctrines also actively use new theories of organizational learning.

Following in the footsteps of Barley and Kunda (1992), Adler characterizes commitment-oriented doctrines as normative, and control-oriented doctrines as rational. He suggests that hidden behind the zig-zag movement is the trend towards

increased collaborative interdependence. The sequences of normative approaches have implied a shift from traditional blind trust to a more modern reflective form of trust. One specific consequence of this development is that control-oriented innovations have become increasingly hospitable to commitment-oriented variants. Proponents of the Business Process Reengineering approaches learned to soften their rhetoric's over a few years, a process that took scientific management nearly two decades.

The management doctrines that highlighted worker commitment, or soft management, seemed to emerge and spread during the down-swing periods, while the "hard" and control-oriented doctrines gained ground during the upswings. This notion contradicts fairly common interpretations according to which soft managerial methods become common during favorable economic periods because employers have more resources to invest in their personnel and its development (Julkunen, 1987). One possible explanation is that the control-oriented new doctrines were created to meet the new challenges and needs posed by the expansion of work activities during the upswing, while managers had to concentrate on making the best of the existing organization during the down-swing periods.

Adler makes another important observation. Management doctrines are not purely control-centered or commitment-centered, but have elements of both. The more recent a control doctrine is, the more quickly it has been complemented with the commitment doctrine. The emergence and spreading of new management doctrines do not necessarily directly change the practices of production, but they do reveal the contradictions managers have to deal with.

From the perspective of learning in and for production, Adler's analysis is important in that it shows that, regardless of whether the management doctrines of the last century were integrated or diametrically opposed, they nevertheless reflected new needs in the management of production. Management systems and types of shop-floor production are mutually interdependent. Managers and workers both contribute to the development of forms of learning in and for production. Doctrines emphasizing control ascribe the principal agency of learning to managers and designers, while those emphasizing commitment also ascribe agency to workers. New management doctrines such as Business Process Reengineering, Knowledge Management and Communities of Practice all emphasize the utilization of information and knowledge as prerequisites of collective learning.

Adler's analysis provides particular insights into the changes in management doctrines that took place during the motorization wave. A comparison of the evolution of these doctrines and the structural changes identified by Freeman and Louçã (Table 3.3) reveals a two-to-three-year cultural lag in the former.

Table 3.3 A comparison of the evolution of management doctrines as reported by Adler and by Freeman and Louçã¹⁸

Constellation of technical & organizational innovations	Management doctrines (Adler)	Managerial & organizational changes (Feeman and Louçã)	Kondratiev wave
1. Water-powered mechanization of industry		Factory systems Entrepreneurs Partnerships	1780–1815 Upswing *
			1815–1848 Downswing
2. Steam-powered mechanization of industry and transport	1872–1894 Welfare work.	Joint stock companies Subcontracting to responsible craft workers	1848–1873 Upswing *
			1873–1895 Downswing
3. Electrification of industry, transport, and the home	1895–1920 scientific management	Specialized professional management systems "Taylorism"	1895–1918 Upswing *
	1921–1944 human relations	Giant firms	1918–1940 Downswing
4. Motorization of transport, civil economy and war	System rationalization 1944–1977	Mass production and consumption Fordism, Hierarchies	1941–1973b Upswing *
	77– Employee involvement	Lean production; TQM	1973–1990 Downswing
5. Computerization of the entire economy	1990 Business-process reengineering, Outsourcing, Networks, Knowledge Management Communities of practices	Internal, local, and global Networks	1990– Upswing

¹⁸ The beginning and end of the periods deviate by two years from those used by Freeman and Louçã. I use Freeman and Louçã's periodization in the following.

3.4 Victor and Boynton's developmental model of work types

Bart Victor and Andrew Boynton claim that, in order for a company to maximize internal growth and profitability, it has to learn to develop its production along "the right path". The right path is a general sequence of historical types of work from craft to mass customization. In order to provide the kind of value the changing markets demand, companies have to completely transform their production from time to time. They have to learn new work organizations, new processes, new types of knowledge, new kinds of manager worker-relations, and new kinds of information systems. These elements are qualitatively different in each work type: craftwork, mass production, process-enhancement work, and mass customization. The following describes Victor and Boynton's model of work types and the necessary transformations.

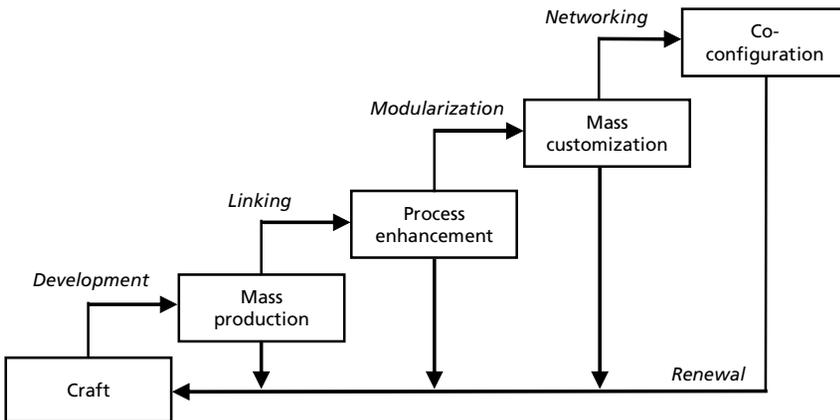


Figure 3.2 The right path transformations (Victor & Boynton, 1998, p. 233)

Thus, each type of work has its own strength in creating a special kind of market value.

Craft is strong in inventing and creating high-priced novel products that make *strong, unique* impressions on customers. Mass production is strong in discipline and in achieving value through predictable, standard, "no-surprise," *low-price commodities*. Process enhancement is strong in thinking and doing products that customers perceive as having superior *quality*. Mass customization is strong in modular configuration and can dominate a market with *precision*, providing made-to-order; affordable, tailored products and services. (Victor & Boynton, 1998, p. 7)

Each historically evolved type of work is also related to the preceding and the following types in a specific and predetermined way.

Mass production cannot be reached but through some form of craftwork; process enhancement is impossible without the company's first having made some effort at learning from mass production; Mass customization is unfeasible without the learning from process enhancement. We think of the four work capabilities as four destinations on a map, because there is a single path of learning between them; that is why we call it the right path. (ibid., 1998, p.7)

A specific kind of knowledge is required in managing each of the four types of work. Learning is needed for managing the type of work, and also in the transformation from one type to another. The "additional learning" that is not used in any particular form of work produces part of the knowledge that is the foundation of the next type.

One type of knowledge is the foundation of each of the four types of work. This foundation knowledge has to be managed for a firm to excel, be it craftwork, mass production, process enhancement or mass customisation. Under each type of work, learning occurs and a by-product of work is generated: additional learning and knowledge, the key ingredients for firms taking the right path. (ibid., 1998, p. 9)

Craftwork consists of independent work performance that is decentralized to specialized groups or individuals. The craft organization that focuses on product novelty is fluid, adaptable, loosely coupled, and organic. Its highly informal nature is also reflected in the relationships between managers and workers. Managers also work and workers also have managerial tasks. The roles of workers and managers are undefined and often ambiguous.

Craftwork is based on tacit knowledge that is transferred to the other workers through on-the-job-apprenticeship. The learning and experience that the workers acquire also allow them to describe the details of how they do the work. This type of description covers the steps or processes of how the products are made or the services are delivered. The resulting *articulated knowledge* can be used to instigate the mass production of the former craft products or services. With the help of engineers' know-how, managers can then identify and codify the articulated knowledge gained in the craft into machines or standard procedures, and rapidly transfer it to all workers to be used repeatedly. Victor and Boynton call the activities underlying the codification of articulated knowledge *development*.

Using tools such as time and motion studies, process engineering, and automation, development captures the best approaches discovered in craft and applies

them across the company. Development instills discipline through processes, procedures, or automation so that work can be replicated anywhere, at any time, in any amount. Repeatable tasks, hierarchical control systems, functional structures, standardized routines and processes automation, and division of labor characterize mass production. (ibid., 1998, p. 126)

The process of manufacturing standard commodities in mass production is linear and centrally controlled. The worker's task is to do the specialized job that is planned by the management. The organization is bureaucratic, hierarchical and based on functional specialization. While knowledge is located "in the heads" of the workers in craftwork, articulated knowledge is located in the "firm's head", in documents and standard procedures.

When following the standards the workers also learn about the work through observation, sensing, and feeling. They learn where the standards are effective and where they are not. This learning leads to *practical knowledge*, which accumulates from doing a job over and over again. *Linking* leverages practical knowledge and creates a new type of work that Victor and Boynton call "process enhancement work", also called "lean production". It involves eliminating the gaps that remain after a company has developed its work processes under mass production.

Linking creates a system of overlapping processes that managers can continuously improve. The tools used in linking include process documentation and mapping, team building, customer satisfaction measurement systems, process improvement tools, and techniques such as quality function deployment and brainstorming. (ibid., pp. 126–127)

Process-enhancement work is based on a horizontal team organization. The workers are task-oriented and managers come down to the shop floor as their coaches. Together they are creative team players who make sure that every process contributes to satisfying the customer by achieving consistently higher quality. The workers are equipped with the tools and techniques to apply their practical knowledge in improving the tasks and processes. They conduct experiments, analyze the causes and effects of process changes, and evaluate the value added by a change in procedures. They can continuously use and modify their practical knowledge, which is located in a dynamic network of workers – no longer in the head of the firm.

Practical knowledge allows the organization to identify weaknesses and fix them, to respond to slight changes in product requirements quickly, and to identify new sources of customers. Although the work is highly specified and routine, workers define the routines themselves. Victor and Boynton found in their study that employees had to use the new skill of *role switching* in order to use their practical knowledge for process enhancement.

In switching, employees go back and forth between standardized production and creative process enhancement. At one moment, the employee focuses on doing the work, such as assembling a car door or responding to a customer service call, and then switches to thinking about how to do the work better. This switching occurs over and over, and the information cues, incentive and reward systems, and structure encourage workers to do, then think, do, then think – to achieve efficiency and create ideas on improving the work itself. (ibid., p.79)

As process enhancers modify, adjust, add, and subtract activities, technology, and inputs, employees learn what happens in the process. The additional learning that results comprises a deep understanding of the complex interactions and interdependences of the production processes. Victor and Boynton (p. 88) call this knowledge *architectural knowledge*. It enables transformation to the next type of work, mass customization.

Mass customization is based on product modularization. It transforms work by creating a network of modular processes that can respond to market demands, enabling a company to customize a product or service to meet ever-shifting market needs. It thus creates a dynamic network of robust units.

With modularization, a firm separates the overlapping work capabilities developed under process enhancement and forms them into a dynamic network of modular units. The firm can then configure and reconfigure the units to respond quickly to market change. This can be done only after architectural knowledge is developed under process enhancement. Modularization captures that learning as part of the transformation path to mass customization. (ibid., 1998, p. 127)

Mass customization is based on market demand when customers seek products or services that not only offer quality, but also meet precisely their specific needs at little or no additional cost. Victor and Boynton call this *precision* demand. The firm has to be efficient and fast and its products low-priced and customized, all at the same time. Firms employing a precision strategy compete in meeting unique customer or market-niche requirements.

The mass-customization firm has to understand not only how its processes work in sequence, but also how to combine, recombine and reconfigure and reorder them to create new processes for making customized, personalized products. It cannot succeed without a highly responsive dynamic network organization that can modularize linkages integrated for customers. The managers are traffic cops and the workers engage in hubs of a complex web of activities. These organizations use architectural knowledge for continuously rearranging the networks.

Mass customization demands that the product and process are well known inside-out. Without a deep understanding of the product, the firm cannot know which variations create value for the customer and which are simply a source of expense and difficulty. Firms that fail to develop new capabilities that better address customer requirements will run into trouble. If they reach this point they may choose to follow a process that Victor and Boynton call *renewal*, which offers a way back to innovation and creativity. It brings new insights in terms of the firm's capability and limits, using them to direct the process of invention. New capabilities develop from new ideas generated in the ongoing work that involves meeting changing market expectations.

According to Victor and Boynton (*ibid.*, p. 93), mass customization is a new developing kind of work: "The twenty-first century may be the mass customization century, but it is only at the beginning".

The authors suggest that, through additional learning mass customization generates still another type of knowledge that can lead beyond it. The challenges involved promote truly systemic understanding of the dynamic interactions between the product, the customer, and the firm. They call this knowledge *configuration knowledge*, and it is needed to produce a product that continuously adjusts to what the customer wants. Co-configuration creates *customer-intelligent* products that adapt to the customer's needs continuously over time. As customer needs change, so does the product.

In developing customer intelligence a company will have to continuously configure its products and services in interaction with the customer. It will not make a product only once, but will constantly remake it as both the company and the customer learn. It seems that co-configuration work never ends: it is like a continuous human chain between customer, product and company. The relations within this triangle are at the same time long-lasting and unpredictable (*ibid.*, 1998, p. 204).

Victor and Boynton call the leveraging of the necessary and historically emerging configurative knowledge *integration*, by which they mean series of activities that form a nexus of the firm's knowledge of a product or a service and of a customer. They cite Microsoft as a pioneering company on the path to integration. Microsoft's organization is rather like a complex of adaptive systems or a city of forest ecosystems, the immune system, and the Internet than an organization in the traditional sense of the term.

Further they predict that customer intelligence will be the new competitive advantage of the twenty-first century. They also highlight the promise in technological innovations such as the Internet, neural networks, and artificial intelligence in terms of enabling the development of co-configurative work. They maintain that the key prerequisite of integration is the preceding phase on the "right path". Their description of this emerging type of work and integration necessarily remains on a general level given the novelty of the phenomenon and the lack of data.

Table 3.4 A condensed summary of the right-path theory; the elements of the four types of work

Type of work/ features	Craft	Mass production	Process enhancement	Mass customisation
Specific kind of value produced	Novelty	Commodity	Quality	Precision
Organization	Fluid, adaptable, loosely-coupled, organic. Highly informal.	Bureaucratic, functionally defined, hierarchical vertical integration, mechanistic. Top-down.	Team-based, horizontal. Value-chain integration; knowledge overlap; Bottom-up communication	Dynamic Network, renewable, virtual integration, cohesive. Highly responsive
Managers	Not purely managers	Thinkers	Coaches	"Traffic cops"
Workers	Not purely workers	Doers	Task-oriented	Hubs in a complex web of activities
Manager-Worker relations	Dual roles	Specialized, trained on the job	Creative team players	Independent team working
Process flow	Independent work, decentralized to specialized groups and individuals.	Serial, linear; executed to plan; centralized control, information-specialized	Intensive and reciprocal within teams	Modularized, linkages integrated into customer/product-unique value chains
Knowledge	Tacit knowledge transfer through on-the-job training.	Articulated knowledge, which resides with the firm, transferred through training	Practical knowledge flows constantly from employee to firm	Architectural knowledge for arranging dynamic networks, and flexible combinations.
Information technology	Development and distribution of customized systems	Automation of manual process to achieve cost-justified efficiency enhancement; vertical information control	Design of cross-functional information and communications systems that support micro transformations.	Integration of constantly changing network information-processing and communicating requirements; networking efficiency
The process of creating the form of work	Transferring tradition (but also renewal)	Development	Linking	Modularization

Victor and Boynton's model depicts the qualitative differences in structural elements of production such as organization, manager roles, worker roles, information technology, knowledge, and process flow in various types of work. They also

give managers and developers guidelines for carrying out the transformation from one work type to another. They show how to analyze the organization's developmental phase and how to respond to new market demands. Development, linking, modularisation, renewal, and integration are key sets of actions by which companies learn to master qualitatively different types of work.

The theory gives further insight into the historical transformation of learning in and for production, which is deemed to consist of a) learning to master a specific type of work b) "additional learning" that creates the knowledge necessary in the next type of work, and c) the learning that is necessary in the process of transforming the work from one type to another. The theory also shows that the challenges of learning as well as its forms differ qualitatively in the different types of work, as does the kind of knowledge needed and produced in them. It does not, however, create concepts for analyzing or facilitating these learning processes.

3.5 Observations on the three historically oriented theories

My conclusion in Chapter two was that theories of organizational learning do not provide concepts for understanding the historical changes in work-related learning. It could be maintained, however, that the connection between history and such theories works the other way: historical changes explain their emergence and content.

The three historically oriented theories presented in this chapter conceptualize current changes in work and learning from different points of view. Freeman and Louçã's theory of long waves concerns macro changes in the world economy and techno-economic paradigms Adler's theory of "the zig-zag movement of management doctrines" relates the transformations of management doctrines to long waves of economic growth, and Victor and Boynton's theory bridges these two perspectives by providing concepts for describing qualitative changes in production logic.

Discussion of organizational learning started at the time when the long upswing of the motorization cycle turned downwards. It has, nevertheless, been dominated by theories that emphasize commitment rather than control, and they all clearly resonate the specific managerial problems of their time. Argyris and Schön's theory contributes in addressing problems of commitment, as does Lave and Wenger's theory in seeking the solution in craft work. The theory developed by March and Olsen is applicable in the bureaucratic context of mass production, while Nonaka and Takeuchi address the specific challenges inherent in the continuous innovation of the techno-economic paradigm of the ICT-based network economy. In what follows I will summarize the ways in which historically oriented theories conceptualize and elaborate on the understanding they promote in terms of learning in and for production.

According to Freeman and Louçã, the principles and concrete manifestations of the new budding paradigm are based on corporate competition in global markets, in which financial markets have gained in importance. The entire production process is based more and more on the continuous development of innovations (Freeman & Louçã, 2001, p. 302), and their new role in business is reshaping products and production methods. Higher development costs are forcing companies to specialize. On the other hand, the use of information networks facilitates collaboration between these specialized bodies. End products are manufactured by flexibly combining the know-how and products of several organizations in so-called virtual companies (Piore & Sabel, 1984; Vikström et al., 1994; Ollus, 1998).

Information technology makes the mass customization of products and services possible. Mass products and standard services remain, but they are increasingly only components in a more comprehensive service, which may also include co-configuration between producer and customer. Innovations may lead not only to changes in the production process but also to the renewal of entire business concepts (Burgelman & Sayles, 1988). We have good reason to assume that co-configuration and mass customization are forms of work that are genuinely based on the information-technological network economy. Mass customization could be interpreted as a transitional form of work between the techno-economic paradigm of mass production and the ICT-type of network economy comprising both motorization and computerization. It is still based on the idea of the cheap mass product, but product variation is carried to the extreme. Victor and Boynton claim, however, that this is possible only with the help of computers and computer programs.

The dominating forms of work during the motorization period were mass production and the flexible production that is based on the continuous improvement of processes. Both are relatively well-established historical types of production that have already reached their mature period of development. Flexible production began to spread significantly after the oil crisis and, the fact that Japanese plants had the highest productivity numbers in the world during the down-swing of the motorization wave was challenged the mass-production paradigm. The emerging new forms of work that are gaining ground in the upswing that started in 1990 are mass customization and co-configuration.

As Adler shows, the mass-production model was already being questioned in the early 1920s by the human-relations school. One consequence of this movement was Socio-Technical Systems Design (STSD), which spread worldwide with the beginning of the down-swing in the motorization wave produced by the oil crises at the turn of the 1960s and 1970s (van Einjatten, 1993; Julkunen, 1987; Kelly, 1982). The concrete innovations that STSD brought included semi-autonomous work groups and experiments in automobile plants to remove the assembly

line entirely and replace it with parallel work stations. It has spread as a developmental method rather than as an actual type of production.

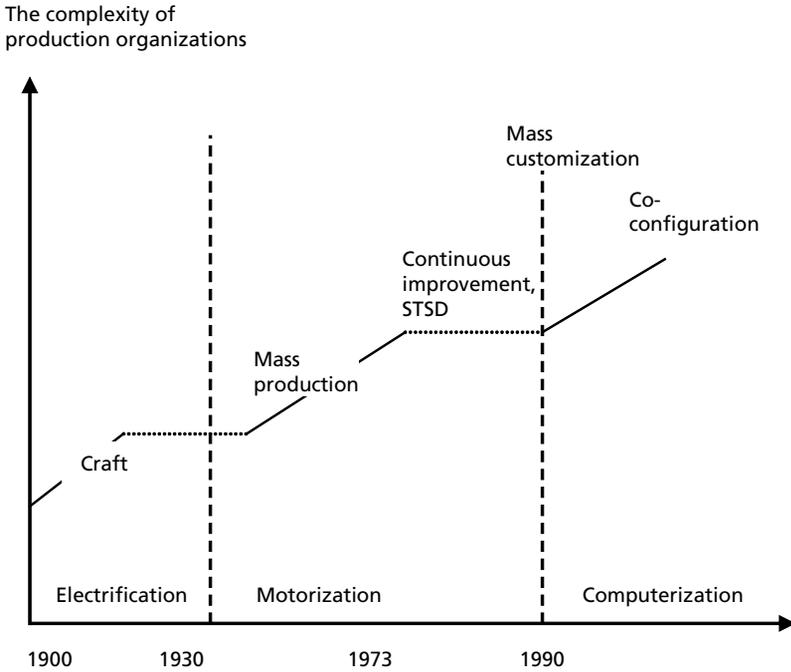


Figure 3.3 The historical background and the current transformation from motorization to computerization

The research carried out within the International Motor Vehicle Project (Womack, Jones & Roos, 1990, p. 92) on global automobile production defined mass production, lean production, and socio-technical production as the main alternatives in organizing automobile manufacture. One could say that mass production, flexible production and socio-technical production have been the main forms of production mastery during the motorization wave of economic development (Alasoini, et al., 1994; Berggren, 1990; Naschold et al., 1993, Adler & Cole, 1994; Cole, 1989). They are based on different methods of securing mastery *and also rely on different forms of learning in and for production: they thus provide the historical basis for the emerging new forms.*

According to Freeman and Louçã, processes of learning are pivotal in the economic-growth interplay between the development of social, technical and economic innovations that produce new techno-economic paradigms. Adler's analysis shows that the contradictory needs of commitment and control, and ways of meeting them, affect forms of learning in and for production. Victor and Boyn-

ton point out that specific forms of learning are necessary for mastering different types of work (foundation learning), and that the preconditions for the necessary learning for the next type of work develop within the previous type (additional learning). They characterized the different processes of learning necessary in each transformation of one specific type of work. According to their theory, learning in and for production is a cumulative process of building on and further developing existing knowledge, capabilities and structures. Individual organizations recapitulate in a condensed form the developmental phases of production logic that have marked the general historical development of forms of production.

Theories of organizational learning provide general, ahistorical explanations that, in terms of historical theories, appear to stem partly from historical phases. These generalizations seem not to be general from a historical perspective. On the other hand, historically oriented theories assume that learning changes in different phases, but do not explicate any common or general typical form of learning in and for production. This raises the methodological question of how to research the phenomenon, which I will seek to answer in the following chapter.

4 Toward historical-genetic method for studying learning in and for production

4.1 The general as a principle of development

I/we Assume that the forms and dynamics of learning remain the same through historical changes, as theories of organizational learning implicitly do, owe could concentrate on testing empirically the validity of proposed theories. However given that forms of learning in and for production develop and change qualitatively over the course of history, as seems plausible on the basis of the historically oriented theories discussed above this method does not apply because the object of study is changing. The methodological challenge of analyzing the historical transformation of learning in and for production is to provide conceptual tools for analyzing the logic of its development.

Freeman and Louçã lean on similar the Kuhnian idea of paradigm change in science. According to Kuhn (1962), paradigms are scientific achievements, which are universally accepted and create, over a period of time, typical scientific problems and their solutions. Paradigms gain their status in scientific activities because they are more successful than their rivals in solving problems that the scientific community has recognized as important. An emerging new paradigm not only challenges the established science, it also creates new kinds of experiments and experimental procedures. "Only as experiment and tentative theory are together articulated to a match does the discovery emerge and the theory become a paradigm" (Kuhn, 1962, p. 61).

Established "normal science" does not search for new facts or theories, although new unexpected phenomena are repeatedly uncovered by scientific research. A new discovery begins from new observations that contradict the prevailing theory.

Discovery commences with the awareness of anomaly, i.e. with the recognition that nature has somehow violated the paradigm-induced expectations that govern normal science. It then continues with a more or less extended exploration of the area of anomaly. And it closes only when the paradigm theory has been adjusted so that the anomalous have become the expected. (Kuhn, 1962, pp. 52–53)

Kuhn's study deals with the history of physics, while Freeman and Louca combined the theory of paradigm change with the theory of Kondratiev waves. New constellations of technological and social innovations emerge as separate unique types of techno-economic paradigm during the downswing periods of the long wave. These periods produce two kinds of "production anomalies". First, the established "business recipes" no longer produce profitable results, and secondly, the utilization of new technologies cannot be managed by applying established management doctrines. Freeman and Louçã do not focus on the nature of these occurrences, which are nevertheless important because the general downswing of techno-economic development cannot fully explain the rise and generalization of a new paradigm. Technical innovations do not directly produce new forms of production. Processes of learning in and for production mediate between technological innovations and production practices.

The philosopher Ewald Ilyenkov (1977) also points out that throughout human history really new phenomena have always arisen as anomalies and exceptions. For example, production for the market was by no means always the general form of production. Before it became established, it was a particular relation occurring from time to time between people and things, and only capitalism made it the accepted form of interrelation between its components. These kinds of transitions from the particular to the general are not rare, but are rather the rule in history (*ibid.*, 1977, p. 368).

According to Ilyenkov (*ibid.*, p. 344) the concept "general" relates not only to the common features of the phenomenon under study, but also to a *common ancestor*, which, as a rule, continues to live alongside its offspring as an individual case among other individual cases. The task of the study of a whole consists in discovering from among the existing separate individual cases the one that emerged first and therefore gave birth to all the rest.

Seeing "general" in terms of a common ancestor means that the general functions as the law or principle of connection between the components in the structure of the whole. The components are related not by virtue of their possessing one and the same identical attribute, but by virtue of their having one and the same ancestor, by virtue of their arising as diverse modifications of one and the same substance of a material character (*ibid.*, pp. 350–354).

General phenomena do not possess anything like a family resemblance as the sole grounds for being counted as one class, and the general in them may be outwardly expressed in the form of differences, even opposites. On the other hand, the general manifests itself precisely in the individual characteristics of all the components of the whole without exception. A father often lives a very long time side by side with his sons. And if he is not present, he was once, of course, i.e. must be definitely thought of in the category of "being there" (ibid., p. 354).

What does this mean in the context of studying learning in and for production? According to Ilyenkov, the task of scientific concept formation is to discover the developmental germ cell, the initial genetic abstraction, of the totality under investigation and to develop it into its full concrete diversity. This is the way to comprehend a phenomenon.

To comprehend a phenomenon means to establish its place and role in the concrete system of interacting phenomena in which it is necessarily realized, and to find out precisely those traits, which make it possible for the phenomenon to play this role in the whole. To comprehend a phenomenon means to discover the mode of its origin, the rule according to which the phenomenon emerges with necessity rooted in the concrete totality of conditions, it means to analyze the very conditions of the origin of phenomena. That is the general formula for the formation of a concept. (Ilyenkov, 1982, p. 177)

Thus, this kind of concept formation consists of two processes: reducing the sensual-concrete or the concrete totality under investigation to crystallized initial abstraction, and deriving from this abstraction the various manifestations of the phenomenon, thus ascending from the initial abstraction to a concrete multitude of its forms and manifestations. The initial abstraction could be characterized as a common, simple constantly repeating relation of the object. According to Davydov (1990, pp. 281–282), it should *firstly* indicate the direction of the system formation, which means that its content should correspond in reality to the beginning of the emergence of the concrete whole. It should comprise the very contradictions that have been resolved through its division into different features that emerge from a broken-down integral system. *Secondly*, the qualitative content of this abstraction should correspond to the nature of this entire system, and it should be a very simple, undetailed type of relationship within the whole and a distinctive feature of it. In its simple form it does not depend on other more developed relationships in the whole. *Thirdly*, as a general, genetic basis of the whole, this abstraction expresses its essential foundation or essence, which provides for the universal breakdown into different, relatively independent components. These properties of the initial abstraction could be expressed briefly as follows: it is the historically initial,

contradictory, simple and essential relationship of the concrete phenomenon that is being reproduced (Davydov, 1990, pp. 281–282).

According to this idea, to comprehend learning in and for production means to find its initial abstraction and to show how the multitude of manifestations have derived from this initial form. In the following, I will elaborate the idea that its initial abstraction is the production of practice-relevant generalizations. I will present and apply theoretical concepts and ideas on generalization created within the tradition of Cultural-Historical Activity Theory (CHAT).

4.2 Learning as the cultural process of adopting, applying and producing generalizations

Cultural artifacts as carriers of generalized human operations

According to activity theory the specifically human form of learning is based on cultural artifacts, and its origin is in man's productive activity. According to Ilyenkov (1977, p. 265), thinking, or "ideal", is an aspect of man's labor activity and exists whenever an object of nature is transformed into an object of labor activity and then into a product of labor. In this process the external thing involved in the labor process is first sublated in the subjective form of the activity and represented by a word. This is followed by the reverse sequence in which the verbally expressed idea is transformed into a deed, and through action into the form of an external, sensuously perceived thing an object. Thinking emerges in this cyclic movement along the route thing-deed-word-deed-thing. Man's productive interaction with external bodies and their transformation first into objects of activity and then into artifacts is itself mediated through cultural artifacts, signs and tools.

According to Vygotsky, *human* individuals do not react to the environment or to other people directly (or merely instinctively) but through forms of behavior that are mediated through cultural artifacts that carry culturally developed generalizations. Human consciousness thus lies not inside individuals' heads as a product of biological development, but in the interaction between the individual and the cultural artifacts created by the labor of mankind. Culturally developed artifacts link individual and cultural learning. Higher psychological functions develop first in practical social activities and only later become internalized as inner psychological processes of individuals (Vygotsky, 1978).

Vygotsky conceptualizes the meaning of signs, such as words as *generalized reflections of reality*, in short generalizations that people use in their life activities. Tools could also be understood as culturally developed generalizations.

The ordinary tool is a societal operation fixed in an object, the way in which it is used. The tool is necessarily linked to an object under specific conditions (and not against the "background" of indifferent things). It generalizes and abstracts the characteristics of the object. It is the material, sensibly perceivable form of the first real human generalization and its carrier – not indifferent to that which it carries, yet *directly not* coincident with it. (Leontyev, 1933, p. V)

The development of human cognition and activity could thus be investigated as the development of forms of cultural mediation and mediating generalizations (Leontyev, 1933, p. III). The generalizations reified in tools or representations do not carry the generalization from one context or person to another in themselves, but *they mediate a generalized operation.* "To appropriate a tool or a meaning means to appropriate an operation" (ibid., 1933, p. V), in other words, to learn to use a tool is to learn to carry out the operation the tool has been created to mediate.

While tools are directed at material objects of nature, words and other signs are directed toward other people as mediators of social cooperation. They entail generalizations concerning recurrent aspects of situations in human practices to which human beings need to direct other peoples' attention. Once developed in social praxis, however, signs may later also become tools for the self-regulation of an individual's behavior, and make creative reflection and self-consciousness possible. (Vygotsky, 1978, pp. 54–55)

The tools and signs are in human activity connected to each other. There is a functional similarity between tools and concepts, that is, generalizations attached to and mediated through words and other signs. These two types of generalizations are complementary and there is no sharp distinction between them. The co-operative use of physical tools is often not possible without a corresponding set of concepts carried by words and other signs. (Leontyev, 1933, p. VII)

On the one hand, communication between people presupposes generalizations: without them it would be impossible. On the other hand, generalizations develop in communication: they are thus products of societal practices and can develop only within them (Leontyev, 1933, p. VII).

The dialectical connection between representation and the process of generalizing

According to Leont'ev, an adequate characterization of the structure of a generalization is reached by showing the process that leads to it. The difference between generalizations is understood as the differences in the contents being generalized

and in the process of generalizing. Different factual contents require different processes, and one and the same content can be understood, generalized, and reflected in different ways (Leontyev, 1933, p. VII).

Representations, whether internal or external, and the process of generalization form a dialectical unity.

The representation and its corresponding process [of generalizing, JP] do not exist apart from each other. But it cannot be concluded that they are one and the same, just appearing differently, now as moment now as process. They are different and opposed things. (Leontyev, 1933, p. IV)

The relationship between a generalized representation and the process of generalization is dynamic. Their "coincidence" merely appears as a *moment*; they can find themselves in open contradiction with one another. The existing representation detaches itself from the process and becomes inert, resisting change. The process in which a generalized reflection develops is unthinkable without the generalized reflection on which it is based, however.

(...) every reflection of reality in the human consciousness (and every reflection is generalized reflection and cannot be otherwise) and the process in which it develops and presents itself form a dialectical unity (that is, one is unthinkable without the other), they form an opposition, are identical processes – pass into one another. Fundamental in this unity is the process that always links generalization with the generalized reality (and the subject with reality). (ibid., 1933, p. IV)

Vygotsky and his colleagues defined the object of research on knowledge and learning in a radically new way. Their studies showed that the opposition between process and generalization was more important than the Cartesian opposition between internal and external processes that had traditionally been regarded as fundamental.

The actual opposition is the opposition between representation and process, whether internal or external, and definitely not the opposition between consciousness (as internal) and object world (as external). (...) The opposition between material-external and ideal-internal began to reveal itself as historical, as a secondary formation, and thus *as an opposition that could not serve as a point of departure*. It must be understood and exposed *as just an historical formation*, that is, as not absolute. (ibid., 1933, pp. IV–V)

Considering the opposition between process and representation to be primary does not deny the existence of a difference between the material-external or ideal-internal processes of generalizing and generalization: it rather postulates their co-existence and interaction.

The process of generalizing presupposes variation in the material about which a generalization is made. Marton (2000) pointed out that *variation, not repetition*, is the "mother of learning". Only variation makes it possible for the subject to discern what is essential and what is irrelevant from the point of view of reaching an objective. There is, however, a dialectical relationship between repetition and variation.

If something varies, that something must be repeated. At the same time, that which is repeated can never be exactly the same if seen from the learner's point of view. Another way of looking at the relationship between variation and repetition (in the sense of the exact same event taking place again and again) is seeing the latter as the limiting special case of the former. There is an unlimited number of ways in which repetitions of the same text (or whatever) may differ from each other. One, and only one, of these is the case when they do not differ at all. And this case in fact does not occur in the context of learning. (Marton, 2000, pp.14–15)

Marton maintains that to be able to do something is to be able to see or experience something. In order to do that, a person has to discern certain critical aspects of the object. We can see or experience specific features in the object only when there is contrast and variety within sameness. Variation within sameness is the basis of all generalization. Following Marton's idea, we could say that there are four basic elements in the process of generalizing: 1) an existing generalization that defines what is being repeated, in other words what the unit is within which it becomes possible to observe and analyze variation; 2) there is variation within this unit of attention; 3) there is a method of processing the variation in order to reach further generalizations, and further, 4) there is a way of remembering or preserving the reached generalization. According to Leont'ev, all these four elements can exist both as internal mental structures and as objectified in artifacts.

The tripartite structure and logic of mediated action provides a quasi-experimental setting of variation in sameness, as some of the elements may vary while others remain the same. When the same person uses the same tool and there is variation in the object, he/she learns about the properties of the objects. When the same person uses different tools on the same object he/she can learn about the properties of the tools. When the same person repeats actions using the same tool for modifying the same object, but varies his or her attention and method of using the tool, he or she may learn to reach the goal more effectively with the tool.

According to Leont'ev, tools and signs do not mediate actions: they only mediate the operations needed to carry them out. Operations are the means of goal-oriented actions. Thus the culturally developed generalizations fixed in artifacts do not completely determine individuals' actions, but rather facilitate certain kinds of actions and restrict the scope of possible goals. Individuals use generalized types of operations in various combinations to carry out actions.

Furthermore, operations can be formed consciously from actions, or they can develop unconsciously as responses to the requirements set by the specific conditions of performing an action. The operations that stem from conscious actions are the results of a process of psychological automatization, and it is just in this automated form that they become included in actions as readily available modules. Leont'ev (1978, p. 66) illustrates the nature of the transformation of action into operation using the example of driving a car.

Initially every operation, such as shifting gears, is formed as an action subordinated specifically to this goal and has its own conscious "orientation basis". Subsequently this action is included in another action, for example, changing the speed of the car. Now shifting gears becomes one of the methods for attaining the goal, the operation that effects the change in speed, and shifting gears now ceases to be accomplished as a specific goal-oriented process: Its goal is not isolated. For the consciousness of the driver, shifting gears in normal circumstances is as if it did not exist. He does something else: He moves the car from a place, climbs steep grades, drives the car fast, stops at a given place, etc. Actually this operation of shifting gears may, as is known, be removed entirely from the activity of the driver and be carried out automatically. Generally, the fate of the operation sooner or later becomes the function of the machine. (Leont'ev, 1978, p. 66)

Operations that develop spontaneously as ways of adapting an action to the objective conditions in a situation, or through simple imitation are largely unconscious. The individual cannot control them or the conditions to which they respond consciously without special effort. These operations may be brought into conscious control only if they become objects of special actions and are specially recognized. A child does not need grammatical knowledge in order to learn his/her native language. In order to control the practically adapted knowledge consciously, however, he or she has to make the forms of grammar into the object of goal-directed actions of inquiry (*ibid.*, p. 165).

On the other hand, operations that are formed as results of conscious actions are easier for the actor to change and more flexible than those that evolve spontaneously and unconsciously. The latter are inadequately controlled, rigid and inflexible while the former can be transformed from automated operations to conscious actions and back (*ibid.*, p. 166).

Every action, even the "reaching of point N," is always accomplished in a certain objective situation. Thus actions are determined not only by their goals, but also by the conditions of achieving the goal. The conditions "formulate" the specific and particular operations (how, by what means) through which the action is accomplished. (ibid., p. 64). Because objectives and conditions vary somewhat independently of the available signs and tools the generalizations objectified in them do not always coincide with them. The tensions between the changing objectives and conditions and the available signs and tools create needs to change and develop existing artifacts and the generalizations embedded in them.

Two origins of generalizing

Davydov maintains that generalizing processes emerged in human history from two different sources and orientations. On the one hand, peoples' elementary rational orientation toward objects and means of labor brought *the conceptions that established the immediate properties of objects*. These were translated through language into abstract generalities, no longer closely connected to the objects and means of production.

This was an orientation toward the settled and canonized methods of production with relatively stable tools requiring "training", the acquisition of "skills". This type of orientation towards the presently external being became the basis for the empirical thinking of the mass of the toiling performers of social and labor operations. (Davydov, 1990, p. 244)

On the other hand, human beings developed an ability to plan production, and to create designs for new tools and the techniques for making and using them. Another kind of practical action emerged that was taken in order to delineate the universal properties of things. These generalizing processes apparently developed through a different route.

It can be presumed that the sensory-practical action retained its external, object related form, but for cognitive purposes in the role of "fitting", "testing" or "trying out". This engendered specific sensory-object actions of a comprehending nature, which reproduced a certain form of the movement of things. For example, operations (...) can solve problems in evaluating the suitability of raw material or of a by-product by a preliminary testing, a practical "trying out" of it. Operations of this kind, which are subordinate to the cognitive purpose, whose result is the knowledge obtained through them, are genuine thought in its external, practical form. (ibid., pp. 263–264)

The nature of recurrent methods of production activity was idealized in the kind of thinking that prevailed out in the external form of trying out and testing. Davydov called this form of generalizing sensory-object experimentation. It was a mental activity that was gradually converted into "internal activity", into work done by man "for himself".

Humans' rational orientation toward the objects and tools of production, and habituation in the form of practice on the one hand and the ability to plan production and to experiment on the other were the essential early processes that produced the first generalizations, the first forms of human thinking in history. They made it possible for people to sustain, change, and develop their labor activity.

We might presume that the operations used in this different kind of thinking were objectified in different types of artifacts, which further made possible different types of practical and intellectual actions and also different forms and levels of learning. Marx Wartofsky (1979, p. 201) characterizes the artifacts directly used in production, e.g., tools, models of social organization, and bodily skills in the use of tools, as *primary*. The symbolic communication of such skills in the production, reproduction and use of artifacts is a characteristic mode of human activity. This ability to represent an action by symbolic means generates a distinctive class of *secondary artifacts*, representation of practices in textbooks, designs, directives and prescriptions. Representations of practices make it possible for the practitioners to take an overall view of the activity, to reflect on it and to collect and save their experiences as material for the further development of the work. While primary artifacts mediate the operations needed in directly productive actions, representations mediate those needed in planning these actions, coordinating and teaching them as well as reflecting on them.

According to Wartofsky, there are also *tertiary artifacts* that do not have a direct representational function, but serve the free construction in the imagination of tools, rules and operations that are different from those adopted for the praxis. Such "possible worlds" may reflect the limits of the actual praxis and help to create alternatives for conceivable changes in the model itself. Tertiary artifacts serve as tools for reflecting on, evaluating and developing the secondary artifacts.

Yrjö Engeström (1987) connected Gregory Bateson's theory of the three levels of learning with Wartofsky's different types of artifacts. On Bateson's first level of learning the learner learns a behavior within a situation in which the goal and the means for reaching it are given and the appropriate reaction is learned through habituation. On the second level the goal is given and the learner learns by trial and error or experimentation to select an appropriate tool. In other words, he or she learns the context and rules of the first level. This may take place largely as tacit socialization, or more in the form of conscious strategizing. A worker learns by trial and error, or by experimenting, to select appropriate work instruments, to use

certain kinds of problem-solving methods as a team member and to understand his/her own position as a worker in a factory. Representations of the practice are important tools for the more advanced forms of second-level learning involving problem solving and experimentation.

If the underlying logic of action reveals continuously unstable or contradictory action, the third level of learning is needed, according to Bateson. In this case, the uncertainty and instability become so pressing that people engage in a major effort to make sense of it all. The essence of this level of learning is thus in identifying the right problems to solve. The learner learns not only to solve problems of a certain kind, but also to transform the context so that the problems appear and become manageable in a radically new light. This historically new level of learning emerges when individuals are repeatedly exposed to double-bind situations in the social context, when all efforts to resolve crises seem to lead to deeper crises, but not to a new solution. The only solution is to change the context profoundly. We could say that Wartofsky's third level of artifacts supports the intellectual operations needed on that level of learning.

The interaction between different processes of generalizing: scientific and everyday generalizations

Vygotsky studied the development of children's thinking as the development of concepts, in other words, generalizations. His experiments showed that in the first phases of development the child creates generalizations from its experiences by combining subjectively in its mind individual objects in groups. Later on words begin to function as a means for it to guide attention to the specific features and to abstract them from the totality (Leont'ev, 1997, p. 27). From that phase on, the child's individual experience and the cultural generalizations carried by words interact in the development of its thinking.

The role of words in conceptual development changes when the child goes to school. Vygotsky assumed that some of its concepts are acquired in its daily life outside school, and others inside school. He called these different types of concepts everyday¹⁹ and scientific. Everyday concepts arise in the context of daily life as a result of the child's interaction with adults and the non-social environment. They are not explicitly introduced, they do not form a coherent, hierarchically

¹⁹ Vygotsky used "everyday concept" and "spontaneous concepts" interchangeably. In this text I use only "everyday concept" in order to distinguish it from Piaget's term.

ordered whole, and they are not used in a conscious deliberate way (van der Veer, 1998, p. 90). The highest level of generalization is, in this case, the abstraction of some visual characteristics. The resulting concepts are general ideas, which go from the concrete to the abstract: they are "generalizations of things" (Leontyev, 1997, p. 28). This process of generalizing is largely inductive.

The relationship between the scientific concept and the object, on the other hand is, mediated from the very beginning by other concepts comprising the hierarchical system, within which scientific concepts have a place. The rudiments of this systematization first enter the child's mind by way of its contact with scientific concepts, and are then transferred to everyday concepts, changing their psychological structure from the top down (Vygotsky, 1962, p. 93). Ideally, scientific concepts reflect what is seen to be the essence of a certain aspect of reality (van der Veer, 1998, p. 92).

The formation path runs from the abstract to the concrete, and the child is more conscious of the concept than of the object from the very beginning (Leont'ev, 1997, p. 28).

Scientific concepts presuppose everyday concepts as their foundation, but they are also able to transform them. Both develop as intertwined, but in reverse directions (Vygotsky, 1962, 108). Scientific concepts go down through everyday concepts and everyday concepts grow upward through scientific concepts. Scientific concepts are brought into the child's consciousness in the course of instruction, and stimulate a step of cognitive development through which it has not yet passed.

The development of everyday concepts must have reached a certain level for the child to be able to absorb a related scientific concept (*ibid.*, p. 108). The degree of mastery of everyday concepts indicates the level of the child's actual development while the degree of mastery of scientific concepts indicates its *zone of proximal development*. The instruction "calls into life a whole number of functions, which are in a stage of maturation lying in the zone of proximal development" (Vygotsky, 1962, p. 220). The zone of proximal development characterizes the difference between what the child is capable of itself and what it can become capable of with the help of a teacher.

Using the experimental method of double stimulation, Vygotsky (1962, p. 56) was able to demonstrate how these two processes of generalizing can interact with each other. The experimenter presented to the subject two sets of stimuli, one as objects of his or her activity and the other, "neutral stimuli" as signs that may serve to organize that activity. In the course of these experiments it turned out that the neutral stimuli assumed a specific instrumental meaning for the subject who was accomplishing the task.

Thus, the child actively incorporates these neutral objects into the task of problem solving. We might say that when difficulties arise, neutral stimuli take on the function of a sign and from that point on the operation's structure assumes an essentially different character. (Vygotsky, 1978, pp. 74–75)

In this case, the child creates a hypothesis concerning the instrumental meaning of the artifact in the situation and any possible operation that could be carried out with it. The reasoning here follows neither inductive nor deductive but rather abductive logic, which is the process of inference to the best explanation. Through this abductive inference the artifact becomes an instrument for the subject, who uses it in an action. In a problematic situation the subject associates one object with another in a goal-oriented action through the idea of an operation being realizable by using the other object as a tool.

Although Vygotsky studied concept formation and generalization in child development, his studies are also relevant in terms of understanding the processes of generalizing that take place in production. Generalizations are not created only or primarily in local practice, but develop as an interplay between local processes of generalizing "from below" and through abductive reasoning that uses culturally existing means to reach specific goals.

4.3 Transforming generalizations that are fixed in the human activity system

According to Leont'ev, societal practices have the character of collaborative activity. Human activities are the context in which new generalizations develop, but at the same time they are systems of existing generalizations. They are systemic formations in which the psychological processes of individual persons who participate in an activity and in its societal system are inherently connected to each other. Individuals' actions cannot be considered in isolation from the life of society and the societal systems of activity (Leont'ev, 1978, pp. 62–63).

A constituting characteristic of a system of human activity is its object-orientatedness. The concept of the object is implicit in the very concept of activity. The object of an activity has to be seen in two ways: first in its independent existence as subordinating to itself and transforming the activity of the subject, and second as an image, a generalized representation. The changes that are realized in the object of an activity depend crucially on the adequacy and validity of the generalized representations that the subject uses to orient him/herself to it. Activity is a process of interaction between subject and object, mediated by physical instruments and representations of the object as well as the social relationships of collaboration exchange and the division of labor. While the subject moulds an output of the object

that corresponds more or less to the idea of it the same interaction transforms the subject and his/her thoughts, actions and instruments (ibid., pp. 62–64). Hence the thing-deed-work-deed-thing interaction Ilyenkov speaks about takes place in man's collaborative activities.

Activities differ from each other in their social motive and object:

The main thing that distinguishes one activity from another, however, is the difference of their objects. It is exactly the object of an activity that gives it a determined direction. According to the terminology I have proposed, the object of an activity is its true motive. It is understood that the motive may be either material or ideal, either present in perception or exclusively in the imagination or in thought. The main thing is that behind activity there should always be a need, that it should always answer one need or another. Thus, the concept of activity is necessarily connected with the concept of motive. Activity does not exist without a motive; "non-motivated" activity is not activity without a motive but activity with a subjectively and objectively hidden motive. (Leont'ev, 1978, pp. 62)

According to Leont'ev, activity systems are hierarchical formations. *Activity* refers to institutionalized systems of collaborative activity that evolve over a lengthy period of time in interaction with an object. *Actions*, on the other hand, are relatively short-lived units of activity. They have a temporally clear-cut beginning and end. Activities are always oriented to historically evolved objects, whereas actions are oriented to goals.

In his famous hunting example, Leont'ev shows how the object of the hunting activity of a tribe in prehistoric times was the game. One group of hunters engaged in frightening a herd of animals and sending them toward other hunters who were hiding in ambush to catch them (Leont'ev, 1981, p. 210). The immediate goal of frightening the game was directly opposed to that of the hunting activity, which was to get food and fur. It can only be understood on the basis of the division of labor between the hunters. The actions of the individuals taking part in an activity are launched by the motive of the joint activity that is being realized. The goal regulates the way in which the action is carried out.

The relationship between the goal of an action and the object of an activity depends on the nature of the activity. Actions are typically taken by individuals, but they can also be taken collaboratively by several people. Hunters take actions in order to get flesh and fur, but the way in which they act is directed by the goals of frightening the animals to run to the catchers, and of catching them. In Leont'ev's example frightening the game was an action taken by many hunters. The more

people there are carrying out the same action, the more necessary it is for each individual to know the goal. It has to be transferred from one individual to another, and understood by the individuals engaged in it. The goals may also be more or less conscious to the subject, but what is important is that the object of the activity determines the horizon of possible goals and actions (Leont'ev, 1978, p. 65).

An activity may lose the motive that elicited it, whereupon it is converted into an action that may realize an entirely different relation to the world, a different activity. Conversely, an action may turn into an independent stimulating force and may become a separate activity.

Engeström (1987; 1995; 2001) further developed activity theory by modelling the multiple relationships of mediation of an activity system. The interaction between the subject, the object, and those engaged in the same activity is mediated by tools and signs. The *community* comprises multiple individuals, sub-groups or networks of people who share the same object of the activity and take actions to produce the outcome. The *division of labor* refers to both the horizontal division of tasks between the individuals or groups in the community and to the vertical division of power and status. *Rules* refer to the explicit and implicit norms that control individual action and exchange in interactions between members of the community.

All the elements of the activity system have the character of a generalization. The concept of the object of the activity is a generalization that sets limits on what is and what is not dealt with in it. The tools and instruments, the division of labor and the rules comprise generalizations concerning aspects of the activity. The subjects develop an identity, a generalization of the kind of persons they are. The generalizations embedded in the various mediators have to be aligned in order for the activity to run effectively. The way in which the variation in the activity is controlled i.e. the principle and the logic on which the coherence of the elements of activity systems are based could be called the *concept of the activity* (Virkkunen, 2004 p. 13).

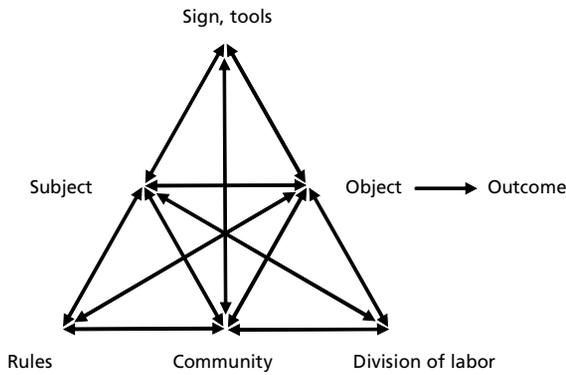


Figure 4.1 The structure of human activity (Engeström 1987, p. 78)

The artifacts that mediate the activity are, to a great extent outputs of other activity systems that produce instruments (research, science, technology), subjects (education and schooling) and rules (administration, legislation and collective bargaining). Thus processes of producing practice-relevant generalizations are distributed between networks of activities.

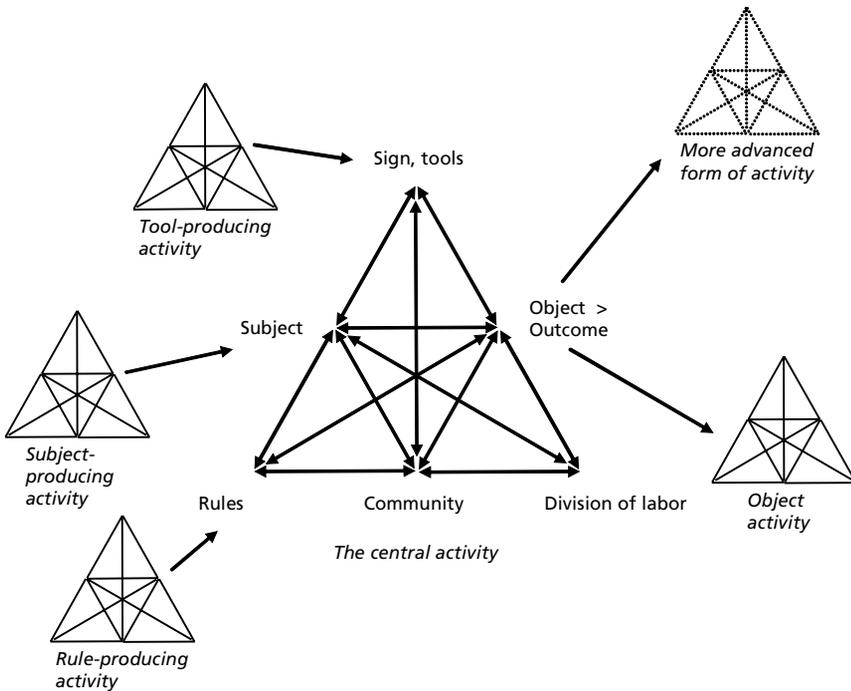


Figure 4.2 The network of activity systems

Because the generalizations inherent in the various artifacts that mediate an activity are functionally interdependent, a remarkable change in one of these leads to a chain of developing new generalizations and of remediation in the system. This kind of chain process of change may be expansive or it may lead to progressive deterioration in the activity. According to Engeström (1987), a cycle of expansive development of an activity typically comprises five phases. It is accomplished when the object of the activity is *re-conceptualized to embrace a radically wider horizon of possibilities than in the previous mode of the activity and when the structure of the activity is changed accordingly* (Engeström, 1999).

Engeström calls the first phase of expansive transformation the need state. A diffuse need for change emerges as the primary contradiction between the use value and the exchange value of the elements of the activity. The outcome of a productive activity system has its use value for a customer, but it also has an exchange value in the markets. As conditions change, the quasi-stationary balance between the different logics of these interconnected aspects of the elements of an activity can be shaken.

Accumulating changes in the object of the activity system, such as setting new rules governing occupational health, may aggravate the first-order contradictions to produce secondary contradictions, which arise when actors face in their daily actions disturbances that seem impossible to resolve. The aggravation may divide work community or the management into diverging camps causing conflicts that often produce crises or the double-bind situations individual actors experience in such a situation: according to Engeström's theory, these are caused by contradictions *between the elements* of the activity system.

The aggravation of secondary contradictions leads actors to search for a new object/motive for the activity and a new model and principle. The new model is the germ cell of the new concept of the activity: it captures in a simplified form the basic internal relations and tensions that make the participants understand their history and strive for possible expansive change in their activity system (Engeström, 2004, p. 12). Implementation of the model will meet difficulties because the previous activity system does not disappear by itself. The old system rebels against the growing new one. The conflicts or disturbances of the implementation phase reflect the tertiary contradiction between the qualitatively new activity system and the traditional one. When the new system finally begins to establish and consolidate itself, it meets difficulties and disturbances again. The activity systems that are in interaction with the central renewed system will face quaternary contradictions between it and the traditional neighboring activities. Expansive learning thus proceeds in cycles, through multiple phases and over lengthy periods of time.

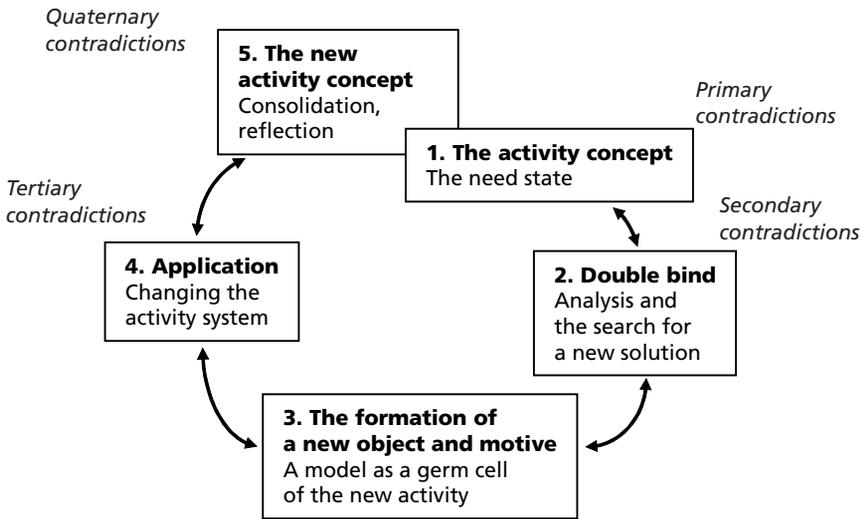


Figure 4.3 The ideal-type cycle of expansive learning and the development of the activity concept

Engeström's theory of activity systems and learning by expansion facilitate analysis of the transformation of local activities, including work places, and the different processes of generating new generalizations for them. The theory does not provide any conceptualization of the historical development of the generalizations, however. In the following section I consider classical studies of cultural-historical activity theory in terms of historical changes in generalization.

4.4 Historical types of generalizations

Perceptual-functional generalizations

The aim of A Luria (1976) in his famous study on the cultural history of cognitive development was to demonstrate the socio-historical roots of all basic cognitive processes. His hypothesis was that the structure of the dominant types of activity in a culture affects its way of generalizing. Thus practical or situational-concrete thinking would predominate in societies that are characterized by practical manipulations of objects, and the more "abstract" forms of "theoretical" activity in technologically advanced societies would lead to more abstract thinking. (Luria, 1976, pp. xiv-xv) This distinction corresponds to the difference between a society in which production is predominantly based on craft work and one based on a more elaborated division of labor and money-mediated exchange.

The subjects in a society predominated by the practical manipulation of things did not interpret words as symbols of abstract categories that were usable for classifying ideas. What mattered to them were strictly concrete ideas about practical schemes in which appropriate objects could be incorporated. Consequently, their thinking was wholly unlike that of subjects trained to perform theoretical operations (*ibid.*, 1976, p. 54).

Among uneducated, illiterate subjects the controlling factor was the tendency to reproduce operations used in practical life. Rakmat, one of the interviewees in this thorough study, was an illiterate, thirty-nine-year-old peasant from an outlying district. The researcher asked him to group certain objects showing him drawings of a hammer, a saw, a log, and a hatchet.

They are all alike. I think all of them have to be here. See if you're going to saw, you need a saw, and if you have to split something you need hatchet. So they are all needed here. (Luria, 1976, p. 55)

Luria's interpretation was that Rakmat employed in his answer the principle of the practical grouping of objects. He was asked more questions in an effort to make him categorize or use abstract thinking, but he always assigned objects functions in a practical way and reverted to situational thinking. Luria also returned to the saw-log-hatchet example in an attempt to provoke an empirical generalization. (Luria's interpretations are in italics)

Which of these things could you call by one word?

"How's that? If you call all three of them a 'hammer' that won't be right either"

Rejects use of general term.

But one fellow picked three things – the hammer, saw, and hatchet – and said they were alike.

"A saw, a hammer, and a hatchet all have to work together. But the log has to be here too!"

Reverts to situational thinking.

Why do you think he picked these three things and not the log?

"Probably he's got a lot of firewood, but if we'll be left without firewood, we won't be able to do anything"

Explains selection in strictly practical terms.

True, but a hammer, a saw, and a hatchet are all tools.

"Yes, but even if we have tools, we still need wood, otherwise, we can't build anything."

Persists in situational thinking.

(Luria, 1976, p. 56)

At the point in the last question at which the researcher consciously used the categorical, classifying term, the subject persisted in situational thinking. Using similar interviews and clinical methodology, Luria showed that the limitation of perceptual-functional generalization was that it could not be used for other purposes.

Our subjects used concrete situational thinking to compile groups that were extremely resistant to change. When we tried to suggest another group (based on abstract principles) they generally rejected it, insisting that such an arrangement did not reflect the intrinsic relationship among the objects, and that the person who adopted it was "stupid", or "did not understand anything". (Luria, 1976, p. 54)

The subjects who gravitated towards this type of classification did not sort objects into formal categories, but incorporated them into perceptual-functional situations drawn from life and reproduced from memory (Luria, 1976, p. 49).

This generalizing process could be interpreted as Bateson's first-level learning, when an actor fits his/her behavior into a situation in which the goal and the means of reaching it are given and the appropriate reaction is learned through habituation. The representations used in this perceptual-functional process consist of primary artifacts such as tools, modes of social organization, bodily skills and technical skills in the use of tools. According to Wartofsky (1979, p. 202) the modes may be gestural, oral, or visual, but obviously such that they may be communicated in one or more sense-modalities: such, in short, that they may be perceived.

Abstract-empirical generalizations

According to Luria, the setting of things in formal categories was typical in industrial societies. It is also the central form of generalization in schools. V. V. Davydov studied types of generalization in school curricula and learning, following an initial observation that the teaching of "generalizations" and concepts was one of the principal purposes of school instruction. He found out that the material in the textbooks of various disciplines was arranged, as a rule, so that the pupils' work with it could lead them to appropriate formal empirical generalizations.

Davydov and his collaborators showed in their theoretically and experimentally oriented studies lasting over thirty years that empirical generalizations were based on observation and comparison of the external properties of objects. Children moved from describing of the properties of a particular object to finding and singling them out in a whole class of similar objects, and learned to find and single out certain stable, recurring properties of that class of objects. The textbooks presented as general the qualities that were similar in all objects of the same type or

class. What occurred during the process of generalization was, on the one hand, the search for a certain *invariant* in an assortment of objects and their properties, and the designation of that invariant by a word, and on the other hand, the use of the invariant that had been singled out to identify objects in a given assortment (Davydov, 1990, p.10).

E. Iljyentkov and V.V. Davydov elaborated on the distinction between formal-empirical and theoretical-genetic generalizations and concepts. Abstract relationships are conventionally objects of formal logic and mathematical science, which examine these connections using formal classifications of numbers and groups. Formal logic describes certain important features of concept formation and thinking that are necessary in everyday life. Formal generalizing entails comparing several objects, identifying some similarities between them, abstracting the similar features from each other, and crystallizing the contribution of the features into a verbal definition. The definition that is based on the common features of a class of objects or the common feature as such is the content of an empirical concept. It enables the classification, systematization, and connection of phenomena or beings. It also enables the connection of successive or parallel courses of events, and the description of cause-and-effect relationships using a similar method.

The process of empirical generalization follows the chain: observation - image linguistic abstraction. "Concrete" is understood to describe an individual, sensually perceivable object, while "abstract" is a separate feature that is common to several objects. Formal logic follows the pattern of inductive generalization. It starts from a particular case and ends up in the "logically abstract", and conversely, it makes definitions and sorts singular objects into classes.

The laws of formal logic, such as "the law of forbidden contradiction" and "the law of double negation", do not describe the way people think. They are rather necessary conditions that thinking should follow to be "formally right", and are prerequisites in the formulation and operation of empirical concepts.

Abstract-empirical generalizations such as Warofsky's secondary artifacts make it possible for practitioners to produce generalizations of an overall view of the activity, to reflect on it, and to collect and save the experiences as material for further development of the work. Processes of generalizing are also equivalent to Bateson's second level of learning, when the learner learns the underlying logic of his/her actions in the given context.

Such generalizations are not significant in relatively isolated rural societies in which the economy is based on craft production, however. They can only develop in activity that looks on the object and product of work from the outside in terms of quantities, which is typical of the work of tradesmen and administrators. One might thus presume that this type of generalization originally developed to mediate these activities. We might also presume that it increases in significance as the

economy transforms from nature-based to money-mediated exchange and wage labor.

Theoretical-genetic generalizations

The limitation of perceptual-functional generalization is its immediate and situational nature that inhibits the creation of abstractions and empirical generalization. Formal logic, on the other hand, operates with abstractions, wherein the empirically derived concepts lose their concrete content. Formal logic does not provide tools for developing understanding of the emergence and development of the object. Theoretical-genetic thinking produces generalizations that differ from both perceptual-functional and abstract-empirical generalizations, and which are based on an act of objective transformation and analysis carried out in order to establish the essential relationships that characterize the object and its genetically original form.

Theoretical thinking is a process of generalization that singles out the general principle of the emergence of the production of a phenomenon. Spinoza's famous example of the good definition of a circle shows the difference between that and abstract thinking. A circle can be defined in an abstract-empirical way as a regular round figure, and identified from a class of figures of various forms. According to Spinoza, a better definition would be that a circle forms at the end of a line when the other end is fixed and the line is turned around. This definition is general in the sense that any size or kind of circle can be produced by applying it, and it is theoretical in the sense that no prior empirical acquaintance of circles is needed. It gives the origin of any circle by describing the contradictory relationships that produce it: free movement contra the fixed end of the line. (Kozulin, 1998, pp. 63–64)

Davydov's (1990, pp. 301–302) analysis of the differences between abstract-empirical and theoretical-genetic generalization is presented in a concise form in Table 4.1.

Table 4.1 A comparison of empirical and theoretical generalizations

Abstract-empirical generalization	Theoretical-genetic generalization
– is produced by <i>comparing</i> objects and their representations	– is produced by an <i>analysis</i> of a certain relations inside a structured system
– discerns the <i>formally</i> general property, of particular objects to be attributed to a certain formal class regardless of whether these objects are connected with one another	– identifies the <i>real</i> and specific essential relationship of things, which is the genetic foundation of all other manifestations of the system
– is based on <i>observation</i> , reflects the <i>external</i> properties of objects and relies completely on visual conceptions	– is based on the <i>transformation</i> of objects, and reflects their <i>internal</i> relationships and connections
– <i>separates</i> the formally common trait from the particular features of the objects	– fixates the <i>connections</i> between an essential relationship and its various manifestations
– fixates empirical knowledge in the word, the term	– is primarily expressed in the <i>methods and models</i> of intellectual activity and subsequently in various systems of signs and symbols in artificial and natural languages

According to dialectical logic, individual, particular things and phenomena in the world are products of the development of a certain concrete whole or system. The basis of the objective process of development is a specific real relationship between objects in the world that one can perceive as sensorial. This relationship is the germ cell of the concrete whole, or of the system that has evolved from it. Although the germ cell exists as a particular form of the relationship, it has at the same time the property of being the universal abstract form, determining the emergence and development of other particular, special and individual phenomena based on that relationship within the whole or in the system in question (Davydov, 1990, p. 285).

The commonly understood concepts of abstract and concrete are redefined in dialectical logic. The concrete is not seen as sensually palpable or the abstract as something mentally constructed. The research both begins from the concrete and ends up with it.

For dialectical logic, the concrete is an interconnected systemic whole. But the interconnections are not of any arbitrary kind. At the core of the interconnections there are internal contradictions. (Ilyenkov, 1982, p. 272)

In promoting understanding of the nature of any particular component of the concrete whole, the task of investigation is to grasp its role within the concrete whole and the history of its origin. This logic cannot be stored in the form of ready-made formulas to be imposed upon the object. On the contrary, "the concrete history of a concrete object should be considered in each particular case rather than history in general" (Ilyenkov, 1982, p. 215).

By "abstract", Ilyenkov means anything that is "picked out, isolated, existing, on its own in relative independence from everything else, any side, aspect or part of a whole, any determinate fragment of reality or its reflection in consciousness." (Bakhurst, 1991, p. 141)

The process of theoretical generalization *ascends from the abstract to the concrete*. Ilyenkov saw this as a reasonable method for investigating historically-developing phenomena. The aim is to understand the development of the object-phenomenon as it evolves from its original contradictory relationship or *germ cell*, or initially single and isolated, and in that sense abstract, relationship into its present mature and complex form. The study starts with the concrete chaotic whole from which it descends to the abstraction of the basic determining categories. Thirdly, it rises again – using the abstraction – to the concrete whole, this time as a rich totality of determinations and relations (Miettinen, 2000, pp. 111–112).

Particular abstract definitions, the synthesis of which yields the concrete thought, are formed in the process of ascending from the abstract to the concrete. Moreover, the concept "expresses a reality which, while being quite a particular phenomenon among other particular phenomena, is at the same time a genuinely universal element, a cell in all the other particular phenomena" (Ilyenkov, 1982, p. 79). The task of genuine concept formation is thus to find out the developmental germ cell, the initial genetic abstraction, of the totality under investigation, and to develop it into its full concrete diversity.

The theoretical process that leads to the attainment of concrete knowledge is always a whole in each of its individual links, and at the same time a process of reducing the concrete to the abstract (Ilyenkov, 1982, pp. 114–115). Although both processes (reduction and ascending) occur in unison, the leading one is ascending, which expresses the nature of theoretical thought (Davydov, 1990, p. 281).

General notions are *formal abstractions* since they separate arbitrary features of objects from their interconnections. Genuine concepts are *concrete abstractions* since they reflect and reconstruct the systemic and interconnected nature of the objects. This systemic nature is not of the static classificatory "genus-species" type but is rather *genetic and dynamic*. A whale is, in empirical terms, a fish because of its external features but theoretically, in relation to its genesis, it is a mammal.

In dialectical logic, the concrete is an interconnected systemic whole. The core of the interconnections lies in the *internal contradictions* that produce the phenomena in the system.

Concreteness is in general *identity of opposites*, whereas the abstract general is obtained according to the principle of bare identity, identity without contradiction. (Ilyenkov 1982, p. 272)

Contradictions become significant if we are to handle movement, development and change conceptually.

Any utterance expressing the very moment, the very act of transition (and not the *result* of this transition only) inevitably contains an explicit or implicit contradiction, and a contradiction "at one and the same time" (that is, during transition, at the moment of transition) and "in one and the same relation" (precisely with regard to the transition of the opposites into each other). (Ilyenkov, 1982, p. 251)

The struggle and mutual dependency of opposite forces or elements is the developmental driving force within objective systems. To create a genuine concept is to grasp and fixate this inner contradiction of the object system and to derive its subsequent developmental manifestations from that initial contradiction.

The dialectical materialist method of resolution of contradictions in theoretical definitions thus consists in tracing the process by which the movement of reality itself resolves them in a new form of expression. Expressed objectively, the goal lies in tracing, through analysis of new empirical materials, the emergence of reality in which an earlier established contradiction finds its relative resolution in a new objective form of its realisation. (Ilyenkov, 1982, pp. 262–263)

According to Davydov, the term knowledge should be used to refer to both the result of thought and the process whereby that result is achieved.

Every scientific concept is both a construction of thought and a reflection of being. From this point of view, a concept is both a reflection of being and an instrumentality of the mental operation. (Davydov, 1988, p. 21)

We might also presume that theoretical-genetic generalizations represent Bateson's third level of learning, when the learner transforms and continuously expands the context of problems. This is a typical area of scientific activity. We might also assume that, in this kind of process of generalizing Wartofsky's (1979, p. 208) tertiary artifacts constitute "possible worlds" and may reflect the limits of the actual praxis, thereby helping to create alternatives for conceivable change in the very model of praxis. Wartofsky points out that primary and secondary artifacts are created in production, on-line, whereas tertiary "off-line" worlds are outside of production.

The artifacts of the imaginative construction of "off-line" worlds I take to be derivative, and abstractive. But there may well be a structural component in all this, which derives from other (though no less social) needs, which transcend the more immediate necessities of productive praxis. (Wartofsky, 1979, p. 209)

Davydov emphasizes that empirical actions correspond to empirical concepts/generalizations, while theoretical actions correspond to theoretical concepts/generalizations. Nevertheless, schoolchildren do not create these kinds of concepts. They are created in scientific work. Children appropriate them as part of *learning activity*, which he claims consists of mental actions commensurate with actions, whereby these products of spiritual culture have been historically elicited. In order to appropriate a theoretical concept, learners have to reproduce the process whereby people have created concepts, images, values, and norms.

Davydov (1988, p. 24) identified the following constituent learning actions as necessary for producing theoretical generalization within learning activity: 1) transforming the situation to find out the general relation of the system under consideration; 2) modelling the relation in question in a material, graphic and symbolic form; 3) transforming the model of the relation for studying its properties in their original form; 4) deducing and constructing a series of particular concrete practical problems having a general method of solution; 5) controlling the preceding operations; 6) evaluating the mastering of the general method.

4.5 The results of the analysis thus far

My study started from the observation that a historical change in learning in and for production is currently taking place. In analyzing theories of organizational learning I recognized that they do not provide concepts for understanding historical change in forms of learning. I then turned to three theories concerning the historical development of forms of production, one approaching it from the point of view of general economic development, one from the historical ideal types of production and one from the perspective of management doctrines. It was through these theories that, I was able to locate the current change in learning in and for production in the transition from the period of industrial mass production to ICT-based network economy. Although these theories support the idea of historical change, they do not specifically elaborate on it.

I then took on the task of finding a method that would allow me to study historical change in learning in and for production. I chose a genetic method that involves finding the initial abstraction of the phenomenon. On the basis of cultural historical activity theory I came to hypothesize that the initial abstraction of learning in and for was the process of creating practice-relevant generalizations.

The changes and the research questions could then be analyzed as changes in the processes of producing generalizations, and more specifically as producing generalized cognitive and/or practical operations that are objectified in artifacts used as mediators in carrying out these operations. Leaning on Marton's observations I came to the conclusion that processes of generalizing require unity of sameness and variation. The sameness becomes defined by an initial generalization that defines the object of attention within which variation is analyzed. Reaching a generalization requires specific processing of the relevant variation. According to classic activity-theoretical studies, the processes and the generalizations inherent in them differ historically from each other. It was possible to identify three rough types of generalization: perceptual-functional, abstract-empirical and theoretical-genetic.

The development of the industrial form of production marginalized the previously dominant craft forms of work and also the form of learning in and for production typical of craft work. Mechanization-based industry reached its mature phase in the mass-production era of the last century. Three main models of work organization and forms of developing production were created during that period: the Taylorist Rationalization of work, Socio-Technical Systems Design and Continuous Process Improvement²⁰.

In order to further understanding of the nature of generalizing in the models, I will, in the following chapters 5–8, analyze the experiments and development processes that produced the "ancestors" of the later variants of these three forms of production and production-related learning with a view to tracing the essential general relationships of these systems in their initial, most simple form. I will follow Ilyenkov's methodological idea of revealing the nature of generalization by studying the process of its creation. I will analyze how Taylor (1911) in his experimental work created the Scientific Management model of generalizing how Trist and Bamforth came up with the idea of Socio-Technical System Design in their study of a coalmine, and how Taichi Ohno of the Toyota Motor Company created a flexible manufacturing system through sustained experimentation.

The experimenters themselves have written about their experimental activities. I will use their reports as my primary sources, and other studies on these experiments and the development of the production types as my secondary sources.

²⁰ see Figure 3.3, page 64

5 Taylor's experiments as the origin of generalizing in mass production

5.1 Taylor's works and experiments

The up-swing of the fourth Kondratiev wave was based mainly on the automobile and oil industries. At that time, cars were built of both interchangeable standard parts and hand-crafted parts. Henry Ford, who gradually eliminated all hand-crafted components in the manufacture of the Model T car, was the first truly to apply mass-production techniques. The assembly line came into being through his introduction of machines and presses that could cut, shape, and stamp out each one of the components of the car in exact measure (Womack et al., 1990). The mass -production paradigm, also called Fordism, dominated management philosophy for more than half a century.

The prerequisites of Fordism were created in the third Kondratiev wave of 1895–1940. Despite the fact that many of the original inventions for the internal combustion engine were made in Europe before the end of the nineteenth century, it was in the US automobile industry that mass production took off before the First World War. By the 1920s, the United States totally dominated the industry.

A crucial prerequisite of Fordism was so-called Scientific Management developed by Frederick Winslow Taylor (1856–1915). Taylor began working at the Midvale Steel Company in 1878 as a machinist. He became foreman of the steel-plant department and applied work study in the measurement of industrial productivity. He developed detailed systems for gaining maximum efficiency that relied on time-and-motion studies, the purpose of which was to determine the best methods for performing a task in the least amount of time. Taylor's best-known works are: "Notes on Belting", 1893; "A Piece-Rate System", 1895; "Shop Management", 1903; "On the Art of Cutting Metals", 1906; and "The Principles of Scientific Management", 1911.

In his main work, "The Principles of Scientific Management", Taylor argued strongly for the new management method he had developed. According to him, the main problem in production was "the inefficiency and waste of human workforce and material things". It was the problem that pervaded the whole country. He aimed to show that "the great loss, which the whole country was suffering" was caused by "the inefficiency in almost all of our daily acts." (Taylor, 1911, p.7)

Taylor worked within large productional units. Although the experiments he illustrated in his "Scientific Management" were from the industrial context, he hoped

(...) that the same principles could be applied with equal force to all social activities: To the management of our homes; the management of our farms; the management of the business of our tradesmen, large and small; of our churches, our philanthropic institutions our universities and our governmental departments. (Taylor, 1911, p. 8)

"The Principles of Scientific Management" consists of two chapters. The first one, "Fundamentals of Scientific Management", concentrates on the general problem of inefficiency and on the need for a new management style, and the second introduces the principles of scientific management, illustrated by his experiments, which are explained in detail. At the end of the book Taylor presents a condensed vision of a standardized production system.

In this chapter I will show how Frederick Winslow Taylor's (1856–1915) experiments, during the period of the third Kondratiev wave provided the foundations of the generalizing process that become prevalent in the era of mass production. I will first elaborate the contradictions in production that inspired his experimental work. I will then explore the nature of generalizing processes and representations in his famous experiment in handling pig iron, the principles of Scientific Management, and his vision of the planning office: my conclusion is that Taylor created *a system of work-related generalizing*, that was typical of mass production. Finally, I will explore the spreading of this system, and the limitations that drove the search for alternatives.

5.2. The sources of Taylor-type generalizing

The electrification industry was the carrier branch of the third Kondratiev wave. The core inputs consisted of steel and copper. Electricity and chemistry were also the two areas in which scientific research first began to be intimately related to industrial development. As a new flexible source of energy electricity affected factory design and layout in almost all sectors of manufacture as old steam-based power machinery was replaced (Freeman and Louçã, 2001, pp. 226–230).

The manufacturers generally understood that the indirect benefits of using unit electric drives were far greater than the direct energy-saving benefits (Freeman and Louçã, 2000, p. 230). The machines in factories using water or steam power had to be arranged along the main axis of the power supply. Electric motors made it possible for the first time to lay out the machines according to the manufacturing phases of the product (Hirschhorn, 1984, p. 10), and the new factory layouts in factories made possible big capital savings in terms of floor space. Factories could be made cleaner and lighter, and production capacity could be improved more easily. Machine tools were re-designed, handling and other production equipment was moved, and many plants and industries relocated-taking advantage of the new freedom conferred by electric power transmission and local generating capacity (Freeman and Louçã, 2000, pp. 230–231).

These changes involved two significant features: the emergence of giant firms and the introduction of professional management. The concentration was strongest in the electrical equipment industry (*ibid.*, 2000, p. 244). The growth in company size meant that large plants could be established in which the management had to control the work of several hundred workers. The changes called for new ways of organizing and controlling the workforce.

Technological innovations placed enormous strains on the decentralized management system. In some heat-using industries a shift from large batch to genuine flow production produced demands for better scheduling and coordination and inevitably, for a larger managerial staff. The growing size of the plant had a similar effect. No matter how the manufacturer sought to insulate himself from day-to-day affairs, his role in the factory, particularly in labour-management relations, inevitably increased. The obvious response was to recruit a corps of specialists. (Nelson 1980, 10)

The increased interdependence between managers and workers, the professionalization of management and the enormous growth in the number of workers caused serious problems in managing the production. Moreover, securing a fluent flow of production became increasingly important because it was the way to increase productivity and to offset the fixed costs associated with the rising capital intensity. Sustaining or improving profitability by using physical capacity more fully and controlling the flow of materials and components became a major management concern (Freeman & Louca, 2001, p. 246). Success was based more and more on product quantity and the rapidity of production flow. Taylor understood this logic of emerging mass production. He was not the only person to emphasize efficiency, however: it was in the minds of all of the managers who had invested in electric machines.

Reading Taylor in this light gives an insight into why his method was so influential. Although he was a practising engineer rather than a historian, his texts tell us about his opinions and about the historical transformation of production that was taking place at the time, because he was substantiating his arguments by revealing the problems and opportunities he saw in the industry of his day.

Electricity and mechanization opened managers' eyes to the possibility of speeding up production. This idea permeates Taylor's texts as he addresses the question of how to perform all industrial tasks as quickly and as efficiently as possible. On the other hand, he complained that managers and workers in general were not interested in efficiency.

Mechanization and electrification did not extend to all tasks in the factory, however. This fact was manifested in a particular way in Taylor's experiments, which focused mainly on tasks that required hard manual work. He worked in a steel company and the studies he reported in "Scientific Management" covered tasks such as loading heavy pig iron, shovelling large areas with spades and laying bricks. These were not the tasks involved in operating electrified mechanical machines but *the remaining manual tasks* that were carried out by great masses of men using simple hand tools. The purpose of Taylor's experiments was to speed up production and in many cases the manual tasks were bottlenecks²¹ in increasing the overall pace of production flow. Experimenting with different methods of heat treatment, Taylor and his colleagues found that a metal-cutting tool operated at maximum efficiency when run at the highest possible speed without melting the steel. Machines could thus be run in machine shops two to four times faster than before. By reducing machine times drastically this invention focused attention on the proportionately greater importance of handling times. Efforts to reduce handling time through job analysis and time study therefore were increased (Aitken, 1960, pp. 32–33). The pace of the remaining manual tasks became the threshold question in terms of electrification: it determined the overall efficiency and pace of production, which explains why they became the critical object of management's developmental activity.

Electrification brought changes into the production process:

1. The use of electric machines facilitated more fluent layouts in plants.
2. There was transition from the large batch production of many products to work-flow production of a few products.

²¹ Only one experiment dealt with 'dedicated' machine work involving cutting metal using different metal-cutting machines, especially the lathe. The experiments, which were eventually successful, lasted for 25 years.

3. The speed of the work flow became the critical factor in competition between companies.
4. The remaining manual work tasks became the major bottleneck that prevented the speeding up of the flow of production.
5. The number of workmen in factories increased enormously (giant firms).
6. Worker specialization and the number of industrial trades increased.
7. Management became a specialized profession.

My interpretation is that the first three changes supported the speeding up of work at the same time as the second three changes had an the opposite effect: the number of workers and worker specialization increased enormously, thus making the management of production more difficult and preventing its speeding up.

The traditional management tool for controlling work was the "incentive-initiative" management system, which Taylor considered to be the best way of managing at the time. It was a method whereby managers induced individual workmen to work hard and use their best initiative, skills, ingenuity and goodwill by giving them promises. The inducements were based on the hope of rapid promotion or advancement, better working conditions, and higher wages in the form of generous piecework rates or bonus payments for good and rapid work. Taylor claimed, however, that this management method was inadequate for speeding up work. He quoted one foreman:

Well, I can keep them from sitting down, but the devil can't make them get a move on while they are at work. (Taylor, 1911, p. 20)

The main obstacle in trying to speed up the pace of work was the application of traditional rule-of thumb methods: workers used their experience-based ways to determine the capacities and features of machines, the properties of raw materials, and the necessary work operations.

In an industrial establishment, which employs say from 500 to 1000 workmen, there will be found in many cases at least twenty to thirty different trades. The workmen in each of these trades have had their knowledge handed down to them by word of mouth, through the many years in which their trade has been developed from the primitive condition, in which our far-distant ancestors each one practiced the rudiments of many different trades, to the present state of great and growing subdivision of labor, in which each man specializes upon some comparatively small class of work. (ibid. 1911, p. 31)

The use of rule-of-thumb methods, which were transferred from generation to generation of workers by observation, led to very different work habits and so the workers performed the same tasks in different ways. The mechanization that straightened the layout of production and the fact that more and more tasks were done in successive order made this internal variation in individual performance increasingly a problem. The rule-of-thumb method helped to sustain the variation in the ways in which work tasks were performed, however: managers could not tighten up the work flow because they did not have access to the knowledge that had been handed down.

This mass of rule-of-thumb or traditional knowledge may be said to be the principal asset or possession of every tradesman. Now, in the best of the ordinary types of management, the managers recognize frankly the fact that the 500 or 1000 workmen, included in the twenty to thirty trades, who are under them, possess this mass of traditional knowledge, a large part of which is not in the possession of the management. (Taylor, 1911, p. 32)

The managers understood that their own knowledge and personal skills "fall far short of the combined knowledge and dexterity of all the workmen under them." "Incentives and initiatives management" left the responsibility of determining how to do the work to the workers.

The most experienced managers therefore frankly place before their workmen the problem of doing the work in the best and most economical way. (ibid., p. 32)

Factory workers operated in comparatively large groups that Taylor called "gangs". The size of the gangs, each under a single foreman, tended to remain fairly constant regardless of the amount of work. It was almost impossible for managers and foremen to find out how quickly the worker really could do the work. The gangs worked slowly because they thought that working more quickly would cause unemployment.

The fallacy, which has from time immemorial been almost universal among workmen, that a material increase in the output of each man or each machine in the trade would result in the end in throwing a large number of men out of work. (ibid., p. 15)

Taylor asserted "without fear of contradiction" that this combination of thinking and doing constituted "the greatest evil" with which working people were afflicted.

(...) because they are ignorant of the history of their own trade even, they still firmly believe, as their fathers did before them, that it is against their best interests for each man to turn out each day as much work as possible. (ibid., p. 17)

Taylor called this phenomenon under working and soldiering. The workmen were "deliberately working slowly to avoid doing a full day's work".

So universal is soldiering for this purpose that hardly a competent workman can be found in a large establishment, whether he works by the day or on piece work, contract work, or under any of the ordinary systems, who does not devote a considerable part of his time to studying just how slow he can work and still convince his employer that he is going at a good pace. (ibid., p. 21)

Taylor also maintained that under-working was in the control of the workmen themselves. If a newcomer tried to earn money the old-timers prevented it. Under the "initiative and incentive" management system the pace of work was almost entirely "up to the workmen" (ibid., p. 38).

The initiative-incentive managers' attempts to speed up the pace of work using different payment methods also seemed to lead to results that were the opposite of what was intended. Payment methods in those times were based on contracts, which were drawn up according to the number of pieces per day, or piecework. If the workers were paid "the standard rate of pay per day" for similar work, the pace was slow because the single worker did not get any benefit from working hard.

Why should I work hard when the lazy fellow gets the same pay that I do and does only half as much work. (ibid., p. 20)

The payment method itself caused soldiering and changed the workmen's attitudes to their employers.

It is, however, under piece work that the art of systematic soldiering is thoroughly developed; after a workman has had the price per piece of the work he is doing lowered two or three times as a result of his having worked harder and increased his output, he is likely entirely to lose sight of his employer's side of the case and become imbued with a grim determination to have no more cuts if soldiering can prevent it. Unfortunately, for the character of the workman, soldiering involves a deliberate attempt to mislead and deceive his employer, and thus upright and straightforward workmen are compelled to become more or less hypocritical. The employer is soon looked upon as an antagonist, if not an enemy, and the mutual confidence which should exist between a leader and

his men, the enthusiasm, the feeling that they are all working for the same end and will share in the results is entirely lacking. (ibid., p. 23)

Taylor was concerned about the relationships between managers and workmen, and disapproved of the opposition between them. He maintained that it was impossible to control the work with the prevailing management methods, which, on the contrary, even caused soldiering. The work methods were based on rules of thumb, which inhibited control. The only solution to this contradiction was to "change from rule-of-thumb management to Scientific Management" (ibid., p. 100).

Taylor conducted and recorded in all 30,000–50,000 experiments as he tried to introduce to and convince managers of the superiority of his system. According to Callahan (1962, p. 40), he was an outstanding scientist and creative thinker. When administrators attempted to bring his system into schools, for example, they showed no real interest in or ability to carry out such painstaking research. Taylor's exceptional stamina in research manifests itself in his most famous experiment, the rationalization of pig-iron handling. I will show in the following how the new way of producing generalizations concerning work methods took shape in this experiment.

5.3 Experimental change in the way of handling pig iron

Before the Spanish War, the price of pig iron was so low that the Bethlehem Steel Company could not sell it at a profit. The produced iron was therefore transported to a storehouse until the climate improved. Taylor took the situation as a challenge to show the workers, managers and owners the advantages of his method. This, probably the best-known of Taylor's experiments, is a good example of how he dealt with the work tasks that had remained outside of mechanization. The workers were used to handling the products that were made in the company blast furnaces using only their physical strength: a group of 75 pig-iron handlers did the work.

They were good, average pig-iron handlers, who were under an excellent foreman who himself had been a pig-iron handler, and the work was done, on the whole, about as fast and as cheaply as it was anywhere else at that time. (...) A railroad switch was run out into the field, right along the edge of the piles of pig iron. An inclined plank was placed against the side of a car, and each man picked up from his pile a pig of iron weighing about 92 pounds walked up the inclined plank and dropped it on the end of the car. (Taylor, 1911, p. 42)

According to Taylor's calculations, the men were loading on, average, about 12.5 long tons per man per day. After further study, he and his assistants came to the conclusion that a first-class pig-iron handler ought to handle 47 - 48 tons per day. These calculations preceded Taylor's period of experimentation that lasted for many years. By studying separate work movements, he endeavored to establish a law concerning the tiring effect of heavy laboring on a workman.

The law is confined to that class of work in which the limit of a man's capacity is reached because he is tired out. It is the law of heavy laboring, corresponding to the work of the carthorse, rather than that of the trotter. (ibid., p.57)

Taylor defined this type of work as moving a heavy thing from one place to another using the force of the worker.

Practically all such work consists of a heavy pull or a push on the man's arms, that is, the man's strength is exerted by either lifting or pushing something, which he grasps in his hands. (ibid., p. 57)

Taylor's aim was to find a law that would "enable a foreman to know in advance, how much of any kind of heavy laboring work a man who was well suited to his job ought to do in a day; that is, to find a standard for the work performance and to study the tiring effect of heavy labor upon a first-class man" (Taylor, 1911, pp. 53-54). He pointed out that he was not "trying to find the maximum work that a man could do on a short spurt", but to study what really constituted a "full day's work for a first-class man; the best day's work that a man could properly do, year in and year out, and still thrive under" (ibid., p. 54).

Taylor selected two strong men for the experiment and set three conditions: double payment, the promise from them to do the work as best they could, and a lay-off condition. A young college man conducted these experiments using recordings and a stopwatch, and gave the men different tasks²².

(...) a young college man (...) who at the same time noted with a stop-watch the proper time for all of the motions that were made by the men. Every element in any way connected with the work which we believed could have a bearing on the result was carefully studied and recorded. (ibid., p. 55)

²² Taylor did not specify the kind of tasks.

Taylor's purpose was then to determine what fraction of one horsepower a man was able to produce, in other words how many foot-pounds of work he could do in a day. Applying contemporary laws of mechanics (these laws are no longer deemed valid in modern physics), he and his assistants tried to work out the law of the tiring effect of heavy labor. Finally, after two failed attempts, they succeeded after enlisting the help of a mathematician in analyzing the data using graphical plotting curves.

We decided to investigate the problem in a new way, by graphically representing each element of the work through plotting curves, which should give us, as it were, a bird's-eye view of every element. In a comparatively short time, Mr. Barth had discovered the law governing the tiring effect of heavy labor on a first-class man. (ibid., p. 57)

The law enabled Taylor to determine the percentage of work hours in a working day that was needed for loading and for rest. For example, in the case of pig iron "a first-class workman" could be under load only 43 percent of the day and should be entirely free from load 57 percent of the time. The new law made it possible to calculate the quantity of work a first-class man could do a day if the load were lighter. If he were handling half pig iron, work under load should constitute 58 percent and the rest 42 percent of the day. Another law had to be determined for much lighter work.

As the weight grows lighter the man can remain under load during a larger and larger percentage of the day, until finally a load is reached which he can carry in his hands all day long without being tired out. When that point has been arrived at this law ceases to be useful as a guide to a laborer's endurance, and some other law must be found which indicates the man's capacity for work." (ibid., p. 58)

This law made it possible to measure and determine *standard* performance, that is the output that could reasonably be expected from a workman using the right working method.

It was our duty to see that the 80,000 tons of pig iron was loaded on to the cars at the rate of 47 tons per man per day, in place of 12.5 tons, at which rate the work was then being done. And it was further our duty to see that this work was done without bringing on a strike among the men, without any quarrel with the men, and to see that the men were happier and better contented when loading at the new rate of 47 tons than they were when loading at the old rate of 12.5 tons. (ibid., pp. 42–43)

In order to test the law he had developed, Taylor and his assistants sought out four physically and culturally appropriate individuals from the 75 men working in the department. The researchers checked the men's history and made "thorough inquiries" into their characters, habits and ambitions (ibid., p. 54). Finally, they selected a man for the test whom they started to call Schmidt.

He was a little Pennsylvania Dutchman who had been observed to trot back home for a mile or after his work in the evening; about as fresh as he was when he came trotting down to work in the morning. We found that upon wages of 1.15 a day he had succeeded in buying a plot of ground and that he was engaged in putting up the walls of a little house for himself in the morning before starting to work and at night after leaving. He also had the reputation of being exceedingly "close," that is, of placing a very high value on a dollar. As one of whom we talked to about him said, "A penny looks about the size of a car wheel to him." This man we will call Schmidt. (ibid., p. 45)

The recorded notes on the men involved in this "scientific selection of workmen" contained an evaluation of how well each man was suited to the experimental purpose. The worker's habits and values concerning their activities outside of work were also recorded.

Taylor had planned how to persuade Schmidt to agree to the experiment. He told him that if he agreed to be tested as a "first-class workman" he would be paid 1.85 dollars instead of his present 1.15 dollars if he followed the experimenter's orders. He consciously neglected to explicate the quantity of work to be done in the experiment, as he supposed the "incentive and initiative" manager would do that, but directed Schmidt's attention to the higher wage instead of the work performance. Obedience to the experimenter's orders and the cover-up of the higher work goals with talk of higher wages were mentioned as rules of the experiment.

Taylor characterized the person whose work he was trying to speed up in a rather inhuman way. He assumed that for simple work there were simple workmen, and that those who did simple work were simple. He compared the requirements of a worker to the qualities of an ox or gorilla.

The man who is mentally alert and intelligent is for this very reason entirely unsuited to what would for him be the grinding monotony of work of this character. Therefore, the workman who is best suited to handling pig iron is unable to understand the real science of doing this class of work. (ibid., p. 59)

As is made clear later this inhuman attitude to workers was connected to Taylor's purpose of making a clear distinction between workers and researchers. The workers had to obey the experimenter's orders.

When he tells you to pick up a pig and walk, you pick it up and walk, and when he tells you to sit down and rest, you sit down. You do that straight through the day. And what's more, no back talk. Now a high-priced man does just what he's told to do, and no back talk. (ibid. p. 46)

The experiment succeeded. Schmidt worked when he was told to work and rested when he was told to rest. He loaded 47.5 tons in the first day and on the following days. He worked for three years in the same way and received the same higher payment all the time. One man after another was picked out and trained to handle pig iron at the rate of 47.5 tons with the same wages. One man in eight was physically capable of handling this amount per day. The men who did not succeed were transferred to other work in the same plant. For Taylor, this was part of the "scientific selection" of the men. The purpose was not to find an extraordinary individual, but merely to pick out from ordinary men the ones who were especially suited to the type of work under investigation.²³

Three features in the way in which Taylor presented the object of his research stand out. First, he separated the performance of the individual worker from the performance of "gangs" in his experiment because "each workman had his own special abilities and limitations, and since we are not dealing with men in masses, but are trying to develop each individual man to his highest state of efficiency and prosperity." Second, he defined work as "push and pull" operations carried by individuals (Taylor, 1895, pp. 172–176). He claimed that work as push and pull permeated all industrial work, but because it had a specific character in each trade it had to be researched separately. Third, the experiment brought to the work situation a new social subject, the experimenter, who used special tools for collecting and analyzing data on push-and-pull work. The experimenter also gave rules to the workmen and expected them to obey them in the smallest detail. The workers' knowledge of the work was not used. The experimenter's task was to objectify the work as movements that were either necessary or unnecessary, to be eliminated or used, to load or to rest. In this sense, the experimental method itself was already an important part of the new structure of management and type of generalizing that Taylor developed. *Taylor's experimental method detached work-related generalizing from the context of direct work in separate steps, to goal-directed actions of generalizing in which the tasks of the experimenter and the subjects differed.*

²³ Taylor's contemporaries criticized his experiments and ideas strongly. The language that he used in describing the pig-iron handler as 'mentally sluggish' led to fear and anxiety among the laborers. Labor leaders and humanitarians were first shocked and then indignant at the way in which Schmidt had been treated. Some of the proponents of scientific management refrained from using Taylor's name. Labor leaders also had suspicions that Schmidt had died because of Taylor's experiments. The man was located, and Taylor had him examined by a physician who declared him to be healthy and thriving. (Callahan 1962, p. 39)

The pig-iron handling experiment consisted of eight steps in which the initiator was always the experimenter:

1. defining the work task to be studied;
2. recording and conducting experiments with the optimal pace of work performance using a stop watch;
3. analyzing the data with the help of mathematical curves and physical laws;
4. finding "the law of heavy laboring" using plotting curves, simple mathematics and physical laws;
5. creating the standard for a specific task applying the law as the experimenter's verbal orders to the worker;
6. selecting a worker who could take part in the test using particular criteria;
7. testing the standard on an individual;
8. using the tested standard as a tool for permanently controlling the worker's performance and extending it to other workers.

These steps fall into five types of actions of generalizing. The first type concerns identifying the work task to be studied. The second type (step 2) incorporates experimental variation in the method and recording performance speed in the given work. The third type (steps 3–4) involves determining the law of the task type and the fourth type (step 5) concerns analyzing the data in order to construct the standard. The fifth type (6–8) is to do with testing the standard and conveying the resulting instructions to other workers doing similar work. In the following, I will elaborate on how these types of actions of generalizing tally with the general principles of scientific management.

5.4 The written standard as a carrier of generalization

Taylor (1911, p. 151) described his Scientific Management in terms of four principles:

1. the development of a true science;
2. the education and development of the workmen;
3. the scientific selection of workmen and
4. friendly cooperation between the management and the men.

He maintained that single "elements", such as time study, could not be implemented if the principles were not understood and study had to follow them. In order to present a broader picture of Taylor's doctrine, I will now briefly describe each principle.

The principle of the development of true science was connected to Taylor's claim that management had to be based on scientific laws of work. The prerequisite here was the time-and-motion study, which he defined in five general steps.

First. Find, say, 10 or 15 different men (preferably in as many separate establishments and different parts of the country) who are especially skilful in doing the particular work to be analyzed.

Second. Study the exact series of elementary operations or motions which each of these men uses in doing the work which is being investigated, as well as the implements each man uses.

Third. Study with a stop-watch the time required to make each of these elementary movements and then select the quickest way of doing each element of the work.

Fourth. Eliminate all false movements, slow movements, and useless movements.

Fifth. After doing away with all unnecessary movements, collect into one series the quickest and best movements as well as the best implements. (ibid., pp. 117–118)

The procedure describes the construction of standards. It corresponds to the chain of actions in generalizing described in the previous section, although teaching and permanent control of performance are missing, as is "the general law of heavy working". In the procedure set out above, defining the standard is the more practical process of eliminating false movements from the work method. Taylor's experiments mainly focused on these practical processes while the processes needed in creating a "law" that would be applicable to many work tasks were exceptions

He also considered work implements important objects of standardization.

Scientific management requires, first, a careful investigation of each of the many modifications of the same implement, developed under rule of thumb; and second, after a time study has been made of the speed attainable with each of these implements, that the good points of several of them shall be united in a single standard implement, which will enable the workman to work faster and with greater ease than he could before. This one implement, then, is adopted as standard in place of the many different kinds before in use, and it remains standard for all workmen to use until superseded by an implement which has been shown, through motion and time study, to be still better. (ibid., p. 118)

Here, Taylor was emphasizing the use of existing variation in methods and implements as the basis of developing optimal solutions. The purpose of the time-and-

motion study is to develop the standard that defines the optimal solution of performing a given work task. The standard could then be transferred from researcher to worker, from one workplace to another, and from one person to another.

The second principle of scientific management concerns the teaching of standards to the workers.

This one new method, involving that series of motions, which can be made quickest and best, is then substituted in place of the ten or fifteen inferior series which were formerly in use. This best method becomes standard, and remains standard, to be taught first to the teachers (or functional foremen) and by them to every workman in the establishment until it is superseded by a quicker and better series of movements. (ibid., pp. 118–119)

Taylor emphasized the "task idea" in his instructions to the workers. He explained the standard and the wage system that gave additional reward, a bonus in addition to their ordinary wage, paid for working according to the standard. In the case of handling pig iron, the standard was set according to the experimenter's orders. It was normally in the form of an instruction card on which were the written instructions: the details of the workman's task, "not only what is to be done but how it is to be done and the exact time allowed for doing it".

The third principle, the scientific selection of workers, referred first to how the workers were chosen to participate in the experiments and in the testing of the standards, and later to carry out the specific task. Instead "of allowing the workmen to select themselves", the management had to select the best men according to their suitability for regular everyday tasks.

The fourth principle, friendly co-operation between individual workers and management, was based on Taylor's idea that standardization could not succeed without co-operation, trust, and "harmony" between workmen and planners. The responsibility for this co-operation rested with the management. If this was not reached, however, in an extreme case the task of the management, was to *enforce* cooperation.

Nor has any one workman the authority to make other men cooperate with him to do faster work. It is only through *enforced* standardization of methods, *enforced* adoption of the best implements and working conditions, and *enforced* cooperation that this faster work can be assured. And the duty of enforcing the adoption of standards and of enforcing this cooperation rests with the *management* alone. (ibid., p. 83)

It is not difficult to see the crucial role of standards in these principles: all four principles refer to constructing or using standards. They made the management "scientific".

5.5 The vision of the planning-office system

In order to systematically master and control work performance Taylor presented a model in which the foreman's previous actions were taken care of by a special *planning department*.

The shop, and indeed the whole works, should be managed, not by the manager, superintendent, or foreman, but by the planning department. (Taylor, 1914, p. 110)

The planning officials, who Taylor also called functional foremen or teachers, had to work in the planning office, separate from the workers. They specialized in certain aspects of work according to a functional division of labor. The duties previously carried out by a single foreman were now split up among several officials.

For with the installation of functional foremen, a planning department automatically comes into existence, and the separation of the planning of the methods of doing the work from the doing of the work itself is immediately accomplished. (Taylor, 1911, p. 95)

Each of these planning officials was a specialist in the particular line to which he was assigned, and he was trained to the highest level of efficiency in discharging the particular duties of that line.

Under functional management, the old-fashioned single foreman is superseded by eight different men, each one of whom has his own special duties, and these men, acting as the agents for the planning department (...) are the expert teachers, who are at all times in the shop, helping and directing the workmen. Being each one chosen for his knowledge and personal skill in his specialty, they are able not only to tell the workman what he should do, but in case of necessity they do the work themselves in the presence of the workman, so as to show him not only the best but also the quickest methods. (ibid., pp. 123–124)

Taylor gave three types of justification for dividing workers' and planners' tasks. The first was the one he used in the pig-iron case: the workmen must have been "stupid or sluggish" because they had chosen that kind of work. The other two were more interesting. Even if the workmen did have the opportunity to study their own work themselves, the nature of the study required cooperation between two men, the one who performed the work and the one who measured it. Taylor also believed that the personal interests of the workmen would inhibit them from objectively articulating the outcomes of the studies. (Taylor, 1911, pp. 103–104)

Taylor imagined that the planners would be experts who would stay in the shop all the time helping and directing the workmen. Their task was to show the workmen the best and quickest working methods. The inspector helped them to follow the instructions, the gang boss taught them the best and quickest way to do the work, the speed boss saw that the machine was run at the optimum speed and that the proper tool was used so as to enable the machine to finish its product in the shortest possible time. The workmen also received orders from specialists such as the "repair boss", "the time clerk", the "route clerk" and the "disciplinarian".²⁴ It was their duty to control how the workers followed the standards, because "workmen, if left to themselves, would pay but little attention to their written instructions."

The task idea affected single workmen in another way, too. The time studies made it possible to break down the tasks that had evolved during the history of the plant. Thus they also had an impact on the structure of the trade and on production flow.

The man in the planning room, whose specialty under scientific management is planning ahead, invariably finds that the work can be done better and more economically by a subdivision of the labor; each act of each mechanic, for example, should be preceded by various preparatory acts done by other men. (ibid., p. 38)

As Taylor noted repeatedly, his main interest was neither in the experimenting nor in the production of knowledge as such, but *in the permanent practical use* of the standards for achieving the great ideal of efficiency and maximum output. The initiative and the responsibility for performing the necessary actions rested with the planners.

5.6 The actions of generalizing in Taylor's system

The three first industrial revolutions described by Freeman and Louçã (2001) brought a change in the tools of production from individual hand-used implements to collectively used machines. The increasing use of machines in industry did not destroy the craft tradition, however. The workers who used mechanical tools were skilled and highly respected machine operators. Although the industrial revolutions essentially changed the primary artifacts of production, the secondary artifacts, rules-of-thumb, still represented craft-type work.

²⁴ Taylor (1911; 1914) refers in most cases to eight functional task performers: order-of-work-route man, instruction-card man, time-and-cost clerk, disciplinarian, gang boss, speed boss, repair boss and inspector.

Taylor developed four new kinds of actions of generalizing: 1) identifying and determining a task in industrial work as the object of time-and-motion study, 2) recording the variations in the ways in which the workers performed the task, 3a) comparing the variants and connecting the best variants into a standard method or 3b) in special cases determining the law that was applicable to similar kinds of tasks, and 4) testing and teaching the standard.

The first actions involved choosing "a particular work task to be analyzed". Taylor advised the planners to identify a task or a class of tasks within the industrial activity. In order to do that they had to search for similarities between tasks and to classify them. They started by identifying a class of tasks that were similar enough among the variations of industrial work to be treated as "a task" and then they made comparisons in order to identify the major similarities and differences of the work in the factory.

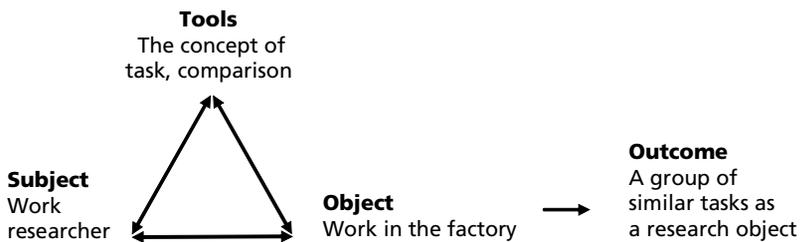


Figure 5.1 The action of identifying a "task" to be investigated

The second group of actions of generalizing involved recording the variation of form and time in the motions used by a set of individuals in performing the task, with a view to finding a basis for selecting the best movements. This requires from the researcher the competence to identify different movements involved in the performance. In setting up time and motion studies, the variation in the time needed to perform the motions and the "elementary operations" could be artificially speeded up, as in the pig-iron example, but it could also be studied in the normal work setting in the way Taylor described as the general procedure for time-and-motion studies. The other tools used by the work researchers in these actions were inherited from traditional mechanical research: a stopwatch, other measuring instruments, and notebooks. Taylor also described how, in the planning-office system, the "scientific" experimentation itself became an important set-up that mediated the relationships between workers and planners. It was the work researcher who took these actions. The workers' role was to adapt to the set-up as on object of research.

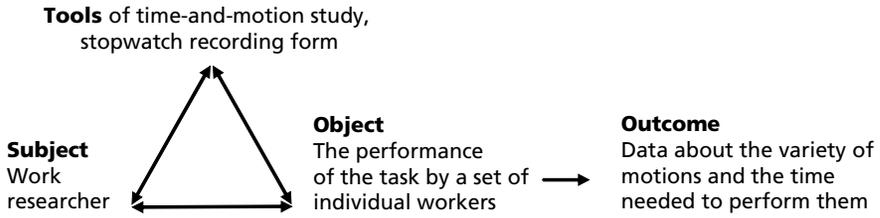


Figure 5.2 The action of measuring and documenting the variation in movements

The third type of actions of generalizing were aimed at constructing the standard. They involved methods for comparing the documented variation in the quality and duration of work movements and usually took only a short time (3a). The comparisons between different ways of doing the task could be made in a very simple way by eliminating false, slow, or useless movements. In special cases (3b) these actions involved determining the "law" of tasks required for defining the standard. These were cases in which the methods were based on the natural sciences; mechanics, mathematics, and physics. In Taylor's practice the simple way (3a) had a prior claim, and here actions 3a and 3b were taken by the researchers outside of the actual work situation in the planner's office. The workers had nothing to do with them.

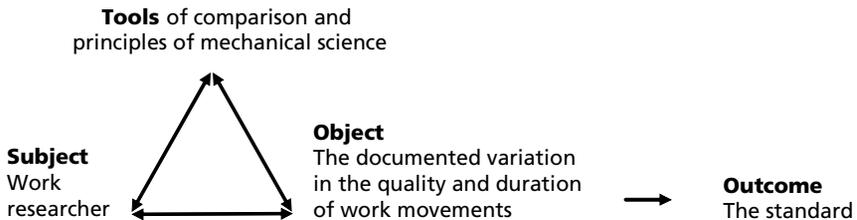


Figure 5.3 The action of constructing the standard

The fourth kind of action of generalizing consisted of testing and implementing the standard in the production process. The planner, now in the role of teacher, used it as a tool when instructing a selected worker to do the task in the best way. In the planning-office model, instruction and control becomes the everyday practice of the planners. The standard serves first as a tool of instruction and is then adopted permanently as the basis of determining the pay of the worker and the possible bonus he gets when exceeding it.

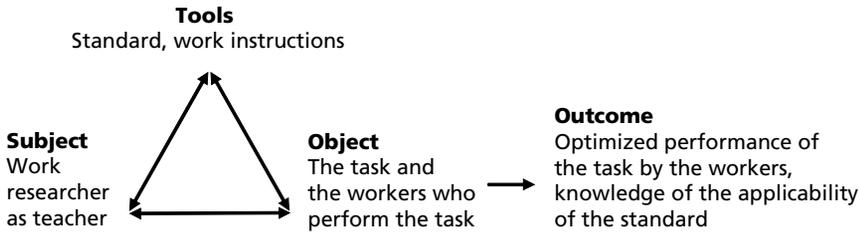


Figure 5.4 The action of testing and teaching the standard with regard to a predetermined class of individual tasks

All these four kinds of actions were carried out by the planners who were, in Taylor's model, experts responsible for creating generalizations concerning optimal ways of performing work tasks. The workers had to adopt and follow the standard. The method of extending the standard was to instruct workers individually one after another.

Taylor acknowledged the fact that, in certain cases the workmen were allowed to suggest improvements, and could also use standards as yardsticks of "their own progress". All of the improvement initiative had to be analyzed by management, however.

Every encouragement, however, should be given him (the worker) to suggest improvements, both in methods and in implements. And whenever a workman proposes an improvement, it should be the policy of the management to make a careful analysis of the new method, and if necessary conduct a series of experiments to determine accurately the relative merit of the new suggestion and of the old standard. And whenever the new method is found to be markedly superior to the old, it should be adopted as the standard for the whole establishment. (Taylor 1911,83)

5.7 Standardizing work methods as a distributed system of generalizing

Work-related generalization before Taylor

In traditional craft production there was always some variation in work that made it possible for the craft worker to compare the relative efficiency of the tools and methods as well as the requirements set by different materials. On the basis of such observations they made incremental changes in the tools and methods of work.

Possible outcomes included improvements in the instrument, in knowledge of the raw material, in the design of the end product, and in the knowledge of the workers performing the operation. This knowledge was preserved in the rule-of-thumb method used in planning the work and in the forms of equipment.

The skills needed in the craft were transferred to the next generation within the "set-up" of guilds, in master – apprentice relationships. The rules of thumb could only be transferred in the immediate context of the work practice because the details of the process were explicated only vaguely. The gradual development of new generalizations was partly a by-product of the production, and partly a result of the actions of designing and testing tools. Those fixed in tools or rules of thumb were largely results of incremental improvements and only exceptionally of *specific conscious actions* of generalizing, although conscious experimenting was not completely alien to craft work (Thurnbull, 2000). Although the craft workers' tools were simple, the necessary skills and knowledge were mastered in general apprenticeship, which lasted for many years.

The form of perceptual functional generalizing described above also continued *in the late craftera*. The work to be done was defined by contract, and the rules of thumb had an important role in the negotiations between employers and employees, and in the use of machines. The immediate employer of many workers was not the entrepreneur but an intermediary, a contractor who had a contractual relationship with the entrepreneur and the laborers. The contractor hired, supervised and fired the workers against the lump sum of money he received from the manufacturer as the work was completed and in turn made a contract with the representatives of the worker groups (Littler 1982, p. 65). In the manufacturing industry, the contracts were in the form of general piece-work agreements covering the work and division of labor of dozens of workers. These agreements were based on estimations about the amount of work needed that were based on rules of thumb.

This tradition-based pattern of work-related generalizing in industrial production prevailed during the three first Kondratiev waves when the major changes were based on mechanization. Machines took the place of hand tools as the primary artifacts of production. Workers adopted the use of machines as they had previously adopted the hand tools of their craft. However, improvements no longer depended on the skills of the individual workers, but rested with the skills of the engineers and technicians who designed and maintained the machines.

The operations of individual workers in electrified factories were more closely linked than in production driven by steam or waterpower machines. Work operations were increasingly arranged in successive order according to the production process. As the individual operations carried out by workers in different positions on the production line thus became interdependent of each other, the broad variation in individual performance began to hinder the process.

As the integration of the production process proceeded, the form of tradition-based perceptual-functional generalizing described above became increasingly problematic. Taylor was the experimenter and ideologist who became the leading figure in constructing a new form of work-related generalizing. He replaced rules of thumb with standards, and thus introduced a new type of secondary artifact to production.

The Distributed system of empirical generalizing

The process of generalizing that Taylor developed to create work standards was based on two forms of *empirical generalization*. He was able to do this only after creating a new unit of analysis and development, the *work task*, which consisted of the various push and pull movements needed to accomplish an objective in production. First, he searched for similarities in and differences between tasks in order to classify them. He saw a work task as a class of actual tasks performed by different individuals at different times that were similar enough to be subsumed under the same category and treated as one. Second, he recorded and compared the variation in the elements of the task, and created the best method by combining the best elements with the production process. The standard fixed the generalization concerning the best method of carrying out the specific task in question.

When men, whose education has given them the habit of generalizing and everywhere looking for laws, find themselves confronted with a multitude of problems, such as exist in every trade and which have a general similarity one to another, it is inevitable that they should try to gather these problems into certain logical groups, and then search for some general laws or rules to guide them in their solution. (Taylor, 1911, p. 103)

Taylor assumed that the standard was generally applicable to all of the individual manifestations of the task. He was also convinced that general laws concerning human beings would emerge if only the research was carried out in a valid way.

It is true that the laws which result from experiments of this class, owing to the fact that the very complex organism – the human being is being experimented with, are subject to a larger number of exceptions than is the case with laws relating to material things. Yet laws of this kind, which apply to a large majority of men, unquestionably exist, and when clearly defined are of great value as a guide in dealing with men. In developing these laws, accurate, carefully planned and executed experiments, extending through a term of years, have been made, similar in a general way to the experiments upon various other elements which have been referred to in this paper. (ibid.,)

Taylor's system replaced the perceptual-functional generalizing of the late craft period with four phases of empirical generalizing, which started from defining the task. The separate tasks comprising all work in industrial production became objects of time-and-motion study. The task was an abstraction: the production was considered to consist of tasks. Those that were identified were then divided by the planners into the smallest units, movements, the variation in which was studied and recorded with the help of a stopwatch, and notebooks in the experimental set-up. Studies of the variation in ways of performing a task could be carried out with quite simple tools, but they also called for the application of the procedures and principles of mechanics.

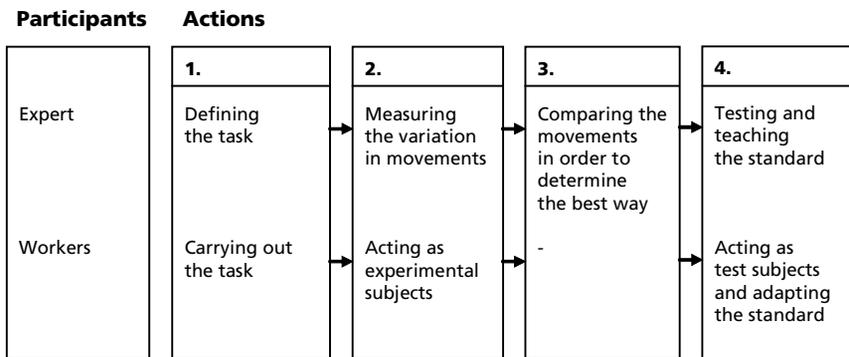


Figure 5.5 The pattern of empirical generalization in creating a standard for a work task

These phases of empirical generalizing are referred to repeatedly in mass production as some parts of process are changed or renewed. The actions of generalizing and the way they are distributed among different actors together form the *distributed system of producing work-related generalizations* in industrial production. This would not have been possible without the innovation of describing the task in the written form, with the standard that started to function as a *secondary artifact*. The system also provided the mode of learning, which Bateson called *second-level learning*. All of the actions of generalizing were taken by the experts, while the workers had the role of experimental subjects. The horizontal line in Figure 5.6 shows the *bifurcation of learning in and for production*.

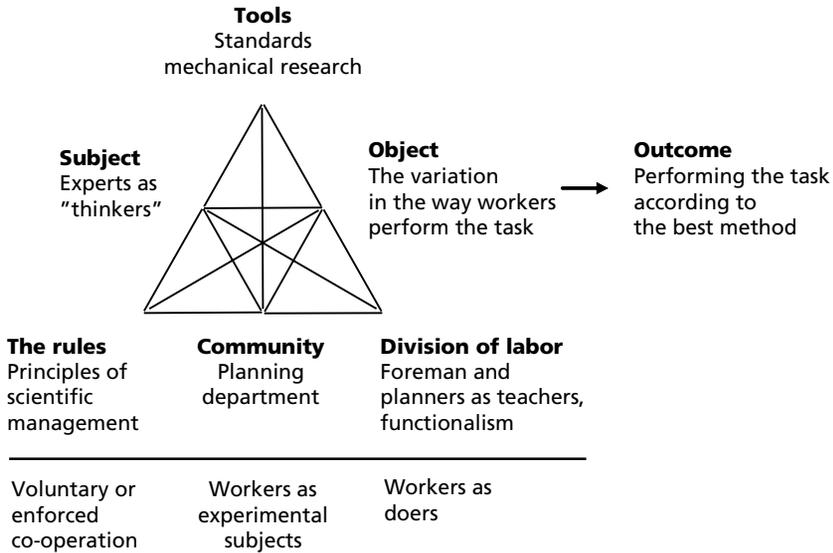


Figure 5.6 Features of the distributed system of generalizing

The spreading of the distributed system of generalizing

According to Taylor (1911, p. 28), at least 50,000 workmen in the United States were employed under his system, which was complemented and renewed through the inventions created in the Ford automobile factory in Highland Park.

Ford’s vision was to produce a car for the masses. For this he had to plan every task of the assembly line and determine and plan the passage of each part of the car on it. The assembly line changed shop-floor operations dramatically. The work that had been done earlier by two to five mechanists was divided between 84 of them. This restricted the workers’ actions to mechanical operations. While a typical series of repeated operations of an individual worker took an average 514 minutes in traditional work, in the new standardized system it took only 1.19 minutes (Womack, 1990, pp. 27–28).

Although carrying out these operations required some instruction, the workers adopted the movements very quickly. This made it possible for Ford to employ cheap labor. The majority, 71 percent, of the workforce in his factory in 1914 consisted of migrant workers from 22 countries (Meyer 1981, p.77). The labor turnover in his manufacturing plant rose to 1,370 percent, and absenteeism to 10 percent (ibid 1981, pp. 53–56). By way of response, Ford drastically increased the number of foremen: in 1914 there was one foreman per 53 workers, but three years later one foreman was responsible for 15 workers. The foremen’s main task was to control the standards and keep the assembly line continuously moving.



Figure 5.7 The Planning Department at the Midvale Steel Company. (Hughes, 1989)

The mass production that started with the automobile production in the USA spread from the US to Western Europe, the Soviet Union, Japan, China, and the rest of the world. It also spread to other branches of production and entirely changed production activities within a short space of time. (Freeman and Louçã 2001; Callahan 1962; Julkunen, 1987).

The spreading of mass production increased the significance of the kind of actions of generalizing that Taylor developed. Rationalizing and standardizing the production process enabled management to continuously cut unit costs, which was the essential challenge (Yelle, 1979). It was also a prerequisite to determine in advance the progress of the components on the assembly line and to plan the standards for the work tasks. Taylor's method of generalizing was needed for this.

The limitations of Taylor-type generalizing

The standards that are empirical generalizations represent an average that necessarily leaves out of consideration some relevant variation in the task. The more variation there is in the conditions of the task, the more important it is that the

actor identifies the essential elements and varies his or her performance accordingly.

Taylor studied work tasks in which the object of the work remained constant such as the loading of pig iron, the stacking of bricks, and the shovelling of sand. The empirical generalization that was objectified in the work standard was rooted in the tools, the rules, the division of labor and the community in a form that corresponded to average conditions. The benefit of this kind of system was in managing predictable industrial tasks, but the limitations became apparent if there was much variation in the object of the work and the conditions.

The application of mass-production principles did not stop workers from learning and making generalizations, although they made them unofficially and even against regulations. The planning of operations in advance prompted the workers to take actions that either strengthened or weakened the plan. Hughes (1989, p. 197) reported that workmen created standards themselves because they felt that the planners could not, as outsiders, understand the demands of the work processes, and that they set unrealistic standards.

Shaiken (1986) described how the machinists on the shop floor could use their own notebooks in order to help them overcome problem situations. The information in these books complemented the planners' actions.

The process planner has the key role of determining how a part is made, selecting the processes the tools, the machines and the sequence of operations. There is of necessity a close relation between the planner and the machinist. When a new job comes in, for example, the planner might go down to the shop floor and chat with the machinist about how a similar job was routed a few weeks ago. Any self-respecting senior machinist has a legendary "black book" that records the problems encountered and shortcuts discovered on previous jobs, usually in some indecipherable shorthand. That carefully constructed knowledge, however, is the property of the machinist, enriched over time, and very much part of the worker's control over production. (Shaiken, 1986, p. 54–55)

Adler (1993, pp. 143–144) documented a third type of worker action in which the original idea of the participant's role in standardizing was reversed, according to one union representative's description. We could call these actions "actions of pretending" or "actions of mutual cheating".

In most plants, management assumes the "divine right" to design jobs as they see it. And in the U.S. auto industry, workers have historically agreed to that in exchange for high wages. Management was willing to pay a ton of money to the workers to preserve its prerogative. But in practice, the old way of setting

standards was just ridiculous.²⁵ An industrial engineer (IE) would shut himself away in an isolated office and consider how long it took for somebody to twist their wrist and move their arm in such and such a way, and calculate times from some manual and try that way to come up with a task design. The IE would take this "properly" designed job to the foreman. The foreman would nod his head, but then said "screw you" to the IE's back and redesigned the task to his own liking. Then he would take this task design to the worker and say "Do it this way or you're out". The worker would nod but would pull the same trick on the foreman. In the end, the job got done however the worker could. When the boss walked by, the worker might pretend to do the job the way the foreman had told him. Everybody involved knew this was going on but no one cared enough to do anything about it.

Multiply that game by the number of shifts and the number of different people involved and you've got a process you can't control. You can't build a quality car like that. You can't even go back and improve the process because the IE lives in a dream world, does not have a clue how the job is actually done and doesn't have any impact. The foreman's impact is also zip. Nobody talks to the worker even though he is the one guy who can do something about the problem. Nobody wants to listen to him. That's basically how most of the auto industry operates even today. So you can see why standardized work is so revolutionary. And why most IEs are uncomfortable with it!

Paul Adler and Kim B. Clark analyzed the interaction between engineers' and workers' learning processes in Taylorist production in a firm producing electronic equipment. According to them, workers' direct labor represents first-order learning that is based on repetition and on the incremental development of skills. Second-order learning, which is based on indirect labor, takes place as engineers transform the production by changing the technology and the production processes. This second-order learning may be based on information gained from production or on knowledge acquired from other sources (Adler & Clark, 1991, pp. 267–270).

Adler and Clark (*ibid*, pp. 278–279) found that engineers' and workers' learning processes could be both mutually supportive and disruptive. In order to solve problems in production, engineers take actions that may have temporarily sizable,

²⁵ The interview was conducted after the union representative had experienced different standardization procedures in flexible production. The 'old way' of setting standards refers to the time before the standardization method was used in 'lean' production.

negative effects on performance and make the workers' learning obsolete. On the other hand, the problems that emerge in first-order learning can cause problems to second-order learning because the workers do not get feedback on the adequacy of the solutions they have created. Adler and Clark's study demonstrates the new, complex relationship between direct and indirect work and first- and second-order learning.

5.8 Assessing change in generalizing

In my view, Taylorism represented an intermediate phase between late-craft work and Fordism. During the late-craft period the raw material was handled successively using manual tools, and the workers' knowledge still determined the details of the tasks. The workers had to have a conscious idea of the result of the part of the work they were carrying out. This detailed knowledge also dominated their communication. The type of generalizing involved was still based on the kind of organization in which the labor consisted of both specialized bodies and trained minds, and rested on the technical knowledge and skill possessed by the workers themselves.

It is also possible to characterize the qualitative change from production-related generalizing fixed in craft-based production to Taylor-type distributed systems of generalizing as expansive transition (Engeström, 1987). Taylor questioned the late craft-based system in his criticism of the "incentive-initiative" management system of 1880–1915. He analyzed the reasons behind the inherent problems, focusing on the pace of production flow and on how the managers could increase it. He modelled the new system of management in his experiments and texts, which was further developed in the light of Ford's inventions and mass-product vision. The worldwide implementation of the new system of generalizing took place with the spreading of mass production during the upswing of the fourth Kondratiev wave in 1945–1960.

The saturation of the markets for standard products and the oil crisis led to changes in the original model of mass production in many areas, and to the development of two alternative forms of production in the 1970s that challenged the original model.

These new forms of mass production were spreading all over the world: Flexible Production with its focus on continuous improvement, and Socio-Technical Systems Design that used semi-autonomous teams. In the following chapters I will show how these methods of organizing work production provided an alternative to the Taylorist system of generalizing.

6 Trist and Bamforth's study as the origin of the socio-technical form of generalizing

6.1 Socio-Technical Systems Design as an umbrella framework for developing production

The oil crisis in the 1970s provoked a lively discussion about alternatives to Taylorist work organization, and by the end of the twentieth century two rival and in many ways opposing potential production models emerged: socio-technical and lean production. In this chapter I will analyze the origin and form of generalizing in Socio-Technical Systems Design with a view to identifying the germ cell that typifies socio-technical production. I will first give an overview of STSD, and then I will chart the progress of Trist and Bamforth's ground-breaking study on the transformation from craft-based coal mining to the mass production of coal. I will analyze how the problems that the implementation of mass-production principles created in the mine were handled, and further consider Trist and Bamforth's solutions from the perspective of work-related generalizing. In this I will follow the line of theoretical discussion that led to the idea of the joint optimization of social and technical systems and to the first socio-technical design method of work organization to be widely used in practice. Finally, I will show how the use of socio-technical work design and semiautonomous teams has spread, and summarize the results of the analyses.

STSD is usually introduced by presenting its main principles. However, its proponents define the principles in different ways. Van Einjatten (1993, p. 3) in his comprehensive analysis, describes it as a paradigm shift from autocratic to democratic work organization. He is referring here not to democracy in terms of indirect representation, as "choosing by voting from amongst people who offer themselves as candidates to be our representatives", but rather to more direct participation aimed at "locating responsibility for coordination clearly and firmly with those whose efforts require coordination".

Wobbe (1991, p. 5) identified the following as the central principles of socio-technically designed production: unity in the design and execution of work, decentralized decision-making, flat hierarchies, collaboration between engineers and workers, skill-enhancing work design, and interaction between design and production.

Van Einjatten (1993, pp.17–18) divides the development of socio-technical design into pioneering, classical and modern periods. In the pioneering phase of 1949–1959, researchers conducting field studies in coal mines in the UK observed composite work groups being used as an alternative to Taylorist work design, and this sowed the seeds of the socio-technical system. Hundreds of socio-technical projects were carried out during 1959–1971. The developmental wave spread from the European Continent (England, the Netherlands, Italy, Germany, Scandinavia) to Australia, Canada and the USA, mostly in the form of job rotation and semi autonomous groups. The theory of the organization as an open system was developed during this phase.

According to van Einjatten, the modern phase of Socio-Technical Systems Design that began after 1971 developed along four separate tracks: Participative Design, Integral Organizational Design, Democratic Dialogue and North American Consultancy. *Participative Design* refers to in-house design without the help of experts or consultants – a “do-it-yourself approach” based on a minimum of theoretical concepts. *Integral Organizational Design* offers detailed structural principles in terms of design content, while at the same time specifying a theory of change by means of worker participation after training. It was a Dutch development, with some roots in German sociology. *Democratic Dialogue* goes beyond the enterprise level. It places the emphasis on the formation of networks and the development of “local theories”. Engelstadt and Gustavsen define networks in terms of relationships between organizations, which are based on voluntary collaboration and complementarity rather than on formal ownership. Democratic Dialogue focuses primarily on open communication and not design. *North American Consultancy* is basically a continuation of the American classical approach. American scholars still rely on the Tavistock STSD experience, which was imported into the US by Davis and Trist in the late 1960s. These classical concepts are still used in expert-driven projects. An essential element of contemporary American STSD is the notion of “empowerment”, which means passing on authority and responsibility to the workers. It happens when power is delegated to employees, who then experience a sense of ownership and control over their jobs (van Einjatten, 1993, pp. 45–80).

As socio-technical design methods are multidimensional and diverse, their representatives have developed separate theoretical foundations. This has decreased the need for theoretical discussion within the paradigm, and highlights its practical orientation. STSD is an umbrella term for a variety of programmatic projects.

6.2 The content and position of Trist and Bamforth's study

The pioneer role of the study in the STS approach

According to Van Einjatten (1993, p.150), STSD developed from the rediscovery of a flexible form of work organization in a British coalmine that was a potential alternative to Taylorism.

STSD means a radical departure from the common practice of Scientific Management, and is clearly ushering in a new era of organization design that is based on participative democracy. (Van Einjatten, 1993, p. 128)

The field study conducted by Trist and Bamforth, which initiated the development of STSD, was reported in "Human Relations" 4/1951 in England under the title: "Some Social and Psychological Consequences of the Long-wall Method of Coal Getting". Van Beinum (Van Einjatten, 1993, xxii), like many other representatives of the socio-technical school, describes the study as ground-breaking.

When in 1949 Eric Trist of the Tavistock Institute and Ken Bamforth, a former miner and at the time a postgraduate fellow at the institute, discovered in the South Yorkshire coalfield the existence of the semiautonomous group, they had their first glimpse of the new organizational paradigm.

Their find was a radical one, it signified the relationship between participative democracy and organizational design; it was a powerful demonstration of the reality of the organizational choice. At the conceptual level, the researchers had begun to realize that the production process had the characteristics of the socio-technical system. (van Eijnatten, 1993, xxi)

Trist and Bamforth's study has been the subject of numerous elucidations and discussions by many authors (*ibid.*, pp. 23–24). Trist wrote forty-two years later that the findings inspired researchers because there finally seemed to be an alternative to scientific management and bureaucratic organization.

For several decades, the prevailing direction had been to increase bureaucracy with each increase in scale and level of mechanization. The original model that fused Weber's description of bureaucracy with Frederic Taylor's concept of scientific management had become pervasive. The Highmoor innovation showed that there was an alternative. (Trist, 1993a, p. 38)

The overall picture of the study

Coal was the chief source of power in England after the Second World War. In those times industrial reconstruction depended on coal production. Many coal mines were nationalized because of economic problems in the industry. The expectation was widespread that management-worker relations would improve and that productivity would increase through the change of ownership. The nationalized mining industry began to use the so-called long-wall method, which was very different from the previous "hand got" method. It was a mechanical form of mining that applied the principles of Taylorist organization.

Although the implementation of the long-wall method improved the equipments and increased productivity, wages, and amenities, the problem was that it also increased the levels of sickness and absenteeism. Employees had also begun to drift from the pits. Some researchers maintained that the social balance achieved in the previous "hand-got" methods, were lost during the implementation of the long-wall method although the reasons remained obscure (Trist & Bamforth, 1951, p. 4).

In researching the causes of the lack of social balance, Trist and Bamforth challenged the methods of both Taylorism and the Human Relations School. They suggested that the change to the long-wall method could be analyzed from the perspective of interaction between two interdependent entities, the technical system and the social structures. The technical system comprised machines, mass-production layout, and the mechanical work design of the mass-production engineers, while the social structures took the form of occupational roles, understood as institutional forms required by the technical system. In the context of Kurt Lewin's concepts, Trist and Bamforth maintained that the technical and social patterns existed as "forces" that had psychological effects in the "life-space" of coal miners. According to this early form of socio-technical theory, the forces and their effects constituted the psychosocial whole, which the researchers defined as the object of their study.

In order to analyze the cause-effect relationships of the "psychosocial whole", Trist and Bamforth made observations based on interviews with miners, their deputies and other informants in the Highmore mine. The collection of this qualitative data continued intensively for two years. The researchers recorded their observations after the discussions, because it was not always possible to use a tape recorder in the pit. They maintained relatively continuous contact with some twenty key informants representing the various coalface occupations over a period of two years, and had similar discussions and interviews with the management and representatives of all other grades of personnel. They also interviewed three psychiatrists who had wide experience of local miners' problems (*ibid.*, p. 5).

In interpreting their qualitative data Trist and Bamforth compared how the imbalance was constructed between different social formations in pre-mechanized and long-wall coalmining. They found that it was possible with the former to achieve a balance between the entire coal-mine group and the working pairs, whereas this was not possible in long-wall mining because the social organization was segmented and the tasks were differentiated. Their conclusion was that the scale of the task²⁶ transcended the conditions under which those concerned could complete a job in one place at one time. The differentiated and sequenced social structures hindered progress in mastering the entire task. The integration difficulties between the larger groups were transferred to internal group relations (*ibid.*, p. 14).

This led Trist and Bamforth to conduct a more detailed analysis of the problematic inter- and intra-group relations in long-wall production. As a tool for understanding these relations they used their knowledge of therapeutic rehabilitation and group dynamics and the early theory of socio-technical forces. They found that the problems manifested themselves as disturbances, as norms of low production in work groups, as the functional isolation of groups, and as group defences. These manifestations were the results of the mechanical work design that could not take into account the psychological aspects.

However, the researchers also found a team of rippers who, in their view, represented a new promising organizational innovation. They suggested that some group relations on the coalface should change immediately, and they also maintained that qualitative change in coalmining could be effected only by combining the design of technical and social aspects of the entire production process.

The nature of pre-mechanized coalmining

Pre-mechanized coalmining was in many respects similar to the late craft industry, except that the size of the piecework groups was smaller. The common practice in the mines was for the colliery management first to make a contract with two colliers, a hewer and his mate. This pair worked on their own small coalface with the assistance of a boy "trammer". Trist and Bamforth describe how hard the work was in the hand-got system.

²⁶ The term "task" had a different meaning for Trist and Bamforth than for Taylor, who saw it as a particular job that had to be done. For Trist and Bamforth it denoted either the entity of coal mining or a specific operation performed in order to carry out this entire task.

To tram tubs was "horse-work". Trammers were commonly identified by scabs, called "buttons", on the bone joints of their backs, caused by catching the roof while pushing and holding tubs on and off "the gates". (Trist & Bamforth, 1951, pp. 7–8)

The pair unit could function in different mine layouts and it could extend its number to eight members, when three or four colliers and their attendant trammers would work together. Although contracts were made in the name of the hewer the group understood it as a joint undertaking.

For each participant the task has total and dynamic closure. Leadership and supervision were internal to the group, which had a quality of *responsible autonomy*. The capacity of the groups for self-regulation was a function of the wholeness of their work task, this connection being represented in their contractual status. A whole has power as an independent detachment, but a part requires external control. (ibid., p. 6)

Trist and Bamforth did not consider the features of the technical implements used in the "hand got" method in detail, but they did emphasize the importance of having many coalface skills. A collier was an all-round workman who was usually able to substitute for his mate. There were no strict occupational borders in the hand-got system.

Though his equipment was simple, his tasks were multiple. The "underground skill" on which their efficient and safe execution depended, was almost entirely person carried. He had craft pride and artisan independence. These qualities obviated difficulties and contributed to responsible autonomy. (ibid., p. 6)

With full awareness of the conditions underground and with long-standing knowledge of each other, the men chose their workmates themselves. The relationships between workers reached beyond occupational borders, and the family relations and the contract system supported each other.

In circumstances where a man was injured or killed, it was not uncommon for his mate to care for his family. These work relationships were often reinforced by kinship ties, the contract system and the small group autonomy allowing a close but spontaneous connection to be maintained between family and occupation, which avoided tying the one to the other. (ibid., pp. 6–7)

The authors concluded that in the contract system of hand-got mining, the wholeness of the work task, the multiplicity of the skills of the individual, and the self-selection of the group were congruent attributes of a pattern of *responsible autonomy* that characterized the pair-based coalface teams. The *small group structure* of the coalmining organization was flexible. Being able to work their own faces continuously, the groups could stop at whatever point may have been reached by the end of a shift. The flexibility had many advantages in the underground situation. When bad conditions were encountered, the extraction process in one series of stalls might proceed unevenly in correspondence with the uneven distribution of these bad conditions.

In the underground situation external dangers must be faced in darkness. Darkness also awakens internal dangers. The need to share with others anxieties aroused by this double threat may be taken as self-evident. In view of the restricted range of effective communication, these others have to be immediately present. (ibid., p. 7)

The small-group organization facilitated good relations among the men. The specific underground activities were spread out in a large coalmining area and the groups therefore became isolated from each other even when they were working in the same series of stalls. The darkness increased the isolation. The small teams and the pairs were often also in competition and quarrels broke out. The inter-team conflicts provided a channel for aggression that preserved intact the loyalties on which the small group depended.

The system as a whole contained its bad in a way that did not destroy its good. The balance persisted, albeit that work was of hardest, rewards often meager, and the social climate rough at times and even violent. (ibid., p. 9)

The long-wall method

Trist and Bamforth maintained that the introduction of coal cutters and mechanical conveyors broke the social balance between the pairs and the entire coalmining group. The new tools enabled the men work on long faces instead of short ones, which made the production more effective. The working of short faces in pre-mechanized coalmining was costly because a large number of gates had to be opened up several feet above the height of the seam to create haulage and traveling facilities. There was a tendency to make full use of the possibility of working long rather than short faces (Trist & Bamforth, 1951, p. 9).

The complexity and the large scale of the production unit thus created conditions that made the development of a technological system impossible without bringing into existence a work-relationship structure that was radically different from the one associated with hand-got procedures. The new long-wall production unit consisted of three shifts and shift "deputies", who were responsible to the pit management for the production of the shifts as a whole.

In the long-wall method, a direct advance is made into the coal on a continuous front; faces of 180–200 yards being typical, though longer faces are not uncommon. The work is broken down into a standard series of component operations that follow each other in rigid succession over three shifts of seven and a half hours each, so that a total coal getting cycle may be completed once in each twenty-four hours of the working week. The shift spread of the 40 workmen needed on an average face is: 10 each to the first ("cutting") and second (ripping) shifts; 20 to the third (filling) shift. The amount of coal scheduled for extraction varies under different conditions but is commonly in the neighborhood of 200 tons per cycle. A medium-size pit with three seams would have 12–15 long-wall faces in operation simultaneously. (ibid., p. 11)

This production method required an intermediate social organization that was more complex than that of a small factory department. The structure of this organization began to threaten the previous social balance between the pair-based work groups and the entire group of workers in the coal mine.

This centering of the new system on a differentiated structure of intermediate social magnitude disturbed the simple balance that had existed between the very small and very large traditional groups, and impaired the quality of responsible autonomy. The psychological and sociological problems posed by the *technological needs of the long-wall system* were those with respect to which experience in the industry was least, and towards which its traditions were antithetical. (ibid., p. 10)

No new social balance emerged after the implementation of the long-wall method. The changes in the group structure of the work affected the morale of the coalminers and that had to be analyzed in social and psychological rather than engineering and accounting terms.

Anyone who has listened to the talk of older miners who have experienced in their own work-lives the changeover to the long-wall cannot fail to be impressed by the confused mourning for the past that still goes on in them to-

gether with a dismay over the present colored by despair and indignation. To the clinical worker the quality of these talks has at times a ring that is familiar. Those with rehabilitation experience will recognize it as similar to the quality of feeling expressed by rehabilitees when ventilating the aftermath in themselves of impairment accepted as irreversible. (ibid., p. 10)

Trist and Bamforth described the nature of the shift work in the mass-production layout *as a spatio-temporal structure* necessitated by the long-wall method. This structure, as part of the *technical system*, caused specific problems in the work that required effective communication and good working relationships.

The production engineer might write a simple equation: 200 tons equals 40 men over 200 yds. over 24 hours. But there are no solutions of equivalent simplicity to the psychological and social difficulties raised. For psychological and social difficulties of a new order appear when the scale of a task transcends the limits of simple spatio-temporal structure. By this is meant conditions under which those concerned can complete a job in one place at one time, i.e., the situation of the face-to-face, or singular group. Once a job is too big for a singular group, a multiple group comes into existence, composed of a number of sub-groups of the singular type. (ibid., p. 14)

The entire task of coalmining had fallen into four groups, concerned with (a) the preparation of the coalface for shot-firing, (b) shifting the conveyor, (c) ripping down and building up the main and side gates, and (d) moving the shot coal on to the conveyor. These tasks were strictly *differentiated but also interdependent*, forming a social structure of occupational roles (borer, cutter, gummer, belt-breaker, belt-builder, ripper, and filler).

Occupational roles express the relationship between a production process and the social organization of the group. In one direction, they are related to tasks, which are related to each other; in the other, to people, who are also, related to each other. (ibid., p. 14)

The face-preparation tasks were all performed on the first shift. They included boring holes for the shot-firer, driving the coal-cutter, taking out the inches of coal, and placing supporting "noggings" underneath it so that this weight did not cause it to sag down to the floor while the "cut" was standing during the next shift (ibid., p.15). These tasks were performed in a given order. Two men were fully occupied boring the holes, two managing the coal cutter, and four in clearing out the undercut. The success of the shots fired at the end of the second shift that made

the coal finally ready for the filler depended on the efficiency with which each preparation task had been carried out.

In the long-wall system, the workers were trained for one occupational role. Trist and Bamforth saw this as an institutionalized form of segregating the workers from each other. This segregation was intensified by the different payment methods, by the exaggeration of status differences, and by the segregation of shifts. The workers on different shifts never met. Moreover, the two preparation groups alternated in the so-called "back shifts", while the fillers alternated on "days" and "afternoons".

Trist and Bamforth studied four "differentiated work groups": *interdependent pairs* of borers, belt builders and belt-breakers, *extended pairs* of cutters and gummers, the *self-sufficient group of eight rippers*, and *the aggregate* of twenty fillers spread out over the 200-yard face. They maintained that the uneven quality of the groups worked "against the social integration of the cycle group as a whole".

The unevenness and unpredictability of the coal load

Trist and Bamforth maintained that mechanized coalmining was different from factory production because the workers had to encounter a large variety of unfavorable and changing environmental conditions, many of which were impossible to predict. Factory mass production required a kind of "constant background to the task", but the threat of some other "untoward activity" was always present at the coalface (Trist & Bamforth, 1951, p. 20).

Work at the coal mine comprised two distinct and ever-present elements. The first task incorporated the normal daily occupational work that had to be done in the mine, while the second stemmed from the nature of the ground. The coalminers continuously encountered danger because the ground was in a state of continuous motion. The problems involved in reconciling these two elements led to the adoption by the miners of norms of low productivity in the long-wall method.

The miners' ability to cope with the dangers they encountered was based on the common fund of underground skills shared by all experienced face workers. The training period for the standard operations of the new production cycle was short, however. The most important skill, the ability to maintain a high level of performance when difficulties arose, developed only as the result of *several years of experience* at the face, and was of a higher order than those that required simply carrying out standard operations.

A work system basically appropriate to the underground situation requires to have built into its organization the findings of this experience. Unless this has been done, it will not only fail to engage the face-worker to the limit of his ca-

pabilities, but will restrict him to a level of performance below his potentiality.” (ibid., p. 23)

Trist and Bamforth did not explain in detail their findings concerning these skills. It is evident from their description, however, that the skills were related to the variations in quality and the structure of the coal loads that were the objects of the miners' work. They maintained that the workers had adopted norms of low productivity because the long-wall method prevented them from building up this knowledge.

They criticized the direct implementation of the rigidly sequenced and differentiated work organization of mass production in the coal mine. Mass production created difficult problems in factories, but the difficulties were even worse in a coal mine. Factory conditions were stable, and it was possible to control the production line, but control was much more difficult in the coal mine. The main problems arose from the "bad conditions" that stemmed from the uneven nature of the coal load, and not from "bad work", a term that referred to human error. Bad conditions emerged even though the seams were well ventilated, cool, dry, and dust-free.

Rolls or faults may appear in the seam. Control may be lost over the roof for considerable periods. Especially in the middle of a long face, certain types of roof are apt to sag down. Changes may occur in the floor; the condition known as "rising floor" being not uncommon. (ibid., p. 20)

The bad conditions meant additional dangers but also additional labor, "bye-work", which was work that was not included in the standards. Many of the bye-work tasks were badly remunerated. From the face worker's point of view, "bad conditions" meant not only more danger and harder work, but also less pay (ibid., p. 20).

Bad conditions also tended to instigate "bad work". The interaction between the two tended to lead to circular causal processes, the disruptive character of which was obvious. The bad work and the bad conditions were distributed unevenly between different faces and among different tasks within the same face. The consequence was unevenness in the level of functional efficiency, and cycle stoppages threatened the entire system of successive shift work. Stoppages were rare, however. The researchers assumed that the coalminers were working quickly towards the end of their shifts in order to prevent the disruption (ibid., pp. 21–22).

The main responsibility for keeping down the number of cycle stoppages fell on the deputy, whose job was to control the entire process of production in the face area. However, the darkness and the wide working area made supervision of the miners difficult, if not impossible. The management complained of a lack of support from the men, who focused only on their standard operations. The work-

ers, on the other hand, criticized the deputies for being outsiders – intermittent visitors and "stick" men, who interfered in their work without sharing its hard, physical conditions and in their in-group life at the face. This strained cycle control tended to produce a "group culture" of angry and suspicious bargaining in which both management and men were in collusion.

Trist and Bamforth maintained that, at the time when the long-wall method was developed, there were no precedents for the underground application of machine technology. In the absence of relevant experience in the mining industry, it was almost inevitable that factory norms would be adopted. There was no psychological or sociological knowledge, at that time that might have alleviated the problems (*ibid.*, p. 23).

According to Trist and Bamforth, the workers' methods of coping with the problems were based mostly on defensive reactions. Interestingly, they also identified a working method that helped groups of workers to minimize these reactions.

Group defences as a way of dealing with the problem of functional isolation

Under the long-wall system, fillers working alone in their "stints" loaded coal on a mechanically driven conveyor. A stint was "a period of time, which you should spend doing a particular job or activity or working in a particular place" (Trist, 1963, p.7). It was a typical work standard. Trist and Bamforth characterized the relationships between members of the filling shift as having "an absence of functional interdependence." Instead of being one of an independent pair, the filler became a member of an "absent group", like nineteen other fillers in the shift. Because of the temporal distance between the shifts, the fillers and the preparation personnel formed a "totally absent group". The relationships between specialized workers were characterized by dependency rather than independency within a given cycle period and operated only in one direction. The fillers were dependent on groups that were not present. This "isolated dependence" meant that they were "left alone with each other and at the mercy of the rest" (Trist and Bamforth 1951, pp. 25–26).

Trist and Bamforth gave a detailed analysis of some of the most common types of bad conditions and of the bad work that caused functional isolation. The local occurrence of certain types of bad conditions, such as temporary unevenness in the floor or roof of the face that reduced the working height, were impossible to anticipate, so that anxiety piled up. Bad work put the filler in a situation in which he would never know what he might find, which provoked another kind of anxiety that produced chronic uncertainty and irritation. In situations of dependent isolation, individuals inevitably erected protective defenses, which were elaborated and shared in the work group.

These defences are reactive rather than adaptive. Their effectiveness therefore is only partial. But without them life at the long-wall would be intolerable for all but those whose level of personal adjustment is rather better than that attained by most individuals in the course of their development. (Trist & Bamforth, 1951, p. 30)

Functional isolation prompted the fillers to develop, as their defense, *an informal small-group organization* in which the miners made private arrangements to help each other. Neighbors, in twos, threes or fours, formed these groups. The miners assumed that the small groups made "things [were] more like the old times in the pit". This kind of group sometimes appeared to be held together by a natural leader or to consist of individuals with generally good personalities. In practice they met the fillers' need for a secure role in a primary group only to a very limited extent. The second type of defence was the development of *reactive individualism*, in which a reserve of personal secrecy was maintained. The fillers plotted with and against their shift mates to get the best places. The middle positions were avoided, because it was "a long way to creep" from them.

The fillers virtually never saw those who worked on the "back shifts". This lack of contact gave full rein to the mutual and irresponsible defense form of *scape-goating*. When there was a filling crisis, one filler could be named by his mates as "a buck" and his name passed to the other shift. The "buck" was frequently also passed to the deputy, who was blamed for not finding substitutes. *Withdrawal* was the fourth form of defense, which complemented mutual scapegoating. For example, a filler returning from his week's holiday might complain that the first two shifts had "knocked it all out of him". The gummings had been left in. His coal was solid. He had had the air-pick on all day. "I've tried cursing 'em but it's no use, and pleading with 'em but it's no use. I'll take a day off for this." According to Trist and Bamforth, absenteeism was a social technique within this type of defense. Although there were local differences, the four defense forms apparently played "dynamically interrelated parts in forming the culture of the work groups".

In some cases, the informants also told the researchers about good cooperation, and suggested that fewer lapses occurred when that was the case. Some temporary payment arrangements reminiscent of the methods used in pre-mechanized contracts had also been applied. These experiments had come up against "long-wall separatism", with no overall goal. "No functionally defined responsibilities" existed for binding the responsibilities together. Thus "the persistence or resuscitation of the old forms of contract were not in themselves enough to restore responsible autonomy" (Trist & Bamforth, 1951, p. 30–35).

Trist and Bamforth openly brought the pre-mechanized type of *responsible autonomy* into their work ideal. The need for such autonomy was seen best in the pair

structures of borers, belt-builders, and belt-breakers who were only superficially an "echo of those pre-mechanized days" and were restricted to work tasks of a singularly narrow component character. This was the reason why they could not feel the satisfaction of accepting responsibility for the conveyor system as a whole.

The "all-in" method as a solution to the problems caused by implementing mass-production principles

Trist and Bamforth found a group of miners applying the long-wall method in a different way than others. A "ripping team" in the same seam used an alternative working method the group called "all in". The discovery of this group was later referred to as the beginning of STSD.

The task of the rippers' team was to "rip" dirt out of the main and side gates to assigned heights, place cambers, build up the roof into a solid, safe and durable structure, and packup the sides. The team carried out all its tasks independently. The tasks required the "highest degree of building skill", but also entailed some very heavy labor. The team was a well-organized work group of seven or eight members with an identifiable overall task for which it carried complete responsibility.

Other miners frequently referred to the rippers as a "good crowd" who seldom "went absent on each other". Their pride in their craft was considerable. The group consisted of a main ripper and individuals with varying work experience, and it managed its internal relationships without status difficulties. A measure of responsible autonomy persisted. (Trist & Bamforth, 1951, p 36.)

The problem with this team, however, was that it focused only on its own tasks and the working method did not spread to the wider organization. It was an isolated group and there was no transfer of its more stable morale to other groups in the system. Working in the main and side gates was felt to be the prerogative of a closed group very much apart from the interaction between the preparation and filling operations.

According to Trist and Bamforth (1951, pp. 36–37), the separation of the ripping team represented in all essential respects "a survival of the hand-got past in the mechanical present". All relevant operations were carried out within the group, which completed them within the compass of one shift.

Rippers have escaped from, rather than become part of, the long-wall system, retaining intact their total task, their multiple skills, their artisan independence, and their small group organization. (Trist & Bamforth, 1951, p. 37)

Rippers' teams worked in a gate, which was part of the production layout. Working in gates was not at all like working on the long-wall faces.

In the gates, the scale of the task remains small; the spatio-temporal structure is simple, and methods are un-mechanized. Changes consequent on the introduction of power-driven tools, or of steel replacing wood, have been assimilated without essential restructuring. (ibid., p. 37)

The difference between the work of the rippers' teams in the gates and of the others on the face was obvious. The introduction of machines on the face changed the scale of mass production and brought out the problems under study.

As a potential resolution of the problems in the long-wall faces, Trist and Bamforth (ibid., pp. 37–38) suggested the need for a qualitative change in the production design, which should be based on an analysis of the *social as well as the technological forces of production*.

Their immediate suggestion was to develop a small-group organization to resolve the fillers' and cutting teams' problems. In order to do that it was necessary to restore the social pattern that, in the previous hand-got system, had supported the coalminers' ability to be productive in dangerous situations.

But it is difficult to see how these problems could be resolved effectively without restoring the responsible autonomy to primary groups throughout the system and ensuring that each of these groups has a satisfying "sub-whole" as its work task, and some scope for flexibility in work pace. (ibid., p. 38)

6.3 Problems in the implementation of mass production as reflections of contradictions in the activity system

Trist and Bamforth's original purpose was to find organizational innovations in the post-war reconstruction of industry. They found the rippers' all-in method in a coal mine in which the implementation of mass-production principles had caused problems. My claim in Chapter 5 was that mass production could not have become the dominant form of production in the motorization wave without its *system of generalizing*.

Trist and Bamforth analyzed a specific case of the application of mass-production principles to coalmining. They did not deny the enormous increase in production that this method achieved nor did they advocate replacing mass production with another production concept. Maintaining that there was a possibility to implement mass production in another way, they were not questioning the whole concept, only the way of designing the work connected to it. In so doing, they also

questioned the system of producing work-related generalizations of mass production.

My interpretation in Chapter 5 was that the core unit of analysis and the core object of the system of generalizing in mass production was the variation of movements *within* a given work task. The artifacts that were used in Taylor-type generalizing stemmed from mechanical research. Trist and Bamforth focused on *relations between different kinds of work groups* rather than on internal relations in a work task. They analyzed these relations using the concepts used in therapeutic rehabilitation and psychodynamic group therapy.

Figure 6.1 below depicts the transformation from pre-mechanized coalmining to long-wall mass production, which Trist and Bamforth analyzed using a general activity system model.

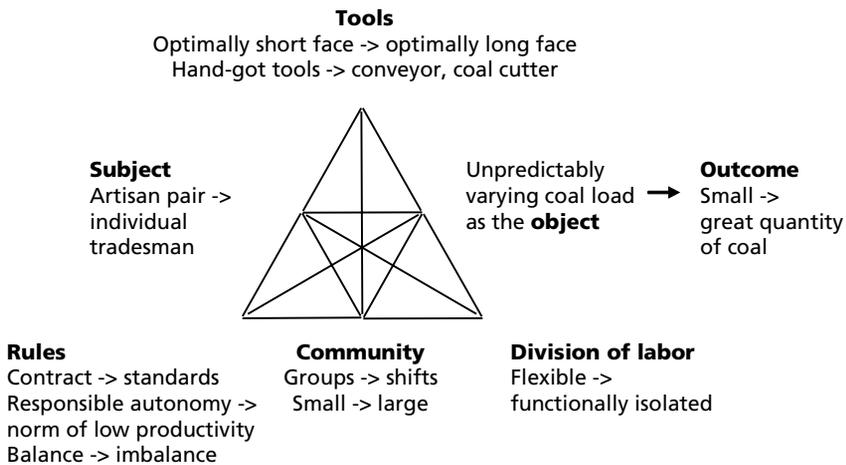


Figure 6.1 The transformation from pre-mechanized to long-wall mining

The difficulties in the transformation were connected to the lower part of the activity system. The rules (the norm of low productivity and imbalance between the work groups) and division of labor (functional isolation) were the critical points. This model does not yet give an adequate picture of reason for the problems, however.

The object of the work activity and of the entire activity system were constant in the Taylor-type system of generalizing. The tools, rules, subject, community, and division of labor were fixed at a formal optimum level. This kind of fixed system made it possible to carry out industrial tasks because the object of the activity varied minimally. In contrast to the well-standardized mass production, the object of the coal-mining activity, the coal lode, *varied in unpredictable ways*.

This meant that the standardized task did not in fact remain the same all the time, as was assumed in the generalization that was fixed in the standard. The standard embedded empirical generalization of the variation in the task. Instead of providing information about the essential variation in the object of the activity, the coal lode, this generalization provided only one way of coping with it. Consequently there were contradictions between the fixed elements of the activity system and its varying object (Figure 6.2).

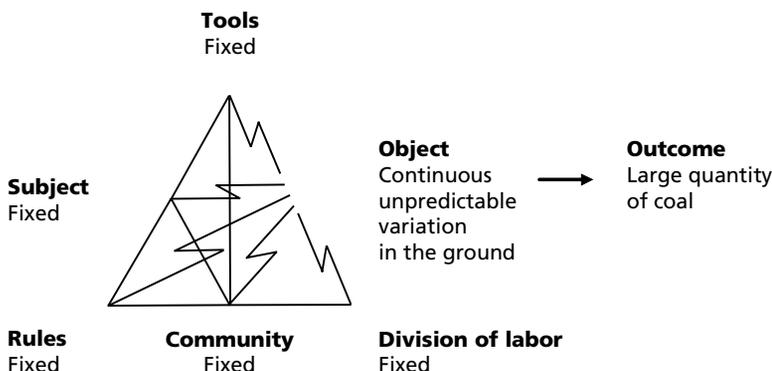


Figure 6.2 The contradiction between the fixed activity system and its varying object

The problematic consequences that Trist and Bamforth describe could be seen as symptoms of aggravated contradictions between elements of the activity system and attempts to cope with it. The dangers and isolation aggravated the workers' experience of these contradictions, but were not the main cause. Orr (1996) described a very similar situation in the work of copy-machine repairers. The standard method of repair was based on the assumption that machines of a certain type were similar, but the problems the repair men met in the field were caused by the interaction between the machines and their users. The different ways in which the machines were used caused variations in the kinds of faults that developed, which the standard operating instructions did not cover.

The contradiction described above was not caused by a lack of precision in the system of generalizing. Taylorist empirical generalization is a generalized representation of average effective work operations that take the object of the work as given and constant. An alternative could be to devise generalized representations of the variation in the object of activity, and of the corresponding variation in work operations.

Did the work of the rippers' team represent a historically new form of work-related generalizing?

According to Trist and Bamforth (1951, p.37), the very existence of the "all-in" method showed that the industry had "the necessary resources and creativity to allow widespread constructive developments to take place". In my view, the processes and representations of generalizing in the rippers' team did not differ from those of the late craft industries in that they were based on the incremental development of knowledge that was fixed in the tools and rules of thumb. They also apparently complied with the traditional form of piecework agreement: wages were paid according to cubic measures of coal produced.²⁷

Many authors (e.g. Vartiainen, 1994, p. 44) assume that the workers themselves created the system. In Trist's view 27 years after the study, however, it was not only the workers who came up with the idea.

The method called the all-in method had been conceived by Reg Baker, the Area General Manager NO.3 Area, formerly manager at Elsecar (...). It was both moving and exciting to talk to the men about the value they placed on their experience in the newly formed autonomous groups. (Trist 1978, pp. 5–6)

Why did Reg Baker conceive of the rippers' team? One explanation is that it was not possible to standardize the entire work of the coal mine as Henry Ford (1924) found with his factories. The rippers' team seemed to be a typical group of craft workers performing residual tasks that could not be organized according to the principles of mass production. As I see it, Trist and Bamforth's conclusion was that mass production could be more effective when complemented with the perceptual-functional form of generalizing typical of craft work. The pattern of generalizing in the rippers' team was based on the transformation of working methods as members of the group reacted spontaneously to the challenges imposed by the situation. The team did not need the low productivity norm because their generalized operations were adequate in terms of carrying out their work task.

A major disadvantage of this kind of generalization is that it is embedded in local forms of collaboration and is not transferable from one group to another. Assimilation had to follow the craft pattern of learning through apprenticeship. A newcomer learns – and possibly contributes to – these forms of collaboration only by following in the footsteps of the more experienced members of the group. This could also explain the isolation of the rippers' team from the rest of the work

²⁷ Trist and Bamforth did not clarify out on what figures the cubic measures was based.

community in the long-wall system²⁸. In terms of producing *work-related generalizations*, the all-in method was a return to the old.

On the other hand, what Trist and Bamforth found was that the rippers' team, *a group with responsible autonomy*, which worked within the mass-production system, could control its work better and was also more effective than the work units organized in the Taylorist fashion in the same coal mine. *A group, as a new unit of work design in mass production* could also alleviate the problems that resulted in the use of social defense and the norm of low productivity. The discovery of the advantages of the new potential unit, the group, was historically significant.

Trist and Bamforth's identification of the *potentiality of the work group* as a new unit of work design inspired further research that focused on the productive outputs of various group-based forms of work organization. Trist (1963) and his colleagues studied and found similar groups in other coal mines and compared "composite" coalmining with the "conventional" type. Composite mining involved the miners working in a group with varying tasks, while conventional production entailed more segregated and permanently divided tasks and less variation. According to these studies, the composite working groups were more effective than the conventional groups.

The answer to the question whether the work of the rippers' team represented a historically new form of work-related generalizing is thus both "yes" and "no". On the one hand, it followed the pattern of perceptual-functional generalizing typical of craft work and on the other hand, the idea of *the group as part of the social system* challenged the foundations of the Taylorist form of generalization, according to which task variation was the main priority. According to Trist and Bamforth the groups and the interrelations between them provided the variations in the social entity, which were dependent on the changes in the technical system. The coordination of the variation in these two systems – the social and the technical – gave rise to the main STSD concept.

The background of this development was, as I see it, that the variation of the object in coalmining contradicted the fixed empirical generalizations. This problem was not unique – on the contrary, the need to manage this kind of variation became increasingly acute as mass production reached its peak in the 1970s and the need to introduce more variation arose.

Trist and Bamforth were not interested in how the new form of work carried out by the rippers' team developed. Early studies on STSD focused more on the existence of groups than on their construction. The famous pioneer study conducted by Rice in Ahmedabad, India reported how the workers in a weaving mill created

²⁸ The rippers escaped the other shifts although the other miners appreciated them.

semi-autonomous teams when Rice had only mentioned the possibility in a planning meeting (van Einjatten 1993, p. 24). Nevertheless, socio-technicians began to place more emphasis on how to construct groups in mass-production work, and this required some theoretical back-up.

6.4 The conceptual development towards dualism

The coalmining studies highlighted the need to analyze the requirements the technical system imposed upon the social system. This made it possible to organize production in a way that satisfied the technical requirements and made the best use of the social system itself (Emery & Hill, 1993, p. 279). The "joint optimization" of the social and technical aspects of production became a major practical and theoretical goal in the socio-technical school.

According to Emery, the Taylorist approach was based on analyzing part problems. The initial motive behind socio-technical theory building was more effectively to identify what was relevant in order to resolve particular problems of work organization. Emery used the concept of the socio-technical system for the first time in 1959 as a frame of reference for ordering the facts in analyses of the interrelations of these two systems, and for revealing the way each of them contributed to the performance of the enterprise (van Einjatten, 1993, p. 30; Emery 1993a, 157).

Emery maintained that the concept "social" referred to people and "technical" to the physical support of their activities. The main dimensions of the technical system were the natural characteristics of the material being worked, the level of mechanization, the unit operations, the degree of centrality of the different production operations, maintenance operations, supply operations, the spatio-temporal dimensions of the production and the immediate physical work setting. Of these the most important was the level of mechanization. The social system consisted of the structure of the occupational roles, methods of payment, the supervisory relationships, and the work culture. The demands created by the technological system were met first by "bringing into existence a work relationship structure" (Emery, 1993a, pp. 161–165).

Emery and Trist (1969) understood an enterprise as an *open* system. This idea was taken from Bertalanffy's theory of open systems of physics and biology.²⁹ The authors saw an analogy between the capacity of biological organisms to survive in their environment and an enterprise's capacity to survive in the markets. The steady state of an enterprise was the state in which the commerce was going on. The conditions for keeping this steady state existed within and outside of it.

²⁹ Note that Taylor has based his scientific management on mechanics, mathematic and physics.

The technical system converted the inputs into outputs, and thus played the major role in determining the self-regulating properties of the enterprise. It functioned as "one of the major boundary conditions" between the social system and the environment. It represented, as it were, an "internal environment". The variation in the output markets and in the inputs in commerce was seen as the most important factor influencing the enterprise's ability to maintain a steady state in its social and technical systems (Emery & Trist, 1969, p. 283).

The concept of joint optimization referred to the objective of achieving the best match between technical instrumentation and social work organization. The socio-technical entity should be optimized.

Any attempts to optimize for one without due regard to the other will lead to sub optimal overall performance, so even if an effort is made in an industrial situation to follow the traditional pattern, i.e., to optimize the technical system and hope the social system will somehow sort itself out, then sub-optimization is certain result. This is also the case when attempting to optimize each system but independently, ignoring the interaction effects. (Trist, 1993b, p. 587)

According to Emery (1993b), the principle of joint optimization could be applied only where the systems were independent but correlative. It did not apply when one system was, in fact, part of another such as when a sales section of a company was part of a social system that was governed by the same laws as the rest of the social system. Socio-technical systems were composed of two distinct systems, however, both of which, although correlative, were governed by different laws. According to Trist, the technical system followed the laws of natural sciences and the social system followed human laws.

Interaction between different systems could be conceived of only under the principle of contemporaneous causation, i.e. past events cannot be causes because they no longer exist, and future events cannot be causes because they do not yet exist. Only systems that exist together can interact. Independent systems cannot be conceived of as coupled together unless, at a certain time, there is movement of information at least from one system to another (Emery, 1993b, p. 563; van Einjatten, p. 86–89). Emery called the symmetric compatibility of the laws governing the social and the technical the Postulate of Dualism. Dualism that separates the enterprise from its turbulent environment that divides the internal activity of an enterprise into two logically different systems, and that develops methods for seeking out the best match between these systems, has been characteristic of Socio-Technical Systems Design. This type of dualistic logic was also evident in the STSD work-related generalizations.

6.5 The basic STSD model as abstract-empirical generalizing

The first widely practiced method for undertaking socio-technical design and research was called the nine-step model, introduced by Emery in 1967 (Emery, 1993b, pp. 569–579). The objective was to help designers and line managers with action groups, and to implement the concept of joint optimization in their own departments in order to improve the level of performance of the whole enterprise. Emery was apparently applying Ashby's law of requisite variety according to which the system has to be able to create a greater amount of variation in its responses than the environment produces. In the following, I will describe this process in terms of four actions of generalizing.

The first action is to make an initial assessment of the variation needed in the task structure of the production system. This means describing the production reality and its environment, and identifying the main problems in the system for further study.

The second action involves analyzing the transformation variance in technical and social systems, and comparing the different elements within each entity. The first task of the action group analyzing the *technical system* is to examine the trajectory of raw material, in other words the phases in the series of operations that have to be carried out to convert materials at the input end of the system into products at the output end. At this point the focus is exclusively on the series of transformations through which the raw material passes, and the effects of machines and people are ignored.

This makes it possible to analyze the "key process variances" and the inter-relationships between them. Variance is defined as deviation from some standard or specification. The focus at this stage is on the key variances that significantly affect the capability of the production system to meet its targets in one or more of its unit operations. First, all the variances in the system that, in the opinion of the action group, are worthy of note have to be identified. The group then draws up *a matrix of identified variances*³⁰ in the form of a table with specific disturbance sources as one input source and factual disturbance controls as the others

Key variance analysis makes it possible to examine the way in which the *social system* contributes to variance control and the attainment of production objectives. Using different descriptions, mappings and analyses, the action group can also assess the extent to which the social objectives and their own needs coincide.

³⁰ The variation matrix (or variance map) was used for the first time in the Industrial Democracy program in Norway at the Hunsfos paper mill (Thorsrud & Emery 1971, pp. 206–208; van Einjatten 1993, pp. 36–37)

A brief review of the *organizational structure*, including the social groupings and types of role, is required.

The workers also describe their roles in the production system. Their psychological needs³¹ can then be assessed in order to check whether their roles meet them and to analyze their *perceptions of their roles*, specifically the extent to which they see them as fulfilling their psychological needs. (This can be accomplished by having representatives of personnel administration in the action group, either for this particular purpose or as a full member. Interviews could also be arranged.)

The third action consists of fitting the objectives of the production system and the directly related systems together. Emery characterizes these analyses only in general terms. The *maintenance system* is examined in as far as it affects the particular production system in terms of achieving its objectives. These objectives are determined according to the nature of the maintenance variance arising from the system, the extent to which the variance is controlled, and the extent to which the maintenance task should be taken into account in the operational design. *Suppliers' and users' systems* are analyzed in order to determine the way in which, as environmental systems, they affect the particular production system. These analyses can lead either to a reduction in variance or to redefinition of the objectives of the production system. It is also important to identify the forces operating in the wider departmental or work environment that either affect the ability of the production system to achieve its objectives, or are likely to lead to a change in them. It is essential to be able to identify the development plans and general policies that have a high probability of being implemented.

In the fourth action, the designers gather all the hypotheses and proposals that have been developed during the analysis process in order to consider their viability and to establish the basis for a subsequent action program. Hypotheses are formed as the analysis of the technical system is being completed. These proposals will be modified as further information is gathered about the social and environmental systems. The hypotheses also have to be tested against appropriate criteria, which must relate to the objectives of the production system in terms of quantity, quality, and general operating costs. They should also cover social objectives, such as those aimed at increasing the extent to which psychological needs are met in role design.

The final stage of Emery's model is to make proposals. He did not include any action plan for carrying out the program as J.C Taylor did with his specific "implementation action" and "redesign plan", for example. This suggests that Emery's model of joint optimization was not meant to encompass continuous activity, and

³¹ Trist (1993b, p. 588) defined six basic general psychological requirements that work roles have to meet.

that its purpose was to construct a new constant production system during one process. This makes the actions of generalizing only *temporary actions* in which an external work designer or local manager, together with the action group, optimizes the social and technical systems.

Moreover, the generalization applied in this design model is based on empirical comparison and the classification of either the social or the technical elements of production. The representations used in all these actions are mainly the procedural models and guidelines, statistical methods, variance matrixes, maps, and given organizational models. The criteria of the production-system objectives in terms of quantity, quality and general operating costs are also important.

The system as a new unit of analysis is much more extensive than a Taylorist task, which makes more versatile analysis of the variations in production possible. Socio-technical actions of generalizing seem to be based on perceptual-functional generalizing, which is evident in the practical applications.

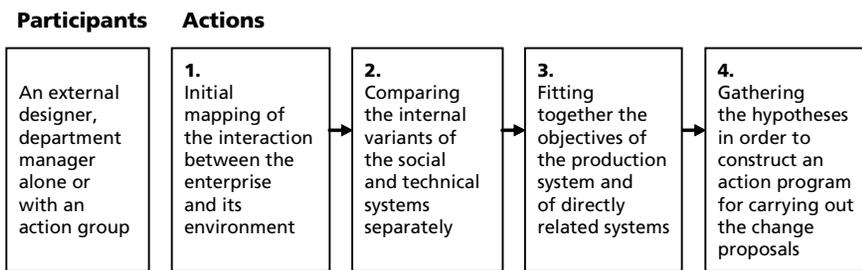


Figure 6.1 The actors and four actions of socio-technical generalizing

6.6 The spreading of socio-technical generalizing

The practical implementation of Socio-Technical Systems Design has spread through the world in the form of semi-autonomous teams and socio-technically designed factories.

Semi-autonomous teams

STSD has come into prominence in showing that the mass product can be produced more effectively by semiautonomous and self-managed work groups (Emery, 1993c, 210; Trist, Higgin & al, 1963). Pasmore et al. (1982, pp. 1192–1193) reviewed 134 reports of socio-technical experiments conducted between 1974 and 1980 and found that the formation of semi-autonomous teams was most prevalent in socio-technical projects, and approximately 200 plants in the US had adopted the practice in the early 1980s). Manz and Sims (1990) and Verespej (1990)

predicted in the early 1990s that as many as 40 to 50 percent of American workers might be involved in some form of empowered team environment by the year 2000. These applications span many industries in both manufacturing and service. The trend has also been widespread in many parts of Europe, especially in the Scandinavian countries (Grootings et al., 1989).

Nowadays these work groups are defined according to their ability a) to select their own work methods, b) to take responsibility for certain decisions regarding production control and design, and c) to regulate the work pace with the help of buffer stocks (Berggren 1990, pp. 243–244). According to Köhler and Schmierl's (1992) account, one tenth of workshops manufacturing capital equipment in Germany had organized their production exclusively around cells or "autonomous manufacturing islands". It is justifiable to claim that these teams represent an alternative division of labor in production, and have become a source of qualitative change. The increasing numbers of articles claiming the superiority of STSD over lean production or advocating combining the models (Manz & Stewart, 1997), point in the same direction.

Many analyses have shown that the problem with semi-autonomous groups is the limited influence they have on organizational practices as a whole. They are often only partial solutions, and problems in consolidating group-based work organization remain. (van Einjatten 1993, pp. 145–149; Trist 1981, p. 35).

Socio-technically designed factories

Toikka (1992, pp. 12–16) divides the development of the socio-technical design of assembly-line work into three phases. At first, the intention was to lessen the harmful effects of assembly-line work without interfering with the conveyor-belt. Then the designers experimented by making some changes directly focused on the assembly conveyor. In the third and most radical phase, the conveyor belt was completely removed from assembly work. The best-known single example of this was Volvo's automobile plant in Uddevalla, Sweden.

At the beginning of 1990, groups of 8–10 workers in the Uddevalla plant, were making cars from beginning to end without any assembly line as quickly as they were made on the assembly line: the production of one car entailed 48 parallel stationary processes with a job cycle of around two hours.

The result of a special "green-field" design, the factory started functioning in 1989. The planning process was based on what was happening in the Volvo Kalmar plant and the design was extended from line to whole-car assembly. The new method was tested in a training shop during the design process.

The training shop functioned as a production laboratory. The tests carried out there showed that it was possible, with appropriate materials arrangement and an effective administrative system, to learn how to build cars without the assembly

line. The manager in charge of training formulated the goal as follows: "In the training shop we learn how to make complete cars. Both manual and intellectual functions are required: planning, organizing equipment and materials, assembling, following up, and reporting. Assembly here involves more than just mounting screws; it is also a matter of functional know how" (Berggren 1993, p. 150). The training shop was closed during starting year of the factory, however, because it had become so isolated that new assemblers needed retraining when they came out of it onto the factory floor.

Nilsson, who was the only researcher who was able to trace the practical development of this potential socio-technical system of generalizing, explained the principles of "expanded assembly work" as follows.

To create the competence needed to master long-cycle work, such as expanded assembly work, it is necessary to develop "an inner monologue". The inner monologue should co-ordinate the relationship between "the work of the hand" and the "work of the mind." (...) The development of "inner monologue" is a primary factor in the creation of a vocational identity in the centuries –old western European handicraft tradition, which is also applicable in the new world in the aftermath of the Taylorist phase of the industrial era. (...) Those who had learned the techniques became instructors for novice workers. This was much like the comprehensive training of the old apprentice- journeymen relationship in the guild system. (Nilsson, 1995, pp. 78–80)

Nilsson clearly saw expanded assembly work as a happy return to the craft principle of learning in and for production. When the plant started functioning in 1988, new employees began on a trainee's wage, which increased in stages until the standard wage was reached. This wage could then be augmented with a qualification bonus depending on how large a proportion of the car's assembly the worker mastered. Workers at the highest competence level were able to build an entire car.

The process of reaching whole-car competence was designed to be a true test of skill and knowledge. The requirement in 1990 was that a worker had to be able to make a complete car with maximum of four small defects in at most twenty hours. Workers were required to have undergone training and then built cars for at least sixteen months before they could take the test at all. In 1990 there were a dozen whole-car builders among Uddevalla's five hundred or so assemblers. (Berggren, 1993, p. 161)

The bonuses were paid both to the individual worker as a team representative and to the team as a whole. The *productivity* bonus was initially based on the productivity of the entire plant and bore no relation to the results achieved by the teams. It

was changed in 1991 to a team bonus (Berggren 1993, p.161). The direction seemed towards individual rewards: if there is a bonus, there has to be a standard.³²

After four years of operation, the Volvo board decided to close the plant because of the merger between Renault and Volvo (Sandberg, 1995, p. 4). Berggren (1990) went on to talk about a new kind of identity in industrial production. The plant and its predecessor, and the model, the Volvo Kalmar plant, have been heralded worldwide as symbols of socio-technical design. Socio-technicians called Uddevalla the "Copernican revolution" of car production, and "the place, which resolves the future of industrial work" (Berggren, 1990). Since the unexpected closedown of the Uddevalla plant no corresponding example of socio-technical production has been reported. Nevertheless, the experiment gave convincing evidence of the potential of socio-technical design.

6.7 Assessing change in generalizing

Trist and Bamforth's coal-face study brought out problems that arose when the Taylorist system of generalizing was implemented in coalmining. Taylor created his system for production activities in a relatively established factory in which there was little variation in the object and conditions of work, and tasks became frequent enough to be standardized, while Trist and Bamforth highlighted the unpredictability of the object of the actions. This variation was in contradiction with standardized work operations, causing problems that, according to the researchers, threatened the very existence of coalmining.

Trist and Bamforth found that the solution was in the limited work entity of mass production. They identified a composite work method in the ripper team's work and made it a model. The same form of work organization was found in the coal mine, and later in other mines. The composite group method was largely reminiscent of the previous pre-mechanized form of work. The group used, adopted and developed rule-of-thumb methods concerning the use of tools and the division of labor. These perceptual-functional processes of generalizing occurred and were handed down directly to other workers. The generalizations were preserved in the methods of collaboration, and in the language and movements of the team members who belonged to the work team and could not be transferred to other groups in the mine or to other mines. This limitation was one reason why these kinds of generalizations were not compatible with large industrial units, in which transfer and externalization were necessary.

³² Toikka (2003) noted that because modern cars comprise 50,000 parts, the need for setting standards is understandable.

The focus of interest for Trist and Bamforth was not in how the composite group method was developed, but in the fact that there seemed to exist an alternative to Taylorist-Fordist work organization. The composite method stemmed from pre-mechanical coalmining from the late craft period, and its establishment did not require any specific developmental method. In this sense, the use of the team did not resolve the contradiction between standardization and variation in the object of the work. It only softened it by limiting the standardization. The team structure made it possible for the team to extend the generalization of the previous production type. The socio-technical system of generalizing was thus a hybrid of the mass-production and craft-type systems.

The authors' observations that the composite group method was more effective and entailed fewer social problems than conventional mass production inspired many researchers to conceptualize work in new ways. It was the job of the socio-technicians to criticize mass-production work as a manifestation of a "technical system", but they also rejected the human-relations view of work as only a social system. The solution was not only in the relationships between these two subsystems, but also in the open-system concept that explained production as interaction between the socio-technical system and the environment. The concept inspired much new research and developmental work. The socio-technical movement could not offer a permanent practical alternative to Taylorism, but it did develop a way of solving some of the problems caused by the Taylorist system of generalization.

Following their pioneering studies, the socio-technicians created new systems of generalizing that were based on empirical generalizations of social or technical entities. These processes have not been embedded as an element of production practice, however, but they have been used as separate interventions concerning the division of labor and the rules in the organization. In green-field factories, socio-technical design has been based on perceptual-functional generalizing.

We could consider the development of socio-technical practice an expansion of the STSD concept. Trist and Bamforth *questioned* some aspects of the Taylorist-Fordist system of generalizing in mass production. They *analyzed* the problems of collaboration and found a hybrid form of mass production in which a limited group of workers could carry out and plan their own tasks. This could happen in conjunction with or apart from the specialist-driven Taylorist-Fordist system. Because the "new" model was a mix of the traditional perceptual-functional and the new type of abstract-empirical systems, it expanded only partially in the form of semi-autonomous teams and experiments with socio-technical factories. It was substantiated in consideration of the workplace as an open socio-technical system, and in the application of developmental methods stemming from research on concepts such as socio-technical and open systems. This led to the expansion and diversification of the STSD developmental method.

7 Post-war experiments in Toyota as the origin of generalizing in flexible mass production

7.1 The rise of flexible mass production

The downswing period of the motorization wave brought with it a questioning of the principles of mass production in Western countries. Mass production was no longer considered the only key to high economic growth. Mass and structural unemployment increased in circumstances of low growth. The oil crisis that triggered the downswing began to threaten US dominance in world markets.

The automobile industry as the carrier branch of economic growth represented fundamental structural, technological, and cultural change in production (Freeman and Louçã, 2001, p. 298). Japanese automobile producers challenged the Fordist manufacturing system. According to Freeman and Louçã, from the shop floor workers to the top management they were accustomed to thinking in terms of the entire production process. The Japanese seemed to have the ability to redesign an entire production system in industries as diverse as shipbuilding, automobiles, and color television.

During the upswing period of the long wave, the usual business cycle in the automobile industry consisted of two or three years of prosperity with, at most, six months of recession. In periods of slow growth, however, the boom lasted at most six months to one year, with the next two or three years showing little or no growth, or even negative growth. During the high-growth phase, the application of the principles of mass production meant that the cost of the automobile decreased in proportion to the increase in quantities produced. However, firms had to carry the costs of over-capacity during periods of slow growth. Japanese automobile producers managed to reverse this dominating model of car production: they were able to reduce the prices even though the volume of production did not increase (Ohno, 1988a, p. 2).

Several studies (Fujimoto & Clark, 1991) have shown that the average performance of Japanese automobile assemblers in the 1980s was significantly higher than that of their North American counterparts in terms of assembly productivity, manufacturing quality, product development, lead time and overall productivity, and by 1989 Japan was producing more cars than the United States (Fujimoto & Tidd, 2002, p. 77). IMPV research conducted in 1988 (Womack, Jones & Roos, 1990) questioned the generally accepted Western opinion about the superior efficiency of mass production. Using simple numbers and thorough and valid methods, the authors showed how the Japanese automobile plants produced cars in half the time it took Western plants applying the mass-production method. Moreover, the Japanese manufacturers produced more model variations, and more reliable products according to the generally accepted quality measurements. The IMVP report showed that average assembly-plant productivity was 17 hours per vehicle in Japan, 25 hours in North America, and 35 hours in Europe. This development was not nation-related, but was the consequence of a new Japanese concept called flexible mass production.

7.2 The Toyota Production System

Historically the Toyota Production System (TPS) was the first model of flexible mass production and combined many industrial innovations introduced by the Toyota Motor Company in 1945–1971. Some of these also developed into a new system of work-related generalizing in Toyota's factories.

The creator of the TPS, Taichi Ohno, maintained that Western mass production was based on the idea that selling price = profit + actual costs. This principle no longer applied during the downswing period, when the excess capacity in car production began to suppress demand.

Our products are scrutinized by cool-headed consumers in free, competitive markets, where the manufacturing cost of a product is of value to the buyer. If a high price is set because of the manufacturer's cost, consumers will simply turn away. Cost reduction must be the goal of consumer products manufacturers trying to survive in today's market place. During a period of high economic growth, any manufacturer can achieve lower costs with higher production. But in today's low growth period any form of cost reduction is difficult. (Ohno, 1988a, pp. 8–9)

In Western mass production the customers were understood to be the last link of the production chain. The product was first designed, then manufactured and finally distributed. The Japanese production model challenged this "push model":

it was the customers who set the selling price of the product and who *pulled* the goods they needed.

According to Ohno, the pull model of automobile production is based on two main principles: *just-in-time* and *autonomation*. Just-in-time means that in the flow of the production process, the parts needed in the assembly reach the assembly line at the time they are needed and only in the specified amount and quality. Production is programmed from downstream in order to introduce, step by step, only the items needed for producing products that have already been sold. Just-in-time production involves a series of innovations in the preparation and feeding of the work, in the production logistics, and in the management of the flows and stocks of intermediate and semi-finished goods. The purpose is to produce only what the market demands (Ohno 1988a, pp. 28–29; Coriat, 2002, p. 218).

The other principle, *autonomation*, also called auto-activation, is not as well known as the just-in time principle. It is based on the prevention of defective production with regard to both machines and management. Machines are equipped with devices and automatic systems that prevent the production of defective parts or products. They are designed so that the line worker's actions only stop because of the emergence of an abnormal situation. Therefore the line worker has to concentrate on the one machine that needs attention when the other machines are working well and can therefore take responsibility for several machines. Moreover, there is a basic rule that any line worker should stop the line if he or she notices an abnormality in the process. Thus the responsibility for product quality is delegated to the shop-floor workers (Ohno 1988a, p. 6; Coriat, 2002, pp. 217–218).

Taiichi Ohno points out that the key principle behind the Toyota Production System is the elimination of waste³³, *muda* in Japanese. (Womack & Jones, 1996,). *Muda* consists of the things that are not needed in the work at all, which Ohno divides into seven categories: waste in the form of overproduction, in waiting (time on hand), in transporting, in the processing itself (too much machining), in stock on hand (inventories), in movements, and in defective products. Waste is a human practice that absorbs resources but creates no value. It has to be defined, recognized and eliminated.

All kinds of waste occur when we try to produce the same product in large, homogenous quantities. In the end costs rise. It is much more economical to make each item one at a time. The former method is the Ford production system and the latter is the Toyota production system. (Ohno, 1988a, p. xiv)

³³ The notion 'muda' was basically an extended version of the same notion used originally by Henry Ford. Ford paid attention to the waste of human labor and to the waste of salvaged material.

According to Ohno (1988a, p. 19), if work is understood to consist of "real productive work" and "waste", the current capacity could be equated to the sum of the two parts: current capacity = work + waste. Under this reasoning, zero waste increases the percentage of work to one hundred and results in the most effective production. In making only the amount needed, manpower must be reduced to trim excess capacity and match the needed quantity. The elimination of waste reveals any excess of manpower. The idea is not to lay off line workers, however, but rather to emphasize the economic significance of their part in the development of production, something that is nonexistent in traditional mass production.

Working means actually advancing the process toward completing the job. Workers must understand this. (Ohno, 1988a, p. 58)

The Toyota company wanted to adopt the method of mass production in its own way. Kiichiro Toyoda³⁴, the managing director of Toyota, announced this goal as follows:

We shall learn production techniques from the American method of mass production. But we will not copy it as it is. We shall use our own research and creativity to develop a production method that suits to our country's situation. (Ohno, 1988a, p. 91).

On the one hand, Japanese innovations such as automation and Just In Time, which were made in the Toyota plant during the pre-war era, spurred the Toyoda family on to believe that it was possible to catch up to the volumes of Western mass production in the post-war situation, while the post-war circumstances, on the other hand, forced the family to do so. Taiichi Ohno often referred to the saying "necessity is the mother of invention".

In the following section, I will analyze the birth of the Toyota Production System and the work-related system of generalizing it involved, and trace the developments that produced the need and offered the opportunity for a new form of generalizing.

7.3 Toyoda's innovations during the pre-war era

The first significant attempts at automobile production in Japan were the knock-down assembly operations run by Ford and GM in the mid-1920s. American cars and trucks dominated the Japanese market between 1925 and 1935. Ford and other

³⁴ The Toyota factory name stems from the owner-family name, but the 'd' was changed to 't' in 1937. I will use the appropriate forms.

American manufacturers planned to build new plants in Japan but they were prevented from doing so by the Japanese government, which introduced the Automobile Manufacturing Enterprise Act in 1936. This Act effectively subsidized licensed domestic companies producing trucks, while ousting the American subsidiaries from the Japanese market. Japanese producers virtually took over the domestic market, which then produced between 30,000 and 40,000 units per year. Attempts to directly transfer the Ford production system to Japan thus came to nothing (Fujimoto and Tidd, 2002, pp. 87–88).

The Toyoda Automatic Loom was first used in engine research and prototyping in a small corner of the company facility around 1931. Kiichiro Toyoda started to develop the idea of reverse engineering in the production of the Smith motor, a small engine commonly used for motorcycles and three-wheelers, and came up with a prototype engine. His vision at this early stage was to develop an automobile and to compete directly with the American models in both price and performance. Toyoda started building a prototype plant in 1934, the same year that the first prototype engine was completed. As for the body, Kiichiro decided to adopt the streamline design that was fashionable at that time (*ibid.*, p. 89).

When Toyoda started its automobile production, its initial attempts were more or less patchwork imitations of American technologies in terms of both product and process. As the user of the technologies Toyoda was active in combining them and adapting them to the Japanese conditions. The Kariya assembly plant was completed in 1936. Its capacity was quite small compared with the American standard. Kiichiro's goal was to attain the same level of unit costs when producing 20,000 to 30,000 units per year as the Americans achieved when producing several hundred thousand units per year. Thus Toyoda modified the Ford production system to small batch production (*ibid.*, 2002, p. 90).

Under the new production system, a series number was given to every 10 vehicles produced and these numbers were used to keep track of everything related to these vehicles right down to the parts from which they were assembled. The producer could thus monitor the progress of manufacturing by checking the number assigned to the parts in each process at any given time. Each phase of manufacturing was carried out in synchronization with the final stage (Toyota: A history of the first 50 Years, 1988, p. 72).

Since the overall efficiency was not as good as expected, Kiichiro wrote the words "Just-in-time" on a banner and hung it on the wall of the plant, because there was great variation between the different manufacturing processes.

People talk about having missed a train just by a minute but of course it's possible to miss a train just by a second. What I mean by "just-in-time", is not simply that it is important to do something on time, but that it is absolutely essential

to be precise in terms of quantity and not, for example, produce something on time but in excess, since excess amounts to waste.” (Toyota: A history of the first 50 Years, 1988, p. 69)

Kiichiro Toyoda visited universities and research institutes in Tokyo in order to acquire new knowledge that could be utilized in shop-floor work. He also wrote memoranda to his staff requesting changes in materials or manufacturing methods. He wrote these memos one after another in order to instill his new ideas in the minds of administrators and supervisors. The new rules and work-procedure sheets he compiled around this time formed a ten-centimeter-high pile when collected. They included standards and attitudes to be observed by each department and person in charge, and concerned issues from design, production and the purchasing of parts to employee welfare, all covered in minute detail. (ibid., p. 69)

Toyota established the Toyota Motor Manufacturing Corporation in 1937. A new assembly plant, much bigger than the one at Kariya, was completed in Koromo the following year. This was where the company continued to select production technologies appropriate to its limited scale of production (Fujimoto and Tidd, 2002, p. 90). The first attempts at Just-in-Time production thus took the form of ”memorandum development”.

It was taken as read in mass production that the machines produced many defective parts. The other pillar of the Toyota Production System, *auto-activation*, incorporated the idea that machines should be designed so that they could distinguish between normal and abnormal conditions. This invention had already been made at the time when Toyota designed its weaving machines. The *autonomated* machine for textile production was designed so that the loom stopped instantly if any one of the warp or weft threads broke. This design principle was applied in Toyota’s automobile production in the prewar era, and later incorporated into production management.

While Toyota was trying to construct its own mass-production system in the pre-war era, the traditional craft system persisted in many of its production processes³⁵. In an interview the production manager Taiichi Ohno suggested that craft skills were needed, but at the same time they prevented the adoption of mass-production methods.

³⁵ The Kariya plant was run under a contract system in which wages were determined on the basis of turnover for each work process. It was not possible to completely to apply JIT in practice because of the unevenness of the processes. The wage system was modified in the new Koromo plant to support the JIT production principle. (A History of the first 50 years, 1988, p. 71)

Many elements of craft production persisted, and craft skills were required in job shop environments. Workers machined a variety of parts, while sharpening their own cutting tools. Process flows were often disturbed, work-in-process inventories piled up, and lack of balance in machine utilization occurred. (Fujimoto & Tidd, 2002, p. 90)

Traditional craftsmanship and its ways of generalizing persisted in many plant operations.

There was a team of five workers for each hammer machine: one for heating, one for rough hammering, two for shaping, and one for finishing. One in the hammer was called "bo-shin", who led the team as master and was responsible for production volume and quality. It was said that it would take three years to master heating and five years to master hammering. Craftsmanship of the forging workers was remarkable. (ibid., pp. 90–91)

There were three big chains of events in Toyota car production: the process of creating mass production in the pre-war era, the process of creating small-batch production, and the process of transformation from craft to a new type of production. The Second World War dramatically interrupted all these processes: the Koromo plant was bombed, for example. After the War the company had to be rebuilt from the ruins (Toyoda, 1987, p. 59).

7.4 The contradictions in production and their first solutions

Post-War crisis

After the Second World War Kiichiro Toyoda introduced an ambitious three-year plan for catching up with America in the production of cars because, in his view, the Japanese automobile industry would not otherwise survive (Ohno, 1988a, p. 3).

Toyota's production volumes were very small, however, its output in 1950 being only 2,685 cars. In the same year the world's most effective Ford factory on the River Rouge in Detroit produced 7,000 cars a day. Toyota's leaders carefully studied the production method used in Rouge. Given the small size and unprofitability of the domestic market the company had to look elsewhere. Moreover, the competitive situation in the domestic markets intensified because huge foreign vehicle producers were anxious to establish plants in Japan. The Japanese government issued a prohibition order on direct foreign investment in the Japanese mo-

tor industry, however, which was a critical development in gaining a foothold in automobile production. The Japanese Ministry of International Trade and Industry put forward a series of plans to merge Japan's twelve embryonic car companies into a Japanese conglomerate that could battle with the large American factories.

The Ministry's plan was based on mass production. Kiichiro Toyoda's purpose, however, was to produce "inexpensive high-quality automobiles, which were able to compete with those of top world companies" (Ohno, 1988a, p. 96). The catch-up goal seemed to be impossible for two reasons. Surviving in the domestic car market was impossible because of the superiority of foreign mass producers, and because, in the long run, the domestic markets were too tiny. The possibility of producing cars for export also seemed weak because Toyota did not have modern mass-production machines or the money to invest in them. The company had to use the few mass-production tools it had and its craft equipment (Ohno, 1988b; Womack, Jones, and Roos, 1990).

The "raw material" was a further problem. Car production involves manufacturing and assembling thousands of parts. In the post-war situation the suppliers were not able to deliver the parts on time, which meant that the entire assembly plant might be idle for 20 days, waiting for parts to arrive. The assembly work was then done during the remaining 10 days. (History of Toyota, 141–142) Ohno also recalls that, after the Second World War, the increased number of orders because of the Korean War led to a shortage of everything from raw materials to parts. Suppliers were also short of equipment and manpower, and assembly work was continuously delayed.

For this reason we could not do the assembly during the half of the month. We were forced to gather the parts that were arriving intermittently and irregularly and do the assembly work at the end of the month. (Ohno 1988a, p. 12)

The Toyota Company almost went bankrupt in the post-war years. The founding family proposed laying off a quarter of the workers, which led to a bitter labor dispute that lasted over two months. After protracted negotiations, the family and the union worked out a compromise. Twenty-five percent of the workforce was laid off as the Toyoda family had proposed, but Kiichiro Toyoda resigned as president in accepting responsibility for the company's failure, and the remaining employees received two important guarantees: lifetime employment and pay that was steeply graded according to seniority rather than to standardized job functions (Womack, Jones, and Roos, 1990, p. 53–54). In Ohno's opinion, the crisis taught the company that production increases and cost reductions had to be carried out within the small-lot production concept.

We got a lesson from the crisis that productivity increase and cost reduction had to be accompanied by "limited volume production", which meant that we had to produce just enough to sell and just when we could sell. We learned that productivity increase for the sake of itself was no good, and that we should not simply imitate the American style mass production. (Fujimoto and Tidd, 1988, p. 91)

Womack, Jones and Roos (1990, p. 54) maintain that the Toyoda family adopted a novel approach to its workforce because of the agreement. They considered the workforce a fixed cost – an even more significant one than the company's machinery. The job contract ran from the time the new worker entered the company until he or she reached retirement. It thus made sense to continuously enhance the workers' skills and to gain the benefit of their knowledge and experience.

This history shows that behind the crisis were significant developmental contradictions that led the company to develop innovations that together formed the Toyota Production System. The new system gradually replaced the late craft-type of production.

The first contradiction was the huge gap between the production volumes that were necessary for the survival of the company and the prevailing volumes. The need for large volumes of production did not reflect unrealistic management hopes, but was rather indicative of the economic conditions of survival. The production of automobiles only for domestic markets was economically unprofitable, but on the other hand, the requirements set by foreign markets were extremely difficult to meet. *The company would only survive by sharply increasing production to make automobiles available to the masses, but it only had capacity for small-lot production.*

The solution was surprising. The company decided to increase its small-lot production, which entailed assembling various car models on the same line in *small batches*. The batches were made as small as possible, in contrast to traditional mass production. This kind of technique had not been tried before, and its purposeful development in Toyota soon began to produce new results.

The Toyota system was a response to the particular need in Japan to produce a small quantity of each number of models; following this, it developed into veritable system of production. On account of its origin, this system is particularly efficient in conditions of diversification. (Ohno, 1988b, p. 49)

Moreover, to the extent that consumer tastes become more diverse, more individualized and clients themselves more demanding...it became more and more urgent to develop production methods which allowed the individual fac-

tory production of unique goods (...) accepting that (...) it is clear that mass production programming, i.e. the Ford system, cannot achieve this objective. (Ohno & Mito, 1988 p. 17)

During the first five years of post-war restoration, Toyota was forced to increase productivity without having sufficient funds or equipment. No new machines could be bought. The usual method of transforming craft-based industry to mass production was to install mass-production machines, but the company had to experiment with other methods. *The second contradiction was between the demand for high productivity and the need to use traditional small-lot production machines and craft methods.*

Because it was not feasible to invest in machines, the only possibility was to focus on "soft" production methods such as standardization, changes in layout, job assignment, and investment in relatively inexpensive jigs (Fujimoto & Tidd, 2002).

The third contradiction was between the need to increase productivity on the assembly line and the irregular and haphazard activity of the suppliers. The main problem was how to increase productivity in a situation in which the suppliers' and the assembler's activities did not match. The implementation of the Kanban information system, beginning with the Kanban card, solved the problem.

The Kanban system, which became the most important tool in JIT production, also gradually developed through experimentation. The results of the experiments often surprised the workers as well as the managers. Ohno describes how he solved problems related to the Kanban system.

There was no manual and we could find out only what would happen only by trying. Tension increased daily as we tried and corrected and then tried and corrected again. Repeating this, I expanded the system of pickup by the later process within the company. (Ohno, 1988a, p. 32)

7.5 Building a system of generalizing to support the small-batch mass-production system

The Two phases of the Toyota Production System

The general solutions to the Toyota production contradictions comprised the development of the small-lot production system, the use of "soft" methods in order to increase quality and productivity, and the creation of the Kanban information system. In this section I will trace the two phases in the development of the Toyota Production System. The first phase consisted of developing "all-out production"

by training the workers gradually to perform new kinds of operations and tasks, the objects of which were quite different from those in traditional mass production. The second phase was one of refining processes of generalizing that were carried out in the implementation of Total Quality Management 1961–1970.

Extensive and successful experiments were carried out in 1945–60 in the form of multi-skilling the line workers, standardizing the tasks on the shop floor, using the suggestion system, developing team collaboration, using the Kanban card and visual process-control tools, and exploring the causes of the problems in small-batch production.

I will show how the successful results of these experiments made it possible to systematically apply processes of generalizing in order to improve and control small-batch processes. The system that was built in 1961–1970 followed the well-known pattern of the Deming cycle: plan – do – act – check. It involved identifying a some deviation from the process as a problem, assessing the current situation, analyzing it, implementing and establishing corrective measures, evaluating the results, standardizing the method in order to prevent further recurrence, and follow-up and consideration of the remaining problems.

Developing multi-skilled operators

From the very start of automobile production in Toyota, the machines were equipped with devices and "baka-yoke" fool-proof systems to prevent the manufacture of defective products. Because of these technological advances, the responsibilities of the workers expanded to cover the many machines and processes that were part of the entire production flow. Traditional craft jobs were replaced by multi-task jobs. Multi-skilled workers were all-round players who did everything related to their trade regardless of the phase of the process or the work standards. Multi-skilling among line workers began in the pre war era.

Rearranging machines on the floor to establish a production flow eliminated waste of storing parts. It also helped us achieve the "one operator, many processes" system and increased production efficiency two and three times. (Ohno, 1988b, p. 14)

Ohno relates how the transition from a single- to a multi-skilled operator went relatively smoothly, although "there was some resistance from the craftsmen". The impact of multi-skilling on productivity was obvious.

For example, there were three or four workers around one machine, particularly when it was an important one, prior to the war. So simply assigning one

worker to one machine increased productivity by three, four times. Workers with craftsmen's mentality resisted such measures, but labor saving was relatively easy as the turnover ratio was very high at that time. (ibid.,15)

Comparing the standards to the actual work performance

The shift from craft production to Taylor-type standardization progressed in the late 1940s at Toyota's machine shops despite some resistance from traditional craft workers. Taiichi Ohno recalls the situation when he was made section head of the machine shop in 1946.

The first thing that I did was standardization of jobs. The shop floor of those days was controlled by foremen-craftsmen. Division managers and section managers could not control the shop floor, and they were always making excuses for production delay. So we first made manuals of standard operation procedures and posted them above the workstations so that supervisors could see if the workers were following the standard operations at a glance. Also, I told the shop floor people to revise the standard operating procedures continuously, saying, "You are stealing money from the company if you do not change the standard for a month". (Fujimoto and Tidd, 2002, p. 92)

It should be remembered that work standardization at Toyota was accompanied from the very beginning by continuous improvement in standards by the line workers. Thus the standardization under Ohno resulted in continuous improvement at the shop-floor level, which was not the case with Fordism, when work standardization tended to mean the freezing of standard operations.

It seems that the production engineers at Toyota first carried out a Taylorist analysis in terms of a) defining the task, b) measuring the variation of movements, c) comparing the movements in order to create the standard, d) testing the standard, and e) teaching the standard. It was then the task of workers to compare the standard with the job, and change it if necessary. The workers themselves began to *compare* their work operations to those defined in the standards. This was a turn away from Taylorist to a new "Ohno type" of standardizing. Given the lack of detailed descriptions of the tools used in the improvement of standards, we have to assume that such improvement was based on these actions of comparison. Another major deviation from Taylor's model was that no standard work sheets were made for individual line workers.

The line workers were taught to carry out several tasks, which were interchangeable within one team. This meant that the productive actions, which were transferable from one line worker to another, became important objects of standardization (Coriat 2002, p. 221).

For a production person to be able to write a standard work sheet that other workers can understand, he or she must be convinced of its importance.

Making suggestions

As a result of the visit to Ford's River Rouge Factory, Toyota adopted the Fordian *suggestion system*, under which individual workers could make suggestions for improvements in various technical and organizational areas. Ford's suggestion system has been criticized (Monden, 1983; Imai 1986) in that the real purpose was to do with labor management and not improvement. According to these interpretations, it was a system aimed at giving the line worker the sense that he was more important to the company than he really was.

Kiichiro Toyoda recognized the suggestion system as a competitive weapon: "In order to survive in the competition with foreign automobiles in future, we have to reduce manufacturing costs by making use of our suggestions." The purpose of Toyota's Suggestion System was expressed in the slogan "Good Products, good ideas". The aim was to improve quality reduce the costs, and also to systematize spontaneous on-site suggestions, which had been a tradition since the company's pre war era. The employees were encouraged not only as individuals, but also in teams and later in Quality Control Circles, to make improvement suggestions and also to implement them (A History of the first 50 years, 1988, p.114; Monden 1983, p. 126).

From the speeding up of set-up times to collaboration on the shop floor

Womack, Jones, and Roos (1990, p. 51–55) give a good example of how the successful process of rearranging the set-up time of die presses was an innovation that made it both possible and necessary for workers to identify problems and collaborate in order to improve the quality of the product.

In those times car manufacture started with a large roll of sheet steel. The workers ran this sheet through an automated "blanking" press to produce and stack flat blanks that were slightly larger than the final part they wanted. They then inserted the blanks in massive stamping presses containing matched upper and lower dies. The huge and expensive press lines used in mass production were designed to make a million or more of a given part in a year. Die changes typically required a full day from the production of the last part with the old dies to the first acceptable part from the new ones. Western manufacturers found that they could dedicate a set of presses to a specific part and stamp these parts for months, or even years, without changing dies. Toyota's production was a few thousand vehicles a year, however.

Ohno's idea was to develop simple die-change techniques and to change them frequently using rollers to move them in and out of position and simple adjustment mechanisms. Because the new techniques were easy to master and production workers were idle during the die changes, Ohno hit upon the idea of letting the production workers also change the dies. Engineers did this work in Western mass production.

From the late 1940s Ohno experimented endlessly with his technique for making quick changes. By the late 1960s he had reduced the time required to change dies from one day to an astonishing three minutes, and had eliminated the need for die-change specialists. In the process he made an unexpected discovery – it actually cost less per part to make small batches of stampings than to run off enormous lots. The consequences of this discovery were enormous. It made the workers in the stamping shop much more concerned about quality. It also effectively prevented the production of defective parts, which were usually discovered long after their manufacture and had to be repaired at great expense, or even discarded. (ibid., p. 53)

To make this system work Ohno needed extremely skilled workers. If they failed to identify problems and did not take the initiative to devise solutions, the work of the whole factory could easily come to a halt. Holding back knowledge, a generally recognized feature of traditional mass production, would swiftly lead to disaster in the factory. This was the origin of worker collaboration in preventing production disturbances.

Using the Kanban card

Pondering upon the contradiction between the need to increase productivity in the final production line and the haphazard activity of suppliers, Taichi Ohno turned to the American supermarket:

A supermarket is where a customer can get (1) what is needed, (2) at the time needed, (3) in the amount needed. Sometimes of course, a customer may buy more than he or she needs. In principle however, the supermarket is a place where we buy according to need. Supermarket operators, therefore, must make certain that they can buy what they need at any time. (Ohno, 1988a, pp. 26)

Ohno (1988a, pp. 26–27) explained how the later process (customer) went to the earlier process (supermarket) to acquire the required parts (commodities) at the time and in the quantity needed. The earlier process immediately produced the quantity just taken (restocking the shelves). In automobile production this would mean that the downstream station had to come upstream to pick up just enough parts, whereas the latter would produce just enough to replenish what was taken by the former. He called the system he devised to link the upstream and the down-

stream by using standardized returnable containers and reusable slips the Kanban system.

The Kanban system was adopted in the machine shop around 1953. To make it work Ohno produced pieces of paper listing the relevant part number of a piece and another and other information related to machining work.

If a supermarket had its own production plant nearby, there would be the production Kanban in addition to the withdrawal Kanban between the store and the production department. From the direction of this Kanban the production department would produce the number of commodities picked up. (ibid. p. 28)

Ohno realized that all the movements in the factory could be unified and systematized with the help of the Kanban.

We felt that if this system were used skillfully, all movements in the plant could be unified or systematized. After all, one piece of paper provided at a glance the following information: production quantity, time, method, sequence or transfer quantity, transfer time, destination, storage point, transfer equipment, container. (ibid., p. 28)

The economic significance of the Kanban became important.

It is not an overstatement to say that Kanban controls the flows of goods at Toyota. It controls the production of a company exceeding \$4.8 billion a year. (ibid., p. 29)

The invention and use of Kanban meant five things. *First*, the information about variations in markets and customers was delivered directly to the shop floor workers, suppliers and subcontractors. *Second*, Kanban cards carried the information in the form of signs, numbers and words, not as tools. The signs did not directly affect on an article moving on the assembly line as machines or tools did. The generalizations fixed in the signs were addressed by one person to another. *Third*, this information affected every operation and all operators in the factory. The other side of the coin was that the use of the Kanban connected all operations carried out by the line workers to the logic of this kind of production flow. In conventional mass production only the top of the hierarchy reacted to the market situation, whereas the Kanban brought the knowledge directly from the customers to the producers. *Fourth*, Kanban information was also changing information. The knowledge it carried became part of the work team's problem-solving process

in managing the variations within the small batches. *Fifth*, the use of the Kanban clarified the role of managers and supervisors in the production. It immediately highlighted flow problems, thus facilitating their study and resolution.

Kanban cards became a new kind of tool for shop-floor workers. They mediated the generalized operations of managing the variation within the small-batch production process.

Using Andon as a visual tool

Andon is a line-stop indicator that hangs above the production line. It was invented as a tool for ensuring the economic flow of production. When operations are normal the green light is on. When a worker wants to adjust something on the line and calls for help, he turns on a yellow light. If a line stop is needed to rectify a problem, the red light is turned on. The workers were told that, in order to thoroughly eliminate abnormalities, they should not be afraid to stop the line. (Ohno 1988, p. 121)

Andon was developed according to the *auto-activation* principle originally used in the design of machines. It was based on the idea that it was economically more profitable to stop the line in cases of defects than to keep it moving. It is also a way of handling single disturbances openly. These kinds of decisions belong to the line managers in conventional mass production. A further use of the andon was to enable the other workers to see the condition of the line. In this sense, it mediated a generalized operation that affected the entire production flow.

The "five whys"

It was also the job of the team to question the root cause of the process deviation they had identified, and to keep questioning it until a solution had been found and a new standard created. The entire procedure used in TPS revolved around repeating the question "Why" five times. Ohno characterized this method as a scientific approach: by asking "Why" five times and answering it each time we can get to the real cause of the problem, which is often hidden behind more obvious symptoms. He gives (1988, p. 17) an example:

1. *Why* did this machine stop?
There was an overload and the fuse blew.
2. *Why* was there an overload?
The bearing was not sufficiently lubricated.
- 3 *Why* was it not lubricated sufficiently?
The lubrication pump was not pumping sufficiently.

4. *Why* was it not pumping sufficiently?

The shaft of the pump was worn out.

5. *Why* was the shaft worn out?

There was no strainer attached and metal scrap got in.

The team could use the procedure in order to find the final solution: attaching a strainer to the lubricating pump.

Developing the Quality Control Circle

With the minimizing of inventories through JIT and the Kanban system, the disturbances were more commonly within and between the production processes: the nature of the production process changed radically. Although the Kanban made JIT production processes possible, it not only controlled the level it also began to *stimulate* the workers to sort out the disturbances. Moreover, problems to do with speeding up the set-up times and discussing the defects were not resolved at one go, but without their resolution normal working on the shop floor was almost impossible. (Monden, 1983, pp. 130–131)

Ohno grouped the workers at the work stations into teams, which had a team leader rather than a foreman. The team's responsibility was to carry out a set of assembly steps that belonged to their own piece of the line. The *processes and the junctions of the processes* became the object of these effective work units. (Womack, Jones & Roos, 1990, p. 54; Ohno, 1988, pp. 23–26).

Toyota decided to adopt the system of Total Quality Control in 1961, and drew up a master plan. The implementation took three years under the guidance of two authorities on quality control, Professor Kaoru Ishikawa and Tetsuichi Asaka.

Quality-control circles (QCC) were unofficial parts of the organization and were closely interlinked with the official parts: the members of the group consisted of workers from the same work station. The circles were also administratively independent. The members decided themselves on the subject matter they wanted to handle, the courses of action they wanted to take and on their leader, a coach, who had his own responsibilities to the QCC, including record keeping. The line manager or the initiative committee had to process the initiatives of the circles within three weeks. In the decision was positive, the work team could put the improvements into practice immediately. If the process led to a negative decision, the decision maker had to give reasons to the circle. The main aim of circles was to formulate and continuously improve the standards, which was also the task of administrative and technical staff.

Ishikawa (1985; 1990) lists the fundamental ideas behind QCCs as follows: self-development, voluntarism, group activity, participation by all employees, uti-

lization of QC techniques, activities closely connected with the workplace, vitality and continuity in QC activities, mutual development, originality and creativity, awareness of quality, problems and improvement. Improvements in production flow were carried out through the stepwise problem-resolution procedure³⁶ (Ishikawa 1985, p. 147). The QCC had to address a number of issues: each one had to select its own theme independently, and then engage in the task of solving problems attached to it.

There were four phases in the improvement process adopted by QCC: Plan-Do-Check-Action. "Plan" means planning improvements in current practices by using statistical tools; "Do" means the application of the plan; "Check" means seeing if the application of the plan results in the desired improvement; and "Action" means preventing recurrence and institutionalizing the improvement as a new practice to be improved. The precondition for this kind of process is that all of the operations of the workstation are standardized. (Imai, 1986, pp. 62–63)

The problem solving in the planning phase consisted of four steps. The first three were to define the problem, identify the causes, and plan counter-measures. Brainstorming sessions or group discussion were used in defining the problem, which in practice was based on observation by the members of the workstation of their work process. Statistical tools, check sheets, pareto-grams, histograms and log booking were used for the data collection in the fourth step. Both statistical and qualitative instruments were used.

The QCC identified the most serious failures using statistical pareto-analysis. The most effective instrument for qualitative analysis is the fish-bone method, which is helpful in understanding the causal relations in the production process, and also in identifying problems (Ishikawa 1991, p. 42).

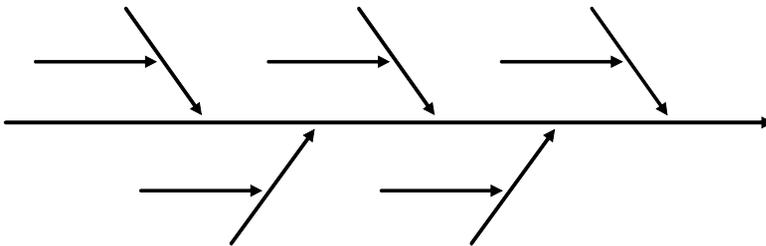


Figure 7.1 The fish-bone diagram (Ishikawa, 1991, p. 42)

³⁶ 1) Deciding on a theme 2) Clarifying the reasons this particular theme was chosen 3) Assessing the present situation 4) Analysis of the causes 5) Establishing corrective measures and implementing them 5) Evaluating the results 7) Standardization, and prevention of recurrence of deviations 8) After-thought and reflection, consideration of remaining problems 9) Planning for the future.

The process can be continued by analyzing the variation and elaborating on the data. Special methods are also used for making corrective steps and for stratification. Experiments with new arrangements are evaluated by means of before-and-after comparisons. The results of the improvement processes typically involve the adoption of a new standard or of rules that might prevent the recurrence of the failure. The QCC also evaluates the results of this research process and considers possible new problems. Perhaps its most interesting feature is the linking of the quantitative or, let us say, graphical, presentation of cause-effect relations by statistical means.

7.6 Assessing change in generalizing

The Toyota Production System was developed with a view to resolving the contradiction that arose in the implementation of Taylorist-Fordist mass production in a long series in a situation in which the only possibility was to produce a number of different products. Flexible mass production of small batches replaced push-type line production with pull-type order delivery.

Three concepts were developed to master this new production type, carrying the generalizations that characterized the post-world-war period of 1945–1961: *Just In Time* and *Autonomation* described the new production type, and *Waste* referred to the methods that were used in making these principles concrete.

Special tools that were developed to support the new type of production, such as the L-type production line, the development of special equipment including the die press, and the invention of production-control tools such as Kanban and Andon, are examples of the outcomes of this production design. They were artifacts that carried generalized operations and made the mass production of small batches possible. They were also outcomes of processes of generalizing that were based on many experiments and new kinds of planning. Their realisation would not have been possible without the development of teamwork structures and quality-improvement initiatives, and the use of multi-skilled workers. The use and design of production-control tools changed the process of generalizing, and the role of the planners and workers involved. The workers had to be able to use these tools and to collaborate in a new way, and the planners had to master the two-way information traffic in the order-delivery chain.

The standardization that was effected by the workers and the search for the root cause of production mistakes were the first representations that were used in the processes of generalizing. They were of help when the workers in the workstations began to form teams to solve the problems in the processes that comprised their own tasks and possibly also other processes on the production line. The workers' own standardizing was a logical extension of the planners' standardizing

task, and involved continuous "restandardizing" as opposed to the stabilizing of the Taylorist-Fordist system. The workers' and planners' processes of generalizing changed, as did their mutual division of labor.

After 1961 the advent of the quality circle and related tools enabled the confirmation and spreading of the new system of generalizing. The actions consisted of a research process in which the variation in the process and tasks of a workstation were continuously compared with each other and with the norms, or the previous results of the process of generalizing.

In sum, it could be said that the change from standardized to flexible mass production followed the logic of expansive transformation, which also entailed the transformation of the distributed system of generalizing. The direct implementation of the Fordist-Taylorist system of mass production, which was based on long series, was more difficult in the post-war situation. Ohno with his assistants *questioned* the direct implementation and *analyzed* the reasons behind these difficulties in trying to combine traditional small-batch production with mass production. Using the supermarket metaphor as a springboard he succeeded in *modelling* the new pull-type of production system in which the object of the new kind of generalizing was the order-delivery chain. The production was a certain type of two-way information traffic. The model was a combination of Taylorist-Fordist mass production, Total Quality Management, and new local innovations and principles such as JIT, automation and Muda as used in Toyota. The *implementation* of the model took over ten years and became known as the Toyota Production System. The concept, later termed flexible mass production, lean production and process enhancement, came into general use in automobile manufacturing and in many other areas. The system of generalizing that was needed was quite different from that in Taylorist-Fordist mass production.

8 The concept of a distributed system of generalizing

8.1 Elements of the system

In this chapter I present my theoretical conclusions from the analyses of these cases, thereby addressing my second research question concerning the general structure and dynamics of the dominant forms of learning in and for production that preceded the ICT revolution.

According to the theories of the historical development of production discussed in Chapter 3, changes in forms of learning are part of the overall changes in forms of production. According to Marx (1973, p. 705), labor processes become increasingly interdependent in their historical development, in other words they become progressively socialized as they come increasingly to embody capabilities developed in the broader society rather than only those that emerge from private experience and the local context. This process of socialization is realized through a deepening of the social division of labor and the development of increasingly complex relationships of exchange and interdependence between occupations, organizations, industries and regions (Adler 2002). It concerns not only the labor process proper, but also the learning related to it. This means that learning processes also become more widely distributed and dependent on "capabilities developed in the broader society rather than only those that emerge from private experience and the local context".

In this chapter I will summarize my analyses of the three transformations of distributed systems of generalizing by viewing them as *qualitatively specific aspects of the labor-socialization process*. I will show in detail how the elements of the system of generalizing have changed in the transformations of production discussed.

I suggested in Chapter 4 that learning could be understood as a process of adopting, creating and changing practice-relevant generalizations. I identified five elements of the process of generalizing that explain learning in and for production:

1) the initial generalization that defines the object of attention and the "sameness" in variation, 2) the variation within the object of attention that is used to reach a generalization, 3) the process of generalizing, and 4) the type of memory that preserves the generalization. The analysis revealed that generalization is always a social process in a community. Although an actor may produce the initial idea, the generalization is a product of social exchange. Thus the agent and the community of generalizing have to be seen as the fifth and sixth elements of the system.

Studies concerning historical types of generalization have shown that it is not only the content but also the form that varies. This led me to add the dimension of the nature of the produced generalizations as the seventh element of the distributed system. The analysis of Taylor's system in Chapter 5 revealed the specific form of the distribution of parts of the process in mass production. Therefore the division of labor and the forms and rules of exchange have to be added as the eighth and ninth elements.

I will now elaborate on this concept of a distributed system of generalizing on the basis of my analysis of the cases. This will help me to localize the reason for and the nature of the changes.

All of the three transformations I have analyzed concern variants of industrial production. In each case, the context of the distributed system of generalizing was a production activity carried out by a group of actors operating machinery and specializing in some functions within the overall production process. In each case a new distributed system of generalizing was created. I will now describe each system in terms of the specific features of the basic elements described above.

8.2 Three systems for generating production-relevant generalizations

The Taylor system

The further socialization of the labor process in late craft-type production took place mainly through mechanization, in other words by developing and bringing new mechanical machines to factories to carry out specific functions within the production process. Up until Taylor's, time this form of socialization was still slow and uneven. The introduction of new machines nevertheless required new occupational groups to use them and also demonstrated the speed with which they made it possible to produce industrial products. Nevertheless, only some of the functions within the production process could be mechanized, and many still had to be carried out manually. The mechanization-based further socialization of the labor process led to a deepening of the division of labor and further specialization within the factory.

Before Taylor's work, the form of producing practice-relevant generalizations was based on experiential learning within occupational groups and "gangs" that created rough, situation-bound generalizations on the basis of their accumulated historical experience. These generalizations were preserved as verbal rules of thumb, as some individually developed improvements to machines and tools, as well as in specific forms of co-operation and work practices. The crucial limitation of this type of generalization was that it could only be transferred from one work group or one individual worker to another in the actual work context.

The enormous growth in production capacity through the introduction of mechanical machines at the beginning of the 1900s collided with this limitation in the form of learning in and for production. This collision triggered the development of a new form of organization based on standardized work-task instructions and standards: the production-relevant generalizations were no longer created within the occupational group, but were produced through a specific process of measurement, analysis and design by the planners in the planning office. This new form of production was further developed as the transfer of work objects was mechanized through the use of the conveyor belt.

The unit and the object of generalization in this system was a task within the production chain. The variation that made the generalizing possible was in the ways in which different workers carried out the same task, and the method was based on a comparison of the empirically devised different "work methods" of various workers through the measurement of time spent on the task. This method of reaching a generalization concerning the optimal way of performing the task comprised two main processes. The first was the "time and motion study" analysis of the variation in performance of the task and the formation of a standard time and method: the planners applied representation methods generally used in mechanical design. The second process involved teaching the standard to workers and controlling how it was carried out.

The "general", or "the generalization", that was reached was the norm time and the *optimal way of doing the task*. This type of empirical generalization was valid on condition that the object of the task and the tools used in performing it did not vary to the extent that the optimality of the work method would be lost. The system also implied that the optimum was the same for all persons who were suitable for the task. Neither did the generalization allow any variation in the division of labor, or any collaboration between workers. Every change in the material to be handled, the objective of or the tools used in performing the task, or in the organization beyond the limits of the standard, required a new process of generalizing in order to establish the optimum performance in this new condition.

The generalization was preserved in the work standard that was a description of the optimal way of performing the task and the norm time that could be used

for performing it. The planning officer and other officials were the main agents in producing the generalizations, although the process required co-operation from the workers within the rules set by the planners. Taylor proposed a functional division of labor between the planners. Of course, the generalizations had practical value only in so far as the workers applied them. Thus the workers were an important element in the system.

As the coal-mine study and the developments in the Toyota car production illustrated, engineers applying the Taylor system met conditions in which its requirements were not met, and which they had to modify by creating of alternative production-relevant generalizations.

The Socio-Technical System

Trist and Bamforth studied the change of the labor process in the coal mine following the application of mechanical technology to a late-craft type of production process. The pre-mechanized means of production used by work groups in the mine were replaced with electric coalmining machines and conveyors operated continuously by shifts of workers according to the Taylor system. Trist and Bamforth's study showed that the new system of generalizing was in contradiction with the unpredictable nature of the object of the coalmining activity. In their search for a solution to this contradiction they found one work team applying the "all-in" method, which they thought might provide it.

The analysis of the work of that team led the researchers to redefine the unit and object of generalizing within the production process. Individual work tasks were replaced by a broader task within the production chain that was given to a team. The work team could handle the unpredictable variation in the object and conditions of its work. The system of generalizing was divided into two subsystems. The production process as a whole and the frame of the teams' activities were designed applying the general principles of the technical design of production processes. However, within the limits and objectives set by the production management, the team was expected to apply the traditional method of experience-based perceptual functional generalizing. The "general" that the planners reached were norms concerning the relationships between parts of the production process, which were preserved *as the tasks of teams*. The generalizations the teams themselves reached were situated action patterns corresponding to different objects and conditions of work that were preserved in their habits, gestures and language. This type of perceptual-functional generalization was produced and handed down only within the framework of the team's work. The rule was that the teams themselves should create and preserve the situated action patterns.

Trist and Bamforth did not define any new process or tools for achieving the kind of generalization the teams needed for mastering the variation in the object and conditions of their work. Ever since the coal-mine study this kind of perceptual-functional generalizing carried out by work teams within their delineated areas of responsibility has represented the STSD ideal, as in green-field-designed factories for example. Much theoretical work has been carried out and many procedures have been developed for delineating the work tasks of teams.

The unit and object of generalizing in Socio Technical Systems Design was two-fold: the first object was the delineation of the team's tasks and boundaries for its "semi-autonomous" action within the production chain, and the second was the way the team performed the work task so delineated. Researchers characterized the former as the technical aspect of production design, governed by the laws of technology, and the latter as the social aspect of production governed by social laws. They suggested a design method for mass production in which the technical aspect could be planned so as to allow the team to work in a way that was based on the use and development of perceptual-functional generalizations. This led to a form of organization incorporating the craft-type system of generalizing into the of mass-production system in order to make it possible for teams to cope with variation, which could not be dealt with adequately in the Taylor system. Following Trist and Bamforth, socio-technicians have re-defined and systemized this one-time change method by developing new design models, but the main idea has remained the same.

The flexible mass-production system

The Toyota Production System was the result of a unique effort to implement the principles of Taylorist-Fordist mass production in conditions in which it was not possible to produce long series of the same product, and in which the same production line had to be used for a number of different products. The Toyota solution to this contradiction between the unifying principle of Taylorist-Fordist production and the actual variation in products was to introduce a new form of production that turned the Fordist "push-type" production-chain management around and replaced it with the "pull-type" management of the order-delivery process. The mechanization and automation of the production phases were carried out as part of this development.

The introduction of the new "pull concept" also led to a radical change in the distributed system of generalizing and changed the way in which the tools developed for Taylorist-Fordist mass production were used. A new kind of subject and agent was created, the multi-skilled team. The Toyota car-production teams differed in two respects from those operating under Socio-Technical Systems Design. First, the team members performed a number of tasks according to the optimal

method, in other words they relied not on perceptual-functional generalizing but on empirical generalizations that they continuously and co-operatively changed. Second, they were empowered and obliged to improve the work methods and the design of the production process, and were taught to apply a number of methods themselves to eliminate recurrent disturbances and various forms of waste.

Thus it was not a question of individual workers focusing only on their pre-determined task as in the Taylor system, or of the team focusing on its own task, as in Socio-Technical Systems Design. On the contrary, the Toyota teams were mindful of the flawless running of the whole production process, and intervened when necessary to prevent or settle disturbances and to reduce waste. The solving of production problems went beyond their manifest form back to the root cause in the earlier phases of the order-delivery process. Thus the object of the team's problem-solving was the development of a sequence of actions within the process that had turned out to be problematic. The generalizations created as solutions to recurrent disturbances and problems of waste incorporated performing specific tasks or sequences of tasks effectively in spite of the variation in the production process caused by changes in products and machine settings, and also by human error. The unit and object of generalizing was thus a problematic sequence of actions or operations within the order-delivery process.

The basic method of generalizing was to analyze the causal chains within this process. One way of doing this was to take the "Five-times-why" approach, the purpose of which was to find the original cause of the disturbance in the workstations or other parts of the line. The other way was to use graphical representations of causal chains (the fishbone model) and statistical data. The results of the process of generalizing were preserved as changes in the tooling and in the "kanban" signal system used in coordinating the production flow, and as improvements in the work-method descriptions and work standards designed by planners and improved by the work teams. Teams, in collaboration with the planners, were the main agents in producing these production-relevant generalizations. The division of labor between the planners and the workers was based on the rule: planners plan, workers improve.

Cooperative processes of generalizing comprised quality-control procedures and "process-empirical" tools. The standards were set in order to continuously improve the processes rather than to establish certain work tasks permanently. Another difference from Taylor's system was that the workers themselves became conscious of their own routines and changed them. This process of generalizing was fuelled from two directions. First, the management and experts who designed the work methods and the process helped the production teams and responded to their initiatives. Second, the teams improved the solutions offered by the planners and management on the basis of their observations and problem-solving processes.

The characteristics of the three distributed systems of producing production-relevant generalizations are summarized in Table 8.1

Table 8.1 A summary of the analysis of the three distributed systems of producing generalizations

The components of the distributed system of generalizing	Standardized mass production	Socio-technical mass production	Flexible mass production
The object of generalizing	Task performance in the production chain	Group task in the production chain	Problematic sequence in the order-delivery process
The variation to be mastered	The different ways workers perform a task	The variation in the object and conditions of task performance	Disturbances and waste in the process flow
Method of generalization	Measurement-based comparison	Team experience	Analysis of the causal chains in the process
The produced generalizations	Optimal way of doing the task	Situated action patterns of the team	Optimized process-sequence/methods
The artefact that preserves the generalization	Work-method description, work standard	Perceptual habits, action patterns and the language of the team	Work-method descriptions and changes in tools and signals
The agent and the community of generalizing	Planning officers and their office	The designers and the team of workers	Multi-skilled teams in collaboration with the planners
Division of labor and rules used	The planner plans, the worker performs, rules of sanction and co-operation	Planners plan the frame of the team's independent action	Planners plan, workers improve

In terms of the distributed systems of producing production-relevant generalizations, the main feature common to all three examples is the emergence of the production planners and designers as the new subjects and agents of generalizing. The relationship between designers and workers differed in that in Taylor's system it was polarized, Trist and Bamforth softened it, and Ohno turned it almost upside down at Toyota. During the motorization wave the significance in terms of value creation of not only the work designers but also of other types of designers and planners has continuously increased (Ramirez & Wallin, 2000).

The increasingly important role of planners and designers is related to the emergence of generalization through systematic measurement, comparison and design. Abstract empirical generalizations have been produced with the help of secondary artefacts that facilitate the division of labor and the exchange of partial solutions in the process of producing generalizations. In all three cases the dis-

tributed system of generalization was brought out to support the optimization of the current production process, that is, in Bateson's terms, to effect *second-level learning*.

Taylor's contribution was to devise a way of producing fixed, optimized algorithms for performing work tasks. It was a solution to the contradictions that raged between traditional incentive management and the extensive growth and speeding up of mechanical production. Trist and Bamforth's study revealed the contradiction between the varying objects of the activity and fixed work methods, which was resolved by creating a space for craft-type perceptual-functional generalization within the industrial production setting. The resulting work organization was a hybrid of late-craft work and the new rationalized production process. Trist and Bamforth did not create or find any principally new ways of generating production-relevant generalizations. The establishment of semi-autonomous teams set limits on Taylorist rationalization and complemented it.

A similar contradiction between the fixed production process and work methods and the varying object of activity arose in the development of Toyota's production system. In this case, the resolution brought out a historically new kind of distributed system of producing production-relevant generalizations, as described above. Fixed standards were replaced by constant re-evaluation and improvement of work methods and standards through collaboration between workers and planners. The workers were involved in using the secondary artifacts in developing the work methods.

Toyota's pull system of production coordination and the Kanban signal system were instrumental in the mastering of variation in the order-delivery process. The production system was not unitary, but was rather a production-process platform on which various combinations of productive actions could be taken. In this sense, it was based on two types of generalization, the first concerning the necessary phases and tasks of production that were common to all products, and the second the set of productive actions necessary for producing a specific product. The former is more basic and, in a sense, more theoretical than the latter, and describes the common structures in the production of a number of different products.

Although the systems of generalizing described above are different, the process and the type of generalizations produced are rather well defined in all of them. The process has become a permanent part of the management system. In all cases the objective of the new system was the optimization of production. All of the processes were connected to a sequential production process. The ideas and representations used in producing the generalizations were derived from mechanical machine engineering and technology; information technology had a role only in the automation of Toyota's automobile production.

8.3 The development of a new system of generalizing as expansive learning

The analyses of the three cases showed how the pioneers developed, in a long-lasting and complicated process, a new form of mass production and new systems for producing generalizations within it. Despite the very different histories, these processes can be characterized as processes of generalization. The outcomes were the new forms of production and production-relevant generalizations.

Compared with the type of well-ramified problems in the systems of generalizing that were developed, the object of these processes was much more vague. It was partly defined in terms of the various manifestations of contradiction between elements of the production activity: in Taylor's case it was the contradiction between the need to master the production line and the old management system, and in the Trist and Bamforth and Toyota cases it was between rigid forms of generalizing and the varying object of the activity. On the other hand, the object was partly defined in terms of the actors' visions of a new form of production and related normative stance, but also had, to a great extent, the character of an "epistemic thing" as defined by Rheinberger (1993, p. 28).

They are material entities or processes – physical structures, chemical reactions, biological functions – that constitute the object of inquiry. As epistemic objects, they present themselves in a characteristic, irreducible vagueness. This vagueness is inevitable because, paradoxically, epistemic things embody what one does not yet know.

We could say that, in all three cases, a contradiction in the established production practice made the understanding and resolution of the contradiction and the development of a new form of production into an epistemic object that motivated those involved to engage in sustained search, inquiry, experimentation and development. The outcome in each case was a new, expanded idea of production and learning in and for it. In this process they criticized the prevailing production concept, analyzed the root causes of the problems, modelled the new form of production, studied and experimented with new solutions, and implemented new forms of production through these experiments. Thus the pioneers were engaged in a learning and development process that had all the characteristics of what Engeström (1987) has called expansive learning.

During this process the pioneers naturally focused more on the epistemic object of creating a new form of production and less on the process and methods they used to reach their goals. The nature of this kind of expansive learning process attracted attention, and became the object of theoretical conceptualization

and empirical research only much later (see, for instance, Engeström, 1987 and Fujimoto, 1999)

Here we see two very different processes of generalization that represent two different levels of learning: first, the processes of expansive learning that produced new forms of production and related systems of generalizing, and second, the repeated processes that resulted in new production-relevant generalizations within the created new system. The former represents Bateson's third level of learning that transforms the context of problem solving, and the latter his second level of learning, in other words solving the problems within the given context. Not only do they represent two different levels of learning, these two processes are qualitatively quite different and have produced qualitatively different kinds of generalizations. The former exhibits features of genetic-theoretical generalization while the latter has more the character of empirical generalization. As was shown, the time span in these processes was also quite different, years in the former and days and months in the latter.

8.4 The need and possibility to master the historical transformation in forms of production

It appears that, as Freeman and Louca suggested (see page 63), the ICT revolution has triggered a new wave of socialization in labor processes. It will change the processes of generating work-related generalizations in many ways. It is probable that new systems of generalizing such as mass customization and co-configuration, will develop to meet the needs of the emerging new forms of production in the era of computerization. It is also clear that the new technology will provide new tools for producing generalizations, and will affect the communities within which these are created. My analysis does not shed light on these diverse trends, but there is one rather obvious change that will have a broad and general impact on learning in and for production.

The increasing investment in research and development will cut in half cycles of business, product and production concepts, and will increasingly transform second-level learning from separate processes into cycles of expansive learning. This will, first of all, increase the need for interaction and dialogue between strategic management and grass-roots operations. Secondly, the growing importance of strategic transformations will highlight the need for mastering the historical change in the conditions and elements of activities as a form of variation that has to be managed (Ramirez & Wallin, 2000). This new, emerging object of generalization is in sharp contradiction with the empirical processes of generalizing typical of the three distributed systems of generalizing described above. Mastery of the historical changes in the elements of the activity system requires *third-level*

learning that transforms the logic and structure of the whole system instead of changing or just optimizing the way individual tasks or processes are carried out. This calls for theoretical-genetic processes of generalization to overcome historically evolved contradiction between elements of the activity systems. The forms these processes take may be very different. It is also possible that there will be not only one dominant way of producing production relevant generalization as was the case during the upswing of the motorization wave, and that the methods will be much more manifold. In the next chapter I introduce a method that supports theoretical-genetic generalization in work communities, the Change Laboratory.

9 “Learning activity” as a historically new form of generalizing

9.1 Expansive learning actions

According to Engeström (1987, pp. 124–137), there is in our time a need and the potential for a new form of activity and learning that he calls “learning activity”:

The essence of learning activity is the production of objectively, societally new activity structures (including new objects, instruments, etc.) out of actions manifesting the inner contradictions of the preceding form of the activity in question. Learning activity is the *mastery of expansion from actions to a new activity*. (Engeström 1987, p. 126)

The object of attention in learning activity is not on solving and preventing problems and disturbances within current practice as such. It is rather on recurrent disturbances and individuals’ double-bind experiences that are indicative of inadequacy or inner contradictions in the prevailing system and logic of the activity, in other words on the basic generalizations and concepts on which it is based. It involves the creation of a new generalization, a new, broader concept incorporating its object and motive so that its logic also changes.

What is specific to this kind of generalizing is that it suggests concept formation on the one hand, but on the other hand it is about changing the structure of the practical activity, including the tools, community composition and division of labor. It involves the questioning of the prevailing concepts used in mastering the activity intellectually, and replacing them with new ones. The object of the learning activity is the expansive transformation required in overcoming current or threatened crises.

Like any activity, learning activity is carried out through individuals’ interconnected actions that are oriented towards the same object, and in this case it is the epistemic object of finding a way to understand the contradictory demands and double-bind situations in the current form of the productive activity. This is done

by following specific epistemic lines of inquiry as to the causes of problems in the current activity, and in finding new concepts. Engeström calls these actions expansive learning actions.

According to Engeström, expansive learning actions can be broken down into the following basic types:

questioning actions that involve criticizing some aspects of accepted practice and existing knowledge;

analyzing actions through mental, discursive or practical transformation in order to find the causes or explanatory mechanisms: analysis evokes "why" questions and explanatory principles, historical-genetic analysis seeks to explain the situation by tracing its origin and evolution, while empirical analysis does so by constructing a picture of its inner systemic relations;

modelling the newly found explanatory relationship, in other words constructing an explicit simplified model of the new idea that explains and offers solutions to the problematic situation. This happens in some publicly observable and transmittable medium;

examining the model by operating, running and experimenting with it in order to fully grasp its dynamics, potential and limitations;

implementing the new model, which means concretizing it and planning its execution by means of practical applications and conceptual extensions;

reflecting on the process and consolidating the practice, in other words evaluating the new model and the process, and consolidating its outcomes into a new stable form of activity.

In an empirical study of natural work teams Engeström analyzed the discussion in one team meeting and found that the members spontaneously took actions of questioning, analysing, modelling, and examining the model (Engeström, 1996). Learning actions as such are not expansive because they are only parts of the learning activity as a whole. An expansive solution is reached only as one potentially expansive learning action leads to another learning action, and these form a chain that leads to a change in the activity. The activity may take the form of small cycles of change in which partial resolutions of contradictions in an activity system are implemented locally in the work place in a new way that may lead to expansive transformation. The learning actions may make the understanding of the causes of problems and the creation of a new form of activity into an epistemic object for the practitioners, which then motivates further learning actions and leads to collaborative learning activity.

9.2 Developmental Work Research – an intervention methodology for supporting learning activity

Developmental Work Research methodology is a specific intervention methodology developed by Engeström for carrying out learning activity in collaboration between a researcher interventionist and the practitioners.

The interventionist's task is to help practitioners undertake epistemic actions of analyzing the need and possibilities for change in their activity, to model the historical development of the activity system and its current developmental contradictions, and to design a new concept as well as new representations and tools for the new activity.

The research setting is a modification of Vygotsky's idea of developmental experiment based on the method of dual stimulation, the purpose of which was to show that potential capabilities and emerging new psychological formations in the child could be identified by analyzing the formation of new meanings, i.e. new generalizations. It provides practitioners with the tools for taking collaboratively expansive learning actions.

In the process the researcher provides the practitioners with data about problematic aspects of their daily activities and disturbances in them in order to help them identify the need for change. This corresponds to the first stimulus, the tasks in Vygotsky's method of dual stimulation. The general model of an activity system is provided as an intellectual tool for modelling both the systemic cause of the identified problems and a new form of activity.

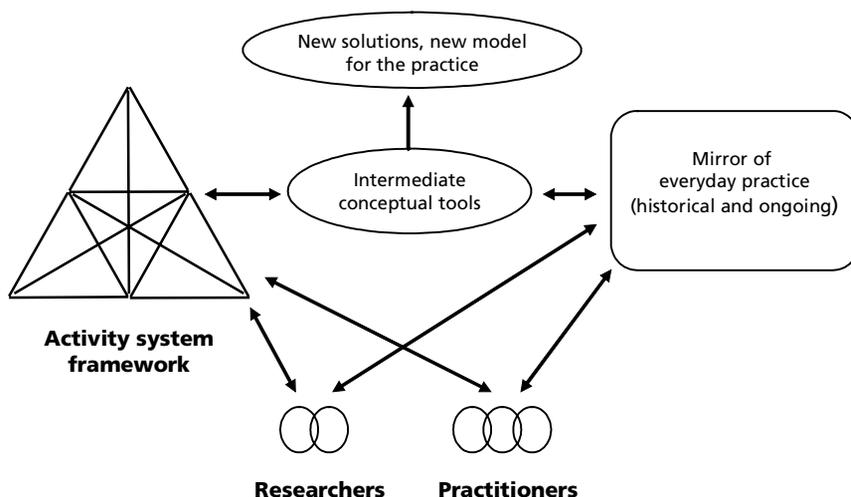


Figure 9.1 The setting of developmental work research for creating generalizations (Engeström, 1991, p.76)

The Developmental Work Research setting comprises three types of artifacts that are used as instruments of expansive learning actions. Data-reflection is used as a "mirror" of daily practice and especially of its problematic aspects. The general model of an activity system is used as a tool for modelling the structure and inner contradictions of the local activity, as well as for creating a model of its new form. Analytical concepts and various representational means are used for analyzing the data in the mirror and for constructing alternative solutions for specific parts of the activity.

The phases of developmental-work-research-based intervention are depicted in Figure 9.2. The intervention process starts with an ethnographic analysis of current practice and of the various problems that practitioners experience in their daily work activities. This makes it possible to delineate the activity in question, and provides data to be used to mirror the practice. All of this helps practitioners to identify problems and to question aspects of current practice.

The next intervention phase consists of three types of analysis of the work activity as a historically developed local system. The purpose of object-historical analysis is to identify the qualitative changes that have taken place in the activity system and to provide an initial hypothesis concerning its current inner contradictions. Theory-historical analysis aims to analyze and to determine previous and current concepts that shape the local activity, and true empirical analysis to reveal and describe in detail the forms of actions and processes involved in the transformation of its objects: to what extent specific tools, rules and forms, and actions and processes are involved in the transformation of the objects of the activity, how specific tools, rules and types of division of labor actually mediate the activity, and what types of disturbances, ruptures and innovative new actions occur in daily practice.

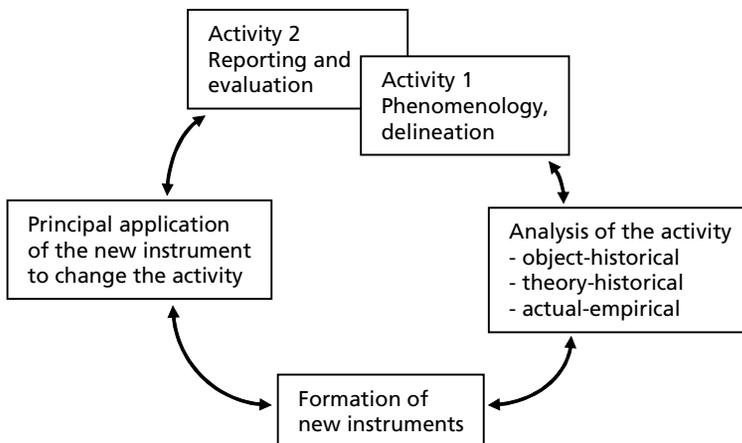


Figure 9.2 The methodological cycle of developmental work research (Engeström 1987, p. 323)

The results of the historical analysis are crystallized in a model of the most prevalent inner contradictions in the activity system. The resulting hypothesis concerning the systemic causes of problems is then enriched, specified and corrected using the data from the empirical analysis. The theory-historical analysis provides sets of concepts for describing and discussing the qualitative variation found in the practitioners' views of their tools and processes, and in the forms of their daily activities. The analyses and the modelling of different aspects of the activity provide rich material for conceptual artefacts that practitioners can use in the production of the new concept for their activity.

The final important and often time-consuming part of the intervention is the practical experimentation with the new concept and the new tools created in the preceding phases. It is in this phase that many new contradictions emerge that call for re-mediation of various aspects of the activity and its interaction with the neighbouring activities.

9.3 The Change Laboratory as a specific application of developmental methodology

The Change Laboratory³⁷ is a specific application of Developmental Work Research, the purpose of which is to help the work community both to implement a deep transformation in its activity and to make incremental changes in its practices.

On the basis of his observations in his research project "Learning and Expertise in Teams and Networks" (Engeström, 1992), Yrjö Engeström formulated five principles for a new method of development, the Change Laboratory.

First, the work redesign has to take place on the shop floor, close to the daily work while still preserving an analytical distance: there was a need for a new interplay between close embeddedness in work occurrences and reflective distance taking. Second, practical problem solving and the construction of challenging future visions have to be combined: there was a need for a new kind of dialogue between solving specific problems and implementing future visions. Third, it has to be possible to manage multiple change processes with different developmental rhythms. Fourth, the methods and tools for everyday work and developmental activity have to be made to support each other: a new dialectic between practice and development was needed. Fifth, the resources inherent in the existing structures and work

³⁷ The CL method is compared to other laboratory methods in Virkkunen, Engeström, Helle, Pihlaja and Poikela, 1997.

practices have to be used in order to take up the new challenges and develop new products and services: a new kind of interaction between innovation and tradition was needed. (Virkkunen, & al., 1997, pp. 155–156)

The idea behind the Change Laboratory is to arrange a separate space as close as possible to the daily work being done. A team, work-group or work unit comes to the laboratory to analyze and develop its own work practices, initially with the help of a research interventionist. The process is typically carried out within a tight schedule because deep changes in work culture are needed in a short time. The method facilitates both intensive, deep transformations and day-to-day improvements.

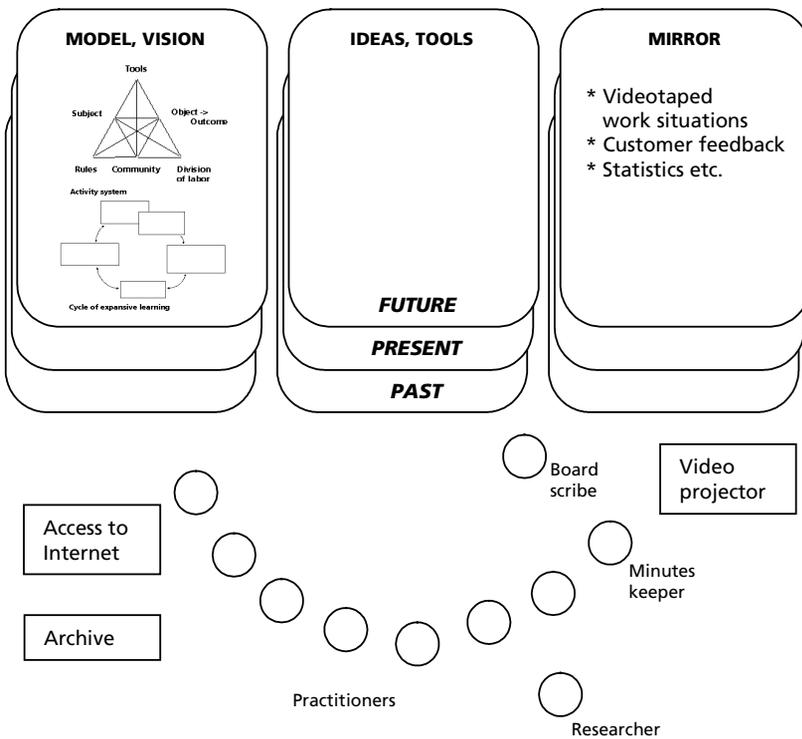


Figure 9.3 A prototypical layout of the Change Laboratory (Virkkunen et al., 1997, p. 16)

The developmental work research setting is realized in the Change Laboratory with the help of a 3 × 3 set of surfaces for representing the work activity. Participating workers face the surfaces so that their discussion becomes mediated through the representations of them. A scribe is appointed from among the participants to write down the ideas that come up. Video equipment is used to enable recordings of problematic aspects of the object of the activity to be shown later. Additional tools such as relevant databases and a reference library may also be available. Thus

the Change Laboratory provides a rich set of instruments, an instrumentality for analyzing disturbances and for constructing new models of work practice.

The horizontal dimension of the mirror, incorporating ideas and model surfaces, represents different levels of abstraction and generalization: models, ideas and data that mirror daily practice. Vertically the boards are divided into three surfaces, the lowest representing the activity in the past, the middle one representing the current situation, and the top one the future form of the activity.

It is possible to enact a whole cycle of expansive transformations with the help of the Change Laboratory, but in general the process involves a smaller cycle of expansive change that is a part or phase of the whole (Engeström, 1999, p. 385).

The Change Laboratory process stimulates many kinds of socio-cognitive processes that support theoretical-genetic generalization. When entering the laboratory, the participants bring their work-related, experienced problems with them and analyze them with a view to developing an activity system. They share their individual experiences with others, and record them on the surfaces. The movement between abstract and concrete takes place as they move between the three boards representing the mirror, the ideas and the model, or the primary, secondary and tertiary artifacts representing the problems of change at work. They also move between temporal layers – past present and future. Finally, the discussions encourage them to bring out different viewpoints and interpretations: the dialogue moves back and forth from one perspective to the other. When the participants go back to work, they consider the ideas developed in the laboratory from the perspective of the realities of their daily activities.

Work in the Change Laboratory typically starts by mirroring current problems, and moves on to tracing their roots of the current trouble by mirroring experiences from the past and by modelling the past activity system. The next task is to model the current activity and its inner contradictions, which enables the participants to focus their transformation efforts on the essential sources of trouble. They then set about envisioning a future model of the activity, including making it concrete by identifying "next-step" partial solutions and tools. Subsequently, the stepwise implementation of the new vision is planned and monitored. Such a cycle induced in the Change Laboratory typically takes three to six months. This kind of cycle leads to the next one, and within them are smaller cycles of problem solving and learning.

The Change Laboratory tools consist of a comprehensive set, a system of developmental tools. The key concept characterizing the system is instrumentality. The instruments form a system that includes multiple cognitive and semiotic means of analysis and design, and also tools used in daily work and brought into the laboratory for examination, reshaping and experimentation. The tool system enables the participants to engage in various kinds of socio-cognitive processes that may

generate a new kind of outlook, a different mentality. Moreover, the tools are under continuous development: old methods are modified and new ones introduced. (Virkkunen, & al., 1997)

The Change Laboratory method clearly represents the theoretical-genetic type of generalizing, which seems to be unique in work-related intervention methods. Moldashl and Brödner (2002, pp. 179-189) identified three basic models of intervention. The traditional, expertocratic model assumes that scientific knowledge is superior to practitioners' knowledge, and allows the deduction of unambiguous, empirically provable design criteria. The intended effects will be achieved when the recommendations are detailed enough and their application is precisely controlled. Secondly, it is taken as given in the proceduralistic model that the relevant knowledge is already present in the organization, and it only has to be mobilized by stimulating and moderating organizational communication. Thus the intervention should focus on supporting the processes of self-organization by incorporating communicative procedures and broad participation: the interventionist is an expert in communication processes. The third model, reflexive design, goes beyond the other two. Reflexive intervention is a social medium of re-negotiation and self-reflection for both organizational members and external experts. According to Moldashl and Brödner, generalized epistemological heuristics could be presented for such reflective processes. This kind of reflection also takes place in the Change Laboratory. The intervention is based on the expansive remediation of actions and activity rather than on general epistemological heuristics. This is made possible by creating conditions for joint learning and the carrying out of specific epistemological actions of analysing and modelling the practitioner's activity system. Specific intellectual tools are provided for this learning activity. Further unique features of the Change Laboratory include the use of the activity system as the unit of analysis and development, the historical-genetic analysis of the inner contradictions in these systems for explaining the daily problems encountered, and the modelling of a new structure in which the current contradictions could be ironed out, and new tools planned for new kinds of actions that would make the change possible in practice (Virkkunen & al., 1997; Virkkunen, 2004).

Chapter 10 describes and evaluates an intervention in which the Change Laboratory method was used for the first time in a project that was carried out in Finnish Post Ltd. in 1996. It incorporates a detailed narrative, and a description of the expansive learning actions that comprised the process of generalizing and the new generalizations and innovations produced, and shows how the organization dealt with the results of the learning activity.

10 Triggering “learning activity” in Finland Post Ltd. using the Change Laboratory

This chapter charts the process and results of launching a mail carriers’ learning activity in Finnish Post Limited. It begins with an explanation of the situation that led to the implementation of the Change Laboratory and an overall review of the project. The learning actions taken in the Change Laboratory and their results are then described, and the chapter ends with a discussion of their significance in terms of delivery work at Finnish Post Limited.

10.1 The starting point

The need to develop mail-delivery work at Finland Post Ltd.

Mail-carriers work run through many organizational changes in the beginning of 1990s. The Finnish Post became in 1990 state-owned limited company that was no longer dependent on state budget. The new company had to let go of its 352-year-old office tradition and to face competition in its operations. It was converted into an incorporated company, Finland PT Group, in 1994. The businesses were divided in five subsidiary corporations the biggest of which were Finland Post Ltd. producing traditional postal services and Telecom Finland Ltd. focusing on providing telecommunications services and acting as network operator.

Finland Post Ltd. serves individual households, businesses and communities. Businesses and communities are the most important customers from the financial point of view: for example in 1996, 90% of the turnover was generated from services for these customers.³⁸ The proportion of first-class mail deliveries decreased in the 1990s, but that of second-class letters grew slowly. The total amount of postal deliveries was still growing in 1995, but this trend was not expected to con-

³⁸ Annual Report of the Finland Post Group, 1996, 4–5.

tinue. In its business plan for the late 1990s Finland Post Ltd. acknowledged that electronic communication would be a serious challenge for the company.

Mail-delivery work is labor-intensive. Up until the 1980s Finnish Post was the biggest employer in Finland³⁹, and it was still the third biggest in 1998 with a workforce of 24,600. The largest employee group in the company was that of the mail carriers (11,400).

In 1994 activities of Finland Post Ltd. were divided into three business groups, each of which was responsible for a certain function and customer group. Publication and Delivery Services took care of delivering mail, direct-marketing material, addressed deliveries, and papers and magazines throughout the country. It was also responsible for providing services for paper and printing firms. The division of labor simplified the transformation into a firm but created borders between the transport, delivery, sorting and sales operations.

Mail carriers reach about 2.5 million Finnish households and businesses daily. The country is divided into 7,000 delivery routes, half of which are covered by van, approximately 1,300 by bicycle and about 2,000 on foot.⁴⁰ The work comprises two main phases: sorting (pre-work) and delivering. Even though both phases have become more mechanical and automated in recent years, manual work still has an important role: 44% of the three million items delivered daily are still sorted manually.⁴¹

Mail-delivery work had been rationalized intensively in the 80s and 90s, resulting in a fragmented division of labor. A norm-time system had been established in order to measure the volume of work and individual job performance.⁴² Union representatives were often involved in defining norm times.

Early-morning and advertisement deliveries had been in competition for a long time, and the government made several decisions in the 1990s that intensified it. The expectation was that Finnish Post Ltd would also face competition for addressed deliveries, which it had been taking care of almost exclusively until then, by the end of year 1995.

The Head of Publication and Delivery Services aimed to improve the capacity of the delivery by trimming expenses. Operations were concentrated in fewer post offices, the work-measurement norms were tightened, and the number of em-

³⁹ Based on the number of employees, the Post Office was the biggest company in Finland in 1980.

⁴⁰ Annual Report of the Finland Post Ltd, 1995, 18.

⁴¹ Annual Report of the Finland Post Ltd., 1995, 13.

⁴² The Work time is divided into three phases: pre-work, delivery work and other tasks. A norm time has been devised for each phase. The total number of working hours is the sum of all the norm times of the workers or cells. Special gauges and coefficients are also used in counting working hours: daily standard and recovery coefficients and the post-office local time.

ployees was reduced. Employers and the employee organizations agreed on new, tighter measurement norms in 1994. As a result, the delivery routes became longer. The wage structure was also changed and individual salaries were tied to performance. In the same year the Head of Publication and Delivery Services decided not to renew the job contracts of part-time mail carriers. However, according to a survey, the consequences of these changes were not totally positive. The mail carriers were dissatisfied with their employers' activities, and an increase in the amount of sick leave caused a lot of extra expense to the company.

A "Good Delivery" project was carried out in the post offices in 1994–1995 in cooperation between the employer and the labour union. The aim was to improve customer and employee satisfaction and to increase delivery profitability by applying so-called participatory management. The head of the business group thought that the project did not improve profitability enough: it apparently improved until 1994, but then slowed down. No significant opportunities were in sight to improve the competitiveness of the delivery operations by decreasing their costs.

Reports on delivery work and employee cooperation compiled at that time gave a dark picture in terms of coping with the competition. According to the 1990 report, 40% of the mail carriers were against the idea of turning Finnish Post's activity into a business, while 25% were in favor. According to another account, 40% of the mail carriers were not familiar with the company goals. It was also pointed out in the reports that the mail carriers' attitude to their work was self-interested: they did not appreciate delivery work as a profession and were primarily interested in the free time it gave them. The work community was more of a family community than a results-oriented unit.

Markku Karkulahti (1994) investigated the delivery workers' views by conducting in-depth interviews and concluded that the employees were not committed to the goals set by the management because they felt that the employer wanted to benefit at their expense. According to Hannu Saira (1995), the mail carriers considered the work community important, and were loyal to their fellow workers. However, they did not believe that the management understood their daily work. They found the managers distant and questioned their authority. Karkulahti maintained that the Post Office would not succeed in future competition because of its work culture. He suggested a change in supervisory work and an introduction of a team concept in mail delivery to increase the mail carriers' work motivation.

The head of Publication and Delivery Services and representatives of the employee organization did not reach an understanding about developing delivery work. They therefore decided to organize a "Developing Delivery Production" seminar in order to discuss the productivity problems. Six representatives of the employer and five representatives of the employee organization participated in the seminar. Discussion topics included in-house entrepreneurship, the possibility

to rationalize and develop the work on the shop-floor level, responsibility taking on the individual and community levels, and the possibilities of developing team-work in the delivery service.

This led to the establishment of a small working group to devise a project plan that would improve work productivity and employee well-being at the same time. Some of the employer and employee representatives of the group had previously heard about the developmental work research method and thought it could be used in order to develop these ideas. The group came up with a suggestion for a development process based on this approach⁴³.

The head of Publication and Delivery Services contacted Professor Yrjö Engeström at the University of Helsinki, who suggested that the Change Laboratory method could be used in developing the mail carriers' work. A steering group was set up and six managers from the Paper and Delivery Group, five representatives of the Postal Union, and Professor Engeström as the external expert were invited to join. The board of the Postal Union confirmed its participation on January 24th 1996.

According to the project plan, the idea was to develop a model for the delivery work that would both increase profitability and improve employee well-being. Five post offices were chosen as pilots to carry out the development work.

Five pilot post offices join the project

The head of Publication and Delivery Services asked the regional directors to suggest post offices in their areas that could participate in the project as pilot offices. The regional directors wanted to select good and viable post offices, but data concerning positive job satisfaction among the personnel in the offices also affected their choice. Eventually the Turku 52 post office, and offices in Outokumpu, Hätilä in Hämeenlinna, Hervanta in Tampere and Malmi in Helsinki were chosen to participate in the change-laboratory project.

Representatives of the project group, the researcher⁴⁴ and representatives of the personnel visited the candidate pilot post offices to introduce the method to the employees. The regional director, his representative and representatives of the Postal Union were also present at the meetings.

The mail carriers' first reactions to the project were positive, and those at three post offices (Turku, Outokumpu and Hämeenlinna) immediately announced their willingness to take part. Mail carriers at the Hervanta office voted unanimously to

⁴³ Internal newsletter, 6.2.1996 on starting up the project.

⁴⁴ The project research group comprised Yrjö Engeström and Juha Pihlaja.

join while those in Malmi were the most reserved. They apparently had the enthusiasm, need and experience, but they feared that it might lead to the awkward situation of "sawing off the branch on which they were sitting". They also wanted an increase in salary. Finally they decided to participate in the project under the same conditions as the other pilot offices.

Compensation for the developmental work was agreed in negotiations between the Postal Union and the employer. There was also discussion about whether the supervisors – in other words delivery managers and representatives of the staff organization – would be able to take an active role in the change-laboratory discussions. The project group decided that they would only take part as observers since the idea of the project was to hear the employees' voices.

The Change Laboratory, which became known in the project as Room 2000, was placed close to the mail carriers' working space. An appropriate room already existed in three post offices, one was created at the Outokumpu office by breaking down internal walls, and the men's changing room was used at Hervanta. The chosen post offices were very different in terms of quality, equipment, size, working area and number of personnel.

The *Hervanta* post office serves a growing suburb of the city of Tampere. The delivery area, with 25,000 inhabitants, includes roughly 11,000 households and 520 businesses. In 1996 there were 22 delivery routes, two by van and the rest on foot. The number of mail carriers was 22, including five women.

Outokumpu is a little town that was developed around a mine. It has around 9,000 inhabitants, of which 60% live in the centre and 40% in the surrounding district. Thirteen mail carriers made basic deliveries, most of them women. Of the eleven delivery routes, eight were serviced by van, three on foot.

The *Hättilä* post office Hämeenlinna, a medium-sized Finnish town, made approximately 12,000 deliveries daily. The majority of the customers were people living in apartments and houses. There were 14 full-time mail carriers and three reserves, mainly men, with a long history of delivery work. Of the 11 delivery routes, three were serviced by van, five by bicycle, two by cart and one on foot.

Malmi post office is located in the northeast of Helsinki, and the delivery area consists of old housing estates, apartment blocks, industrial estates and shopping centers. The number of the postal deliveries in 1996 was around 20,000, of which some 75% went to households. Eleven delivery routes were serviced by eleven mail carriers, most of them by cart. A special feature in Malmi was that the mail carriers delivered to different routes daily, and were familiar with two or three other routes in addition to their own.

Turku 52 post office is located in a business center in the city of Turku. It made 11,000 deliveries a day, of which nearly half were for the businesses in the area. Of the six delivery routes, two were business-enterprise routes and four were house-

hold routes. A lot of express mail was delivered to the business enterprises which also made extensive use of the export and import services. Moreover, many old people lived in the area. Most of the mail carriers had been working for the post office for more than ten years, some for more than twenty years.

10.2 The overall progress of the project

The mail carriers met for the Change Laboratory from seven to ten times, for two to four hours per session. The meetings were held every week or every second week. Because of the tight schedule, most of the meetings lasted approximately four hours. The researcher assigned tasks to the participants to be carried out in and between the meetings. Between the meetings for example they interviewed customers, made themselves familiar with reports of the team experiments carried out in mail-delivery work, and wrote meeting memos. They also produced material for subsequent tasks.

The participants' reports on the results of the Change Laboratory were put together as pilot reports⁴⁵. One or two people compiled most of these reports, but some were compiled in small groups.

The meetings followed the phases of the cycle of expansive learning, starting with initial questioning and ending with reflecting on the process and consolidating the new activity model. The last analysis phase consisted of a seminar in which representatives of the Change Laboratory groups, the Publication and Delivery Services management, regional directors, and delivery managers, project supervisors, members of the project group and representatives of the Postal Union participated. Representatives of each pilot post office presented their group's analysis of the contradictions in the mail deliverer's activity system.

In the next phase, the Change Laboratory groups started to model visions of the delivery work in 2001 and to plan improvements that would be tried out in practice. The new models and experiments were processed further in the second joint seminar. The mail carriers presented a total of 23 proposals, including suggestions for trying out new services and changing the indoor-outdoor division of labor. The supervisory group agreed that the experiments would start in the beginning of May that year. The majority of them did start in the spring, but some required further negotiation. In some cases the mail carriers felt that the time given for preparation was not enough, and suggested that some experiments could be carried out after the summer.

⁴⁵ Pilot reports, part 1, Work-development phases and current contradictions, 15.3.1996
 Pilot reports , part 2, Visions for the year 2001 and suggestions for experiments 3.5.1996
 Pilot reports, part 3, Reports from the experimental phase, 7.6.1996

The supervisory group assessed the results of the project at a meeting held at the beginning of June. They thought it had been successful considering the tight schedule. In August, after the experiments had been carried out, the supervisory group decided to expand the project and to train twenty middle managers to be Change Laboratory instructors. While 82 mail carriers had participated in the first Change Laboratory working wave, over 500 participated in the second one.

The pilot offices of the first phase were made into exemplars of new forms of mail-delivery work, and the participants in the second phase could visit these as "aquariums" in order to collect and develop ideas for their own offices. The innovations of the first phase were not directly transferred to the offices involved in the second phase, but were rather used as a basis for helping the mail carriers to develop their own solutions.

Extending the Change Laboratory project succeeded. Fifteen experiments were carried out during the first wave, and new solutions were found, while 92 were carried out during the second wave. The improvements generated during the second phase were quite similar to those of the first wave: the mail carriers experimented with selling, teamwork and other new working arrangements, and also planned new service concepts.

At the end of the second phase, the Paper and Delivery Service manager asked a task-force group to summarize the results. A delivery supervisor, an instructor, a mail carrier and I were invited to join the group, the task of which was to propose a new concept of mail-delivery work for nationwide use that could be tried out. The task force presented its proposal for a new concept to the Paper and Delivery Service management, the Postal Union, the pilot offices and the Change Laboratory instructors in April 1997. The proposed concept, which was based on the reports of the Change Laboratories followed the principle of mass customization. Many questions arose at this stage, development ideas were put forward, and criticism was voiced. The Chair of the Postal Union did not accept the concept because its representatives had not been included in the process. The Delivery 2001 Project decided on May 26th 1997 to set up a larger working group with union and management representatives.

At the same time, the entire Postal system was reorganized. Business groups that had earlier concentrated on deliveries and transport were united in a Production business group. The persons appointed to manage the new unit did not know about the Change Laboratory method, but they and the union nevertheless approved the new concept of mail delivery work in August 1997.

The new head of the business group started a new project called "The new model for production". Although this project allowed for the application of the Change Laboratory method, the new management was not expecting results on the lines of the work done in the projects. Contrary to expectations, the new

project led to further rationalization, centralization, standardization of work performance, and outsourcing. This change of line in the development of mail-delivery work did not, negate the initial results of the Change Laboratory, which were surprisingly positive. The innovations and the results of the first and second waves and the construction of the new delivery concept reflected a *new type of learning in and for production at the grassroots level within the postal services*. It is therefore useful to analyze how the innovations were introduced and what happened when these results of this new process of generalizing were put forward.

The following description of the Change Laboratory work in the five pilot post offices is based on the reports and memos written by the participants as well as on the notes made by the researcher and some videotaped recordings of the meetings. A few extracts from the discussions are included to give the reader a better idea about the nature of the discussion in the sessions.

At the outset, I as the researcher introduced the tools of the Change Laboratory, the way of working in it, and the project plan. In each office the participants agreed on how the process would be followed in their case. In order to initiate learning actions the research group planned a series of tasks for the participants. In what follows I will describe how these tasks were carried out, what kind of learning actions were taken, what the outcomes were, how the Change Laboratory tools were used, and how these various elements interacted with each other.

10.3 Expansive learning actions in the Change Laboratories

Questioning the prevailing practice

The researcher's task in the first phase of the project was to launch learning actions to do with *questioning the current work practices*. He first explained the purpose and method of the fellow-worker interview and issued a ready set of questions.⁴⁶ The employees interviewed each other in pairs and then the researcher asked them to describe the results. The results of these interviews and subsequent discussions were written in the Mirror/Present fields.

As a positive thing in their work the mail carriers in the Turku 52 office appraised their personal time use: the more quickly one covered one's route, the

⁴⁶ The interview questions:

When did you start working in this post office?

What was the work like at the time?

What are the differences in the working customs between now and then?

What kind of turning points or phases have there been at your work place?

Tell me about the best experiences in your work. Name one specific incident!

Tell me about the worst experiences in your work. Name one specific incident!

sooner one would get home. "Going home early makes it feel like having the afternoon off" (Turku 52 meeting, February 21st 1996). The motive for work, i.e. the object the of activity, seemed to be free time as Karkulahti had maintained in his study. Analysis of the employees' negative experiences that were taken up in the interviews revealed that the turn of the National Post Office into a limited company changed the rules concerning the employees' working. "Nowadays you're sitting on a much less stable chair, it goes from under you a lot more easily" (Turku 52 meeting, February 21st 1996). The mail carriers in all the other pilot offices expressed similar concerns.

One described a bad experience when he had to do the delivery by himself for the first time. Another who had earlier worked in a factory found the chances of making mistakes surprisingly high. Her colleague added: "You might be doing the deliveries wrong, doing the change of address wrong; there are so many mistakes you can make with one letter" (Turku 52 meeting, February 21st 1996). This led to a discussion about training time, the consequences of mistakes, customer complaints and the management system of the Post organization.

In the Change Laboratory discussions based on the peer the questioning of current practice took the form of narratives concerning problematic situations and observations concerning problematic aspects of the activity.

Analyzing the mail-delivery activity historically and empirically

The second stage of the Change Laboratory process was to encourage the participants to trace the historical development of the "essential systemic inner relationships" of mail-delivery work. The purpose was first to create a picture of the major developments and turning points in the ten previous years, and then to analyze the current situation by means of action research. The tasks given to the participating mail carriers consisted of a) *analyzing the results of the co-worker interviews*, b) *tentatively defining the development phase of the mail-delivery activity in each post office*, and c) *specifying these development phases*.

The results of the co-worker interviews concerning changes in the activity were used to launch the learning action of historical analysis: they were written on the Mirror/Past surface.

The researcher first asked the participants to look at the material that had been collected on the Mirror/past surface and to describe the phases they had observed in the development of post-office work. The phases that came up in the discussion were written down on the *Ideas/Past surface*. The participants were then asked to observe how different factors in the delivery work had changed over time using the activity-system model on the Models/Present surface.

The employees were then asked to analyze critically their interpretations of the development phases. They looked once more at what they had written down and specified their observations about the changes of work on the Mirror/Past surface, and the model of the old way of working on the Models/Past surface.

A wealth of material was collected in *Turku 52*, and it was clear from the responses that many changes had taken place. The mail carriers analyzed the differences in working methods between now and then by first discussing the changes in the work environment.

B: Well, the work environment has become more pleasant. We used to work in that old, cold, draughty office, where the temperature was minus two at best, when you were sitting by the window, and so on. So yeah, that's what it was. And we probably had about ten square meters of space for ourselves. So yeah, they've changed, so that now, now the working environment is more human (Turku 52 meeting, February 21st 1996).

The mail carriers suggested that there had been two periods of development: the eras of Lemminkäinen Street and Data City. The change was analyzed with the help of the activity-system model. The participants were very enthusiastic about the analysis.

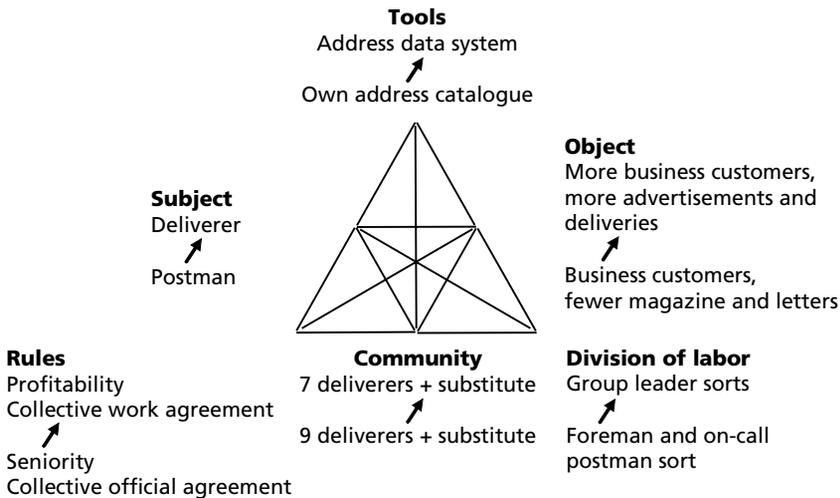


Figure 10.1 Modeling work transformation from Lemminkäinen Street to Data City

The group obviously thought that this result was a true achievement: "That triangle model sure is one of a kind" (Researcher's field notes, 22.2.1996). Other participants were also enthusiastic. Although "mail always had to be delivered into boxes", as one deliverer joked about the stable character of the work, the work with the activity-system model showed that there had also been qualitative changes. The changes in the object only seemed quantitative in that the workload had increased. The researcher also asked the mail carriers to analyze the contradictions that had led to these historical changes, but as this seemed to cause confusion the subject was dropped.

The mail carriers in Hervanta identified three phases of development. Pre-1975 was "The era of Pispala", which a few of the older employees talked about. It was before the Hervanta district had been built, when experience and customer service were appreciated. They called the years 1976–85 "The era of stagnation" and used excerpts taken from the delivery manual of 1985 by way of illustration in their report. The excerpts showed how tightly the work was controlled and specified at that time in the instructions and rules. The tasks, division of labor, working time, letter size and postcard size were all laid down. The work was based on regulations and orders that remained unchanged for a long time. The following period after that was the "The era of change", when civil servants were replaced by mail-delivery workers, and backpacks by carts.

The Hätilä mail carriers thought that their current work practice had evolved over three ten-year periods of development. The 1970s was "the decade of centralized delivery", the 1980s "the time of decentralized delivery", and the 1990s "the age of turmoil". The employees considered the closing down of the post offices the bad side of the age of turmoil, which they thought had led to the "era of business".

The mail carriers in *Outokumpu* also divided the history of their work into three phases. When small post offices abounded at the turn of the 1970s and 1980s there were four village post offices in Outokumpu that also functioned as meeting places for the villagers. When the mail delivery was centralized, the post office was placed in Outokumpu town center. Two worker groups, with different pay, job contracts, collective agreements, and working time, were established. The employees called the development stage that led to the current work arrangement "the era of stress". Village shops-cum-post offices replaced village post offices. The number of delivery vans increased, the schedules tightened, and there was continuous time pressure. New work-measurement and wage systems were taken into use.

The Change Laboratory participants at *Malmi* divided their delivery work into four developmental stages. The sixties was "The era of work pride", when the mail carriers were civil servants and proud of it. The 1970s and early 1980s were "the era of negligence", 1985–90 "the era of crisis" and the present was "a stable but chaotic time".

Although the periodizations of the development of the delivery activity were partly based on superficial landmarks of change, the resulting discussion highlighted the essential changes. The historical analyses produced the first hypothesis according to which the competitive situation triggered the need to develop delivery work. There were also other companies interested in the same customers, i.e. the same object.

Using this initial hypothesis as a guide, the researcher group planned a set of tasks that were supposed to launch the participants' learning actions of *analyzing the present work situation*. The results of these *empirical analyses* were then discussed in a joint seminar, after which the researcher group presented their summary. The main purpose of these actions was to identify the main contradictions within the activity system.

The researcher brought excerpts from video recordings he had made of the mail carriers' work to the meeting as material for analyzing the current work practices in each office, and for identifying typical disturbances. After watching the recordings the employees were asked what they thought were the biggest problems and threats in mail-delivery work. The answers were filed on the Mirror/Present surface.

The researcher then explained the participants the idea of using customer interviews as a way of collecting information about customer needs and postal services. He handed out a customer-survey form⁴⁷ planned by the researcher group for them to consider and suggest amendments, and gave advice on how the interviews should be conducted. Each participant interviewed at least one customer on his or her route. The results of the customer survey were filed as mirror material on the Mirror/Present surface *as customer needs and customer feedback*.

The next task given to the participants was to assess unused business potential in the current form of the mail-delivery work. They summarized their thoughts on the Mirror/Present surface by answering a series of questions⁴⁸ planned by the researcher group. The observations brought up in the discussions were filed on the Ideas/Present surface.

⁴⁷ Questions:

1. What services are available to you in your local post office?
2. What are shortcomings in the services of the post office?
3. Does the post office fail to provide some services relevant to you? If so, what kind of services?
4. How could the post office improve the services that especially concern you?

⁴⁸ Questions:

1. What kind of services does your post office fail to offer?
2. What kind of competition benefits does your post office fail to offer?
3. What working equipment is unused or is inadequate?
4. What kind of teamwork opportunities remain unexploited in your delivery work?

On the basis of these analyses the researcher asked the participants tentatively to identify *the main inner contradictions in the current form of mail-delivery activity* with the help of the model of an activity system depicted on the Models/Present surface.

He then *introduced the next task and learning action, which was to analyze the results in terms of used customer benefits and competitive advantage*. He used a four-field diagram on the Ideas/Present surface to illustrate the concept of competitive advantage. The concept was described in terms of two dimensions: cost savings and customer benefits related to productivity. The researcher asked the participants to estimate whether the possible competitive advantages of Finland Post Ltd. in terms of mail-delivery could be described with the help of the diagram. After due consideration he asked the mail carriers to choose examples of products to be used in the estimation. The sample products, customer needs, competitive advantages, and the positive and negative outcomes of the possible changes in the mail delivery activity were then analysed.

The participants were then asked to *specify the hypothesis concerning the inner contradictions* within the system of their current work activity on the Models/Present surface.

Those in each Change Laboratory then wrote a collaborative report of the analysis phase. The task given to them by the researcher was to describe the development of the mail-delivery work in their post office and to analyze the contradictions within their current work practice. One of them was also asked to present the results of the analyses at a seminar held for all pilot post offices on March 23rd, 1996.

In *Turku 52 the results of the analyses* revealed that the threats and disturbances the mail carriers continuously came up against involved services for business customers, changes in work measurement, and an increased workload caused by advertisement deliveries. On the basis of the customer interviews, they stated that businesses should be serviced better because they were the most important clients of Finland Post Ltd.

The private customer brings such a small profit, it's not worth it. But business firms are the ones that pay for the mail. (Turku 52 Change Laboratory meeting, 11.3.1996)

However, the current regulations and the new standards prevented the mail carriers from developing co-operation with business firms. According to the new regulations, firms had to put their mail boxes outside, thus obviating the need for the deliverer to enter the premises. This eroded the service and removed the

opportunity to do sales work indoors. The mail carriers thought that this kind of cost cutting was wrong and that the rules should be changed: the post should be delivered indoors. Some of them said that, in spite of regulations, they did that in any case. They felt that Finland Post Ltd. would benefit from the sales work, but that work measurement was an obstacle.

According to the Turku 52 mail carriers, the increased amount of advertising material and wide variation in amount also caused disturbances. Coping with the advertising material was a strain: placing the advertisements in-between other mail took time and increased the physical strain.

E: I had to make my own bunches of advertisements, which I carried with the mail, for example three, there's been three, could be, could be even four, that I've carried like that. I had to make my own bunches and throw them into the box and then I took them from there, behind the backpack, and then with the mail, there's been this much stuff per stairway with the mail. So it really comes to health factors here, it's bad for my back when there's so much stuff. (Turku 52 Change Laboratory meeting, 11.3.1996)

The large amount of advertising material compared with the number of letters also amazed the mail carriers. They considered letters to be more important than advertisements, and feared that the increasing numbers of advertisements would increase the possibility of making mistakes in sorting other deliveries. They suspected that if a lot of advertisements were to be delivered to households at the same time, their effect would be weakened. Nevertheless, they considered advertisement deliveries an important challenge given the competitive situation in Finland Post Ltd., and felt that this aspect could be developed. They saw the advertisement situation as a two-edged sword.

G: ...it might sound crazy to others, but Finland Post Ltd. does not do all the advertisement deliveries and it would be a huge competition benefit if it did, anyway it would be a big asset, it would make us a bit like a monopoly ... (Turku 52, Change Laboratory meeting, 11.3.1996)

The researcher used the activity-system model to interpret the initial analysis of the contradictions in the current work practice. His conclusion was that the measurements and boxing regulations were obstacles to improving service and advertisement delivery. There appeared to be a contradiction in the delivery-activity system between the changed object (quality in the customer contacts, delivery peaks, and the increased amount of advertisements) and the rules (the work standardization, boxing regulations). The increased amount of advertising and the morning rush

were indicative of changes in the object of work that created pressure to provide new models for the division of labor. The researcher suggested that there might be another contradiction between the object of the activity and its division of labor could. The mail carriers thought that they could sell postal services to business firms instead of merely conveying the message, but they did not have the appropriate tools. In the researcher's opinion, this was indicative of another emerging contradiction between the changed object of delivery work and the tools provided for carrying it out. These analyses of the inner contradictions of the activity system were filed on the Models/Present surface.

The mail carriers in the *Hervanta* post office considered the small working space, the group leader's lack of time, taking care of special shifts in sorting, and arranging van shifts the biggest problems in their work. Although they described the historical phases with the help of the activity-system model, their attempts to summarize the underlying systemic causes of the many observed problems as inner contradictions within the current activity system did not lead to a clear consensus or model of the main contradictions.

In the *Hättilä* Post Office the mail carriers focused on customer service, thus making the object of the work more multi-layered. They were developing customer contacts at the same time as coping with a larger volume of deliveries, including an increasing amount of advertisement material. They also considered the centralized sorting of the routes a threat because it would reduce the work in the post office. Their analysis showed that the changed and unstable character of the object of their work activity was in contradiction with the current division of labor, rules and tools in use.

According to the analyses compiled by the employees in the *Outokumpu* Post Office, the regulations concerning business activities were in contradiction with the customers' wishes. This contradiction was concretized as a pricing problem. The Post Office lost customers to competitors even in a small town like *Outokumpu* because of the pricing regulations. This was indicative of a contradiction between the object, the business opportunities and the rules. On the other hand, the rapid changes in delivery volume required a more flexible division of labor. The current measurement system made it more difficult to try out new solutions, and consequently there was also a contradiction between the object of work and the division of labor.

The *Malmi* mail carriers described the contradictions in their report as follows:

Pipeline thinking appears to be a constant obstacle. Others are easily blamed and it's not recognized that we ourselves have an effect on the results in the post office. (...) The inner collaboration is problematic. Should Finland Post

Ltd. try to create new customer needs in the future and then develop its services to satisfy these needs? How far can we go in cutting costs and expenses without the service quality suffering too much? Work rationalization is being approached in two different ways: intensifying and developing might lessen the number of jobs. On the other hand, we could try to expand and broaden the jobs (the amount of delivered mail and other possible services). (Malmi report, 20.3.1996)

The project group arranged a seminar for 23rd March 1996 at which the analyses were processed further. The head of the Paper and Delivery Services, representatives of the employee organization, employees from the pilot post offices and the researchers all took part.

Many employees voiced their fears that the new developments would mean lay-offs. One from Hätilä described this contradiction as follows:

If you have ideas, you'll get sacked, meaning this reorganizing. And if you don't have ideas, you'll get sacked too. This lack of confidence in the system, is this the post office's way to eliminate things. (Seminar discussion 23.3.1996)

Another from Malmi talked about the same contradiction.

We have also had this discussion going on about whether to expand the object or not and on the other hand about the developing, are we sawing of the branch we're sitting on. Does all this developing have to be about digging our own graves? We might know that that's not what it has to be, but I suppose it's kind of like what we see as a threat.

Another way of thinking is that we can try to influence the increasing workload. To develop via that, so that we won't be just sitting around thinking that the only effect all the developing will have is to get five of us sacked. (Seminar discussion, 23.3.1996)

The seminar was apparently an exceptional event in the history of developing the mail-delivery work. The employees, the head of the business group, the area supervisors and the head of the labor union had not previously sat down together to analyze problems in the mail-delivery work. The seminar seemed to strengthen the employee's and management's beliefs that new activity models could be created in the context of the project.

The head of the Paper and Delivery Services business unit, addressed the seminar after the employees had voiced their opinions:

This much I can say; during these past few hours my belief in this project has strengthened by at least a hundred percent. (Seminar discussion, 23.2.1996)

In the closing speech he commented on the fears arising from the developing and the conflicting feelings of the mail carriers:

I can assure you that you won't get sacked for having good ideas! (Seminar discussion, 23.3.1996)

The mail carriers from the post offices finished their presentations by giving names to the next phase in the development of the mail-delivery work:

The era of experiments! (Outokumpu); Space Station Alfa! (Turku 52); The unknown future (Hättilä); A development phase involving the employees, so it's like this Delivery 2000 project (Hervanta); Malmi Post Office Ltd, Drive-in Postal Services, A small multi post office lives in all of us! (Malmi)

The Union representatives also thought that the seminar was exceptional.

I thought it was an exceptional seminar. It had a consistency that has never appeared here before. First of all, a big manager of the Post executive team, all area managers and union managers were all present. Then from the research side there were the Helsinki University people. And then in this forum it was mainly the mail carriers who were asked to say what they had been up to for the past couple of months: performing to this kind of group, and using all these new kinds of terms about the subject, and speaking in a theoretical manner. These research triangles came to life and the style of speaking was just totally different than before. (Interview with the union representative Eero Saarinen, February 14th 1998)

After the seminar the research group reflected on the project so far. Even though the contradictions reported by the workers were local, there were similarities. They referred to certain dilemmas ("If you develop, you get sacked, and if you don't develop, you get sacked"), reflecting the primary contradictions between use value and exchange value within the elements of the activity systems as well as secondary contradictions between the elements.

One common observation among the mail carriers was that the workload had increased. They often used the term "stress" in relation to the new developments. They saw the increased workload as a cost-cutting measure that jeopardized the quality of the service in terms of problem-free delivery and employee competence. Nevertheless, the growing workload was not considered only a negative phenomenon. The employees felt the tension: the new competitive situation meant that Finland Post Ltd. had to compete for delivery business, thus a bigger workload increased their job security, while a decreasing one would have been a threat.

This duality was considered by the researchers to be indicative of the latent nature of the secondary contradictions. The sheltered monopoly position of Finland Post had offered protection against the aggravation of the secondary contradictions between the elements of the activity systems, and acute crisis was the result. The elements of work depicted in the activity system model were internally tensed (Figure 10.2). Normally the receiving customer was understood as the object of the activity system. In the Change Laboratory discussions the mail carriers brought up another course of development. The mail carriers' work was not only an end of the logistic process but they were working daily near the customers as well. Developing locally new services to the customers could also broaden the object.

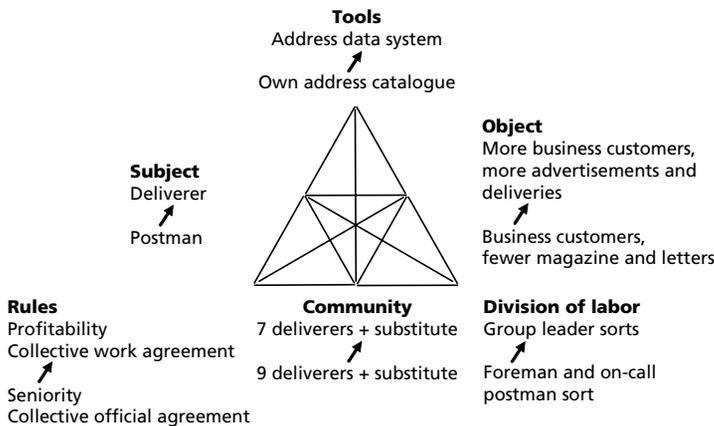


Figure 10.2 The Researcher group's interpretation of the inner contradictions

Developing the services seemed to be an impossible task from the mail carriers' point of view. The delivery work was standardized, and offering new services did not fit into the standard. The measurements used in planning the work and defining the salary structure presupposed individual work, which did not suit the joint customer-service model suggested by the employees. The tight regulations and the measurement system were obstacles that hindered the local development of

the work in each post office. Employees were not free to decide about their own working arrangements or division of labor, even though this kind of independent thinking was encouraged. The rules controlling the activities were thus internally contradictory.

The idea of expanding the object of work brought up problems in the inner and outer divisions of labor. As parts of a limited company, the business groups sometimes focused on their own activities without considering the general good of Finland Post Ltd.. More emphasis was placed on what did and did not belong to individual jobs than on cooperation: the mail carriers deliver, they do not transport or sell; drivers transport, they do not deliver mail or sell; salespersons sell, they do not transport or deliver mail.⁴⁹ The examples given in the reports also showed that this kind of division of labor was uneconomic for Finland Post Ltd. as a whole.

It was not only the external but also the internal division of labor that was problematic. Each deliverer only concentrated on his or her own tasks – a situation that was fostered by the centralized management practice and the measurement system. On the other hand, expanding the object of post offices, in terms of increasing the level of independent planning and cooperation between business groups required flexible cooperation between the mail carriers and other employees. This inner contradiction in delivery work is described in Figure 10.2 as a tension between independent solo work and teamwork, and between the collaborating business groups and the flexible crossing of group boundaries.

Modelling the new principle of mail-delivery work

The main purpose of these actions was to find solutions in each post office to the contradictions they had found, to model a future vision for the work, and to plan the first experiments toward implementing the new model.

After the seminar the researcher used the activity-system model to present the results of the analyses on the Model/Present surface in Change Laboratory meetings. He also put together a video presentation of the analyses by taking the parts of the videotaped seminar in which the pilot-office representatives described the contradictions and making another tape which he then presented as mirror material in the Change Laboratory sessions in the local post offices. He asked the employees to comment on the videotape and to compare the researcher's conclusions

⁴⁹ The gap between selling and delivering was seen as causing daily disagreements between the officials and the mail carriers, about workspace use and tools for example. Dividing the activities into business groups seemed to have widened the existing gap between the mail carriers and the officials.

with their own views. The purpose of this task was to allow each participating post office group to elaborate on and clarify its pre-seminar interpretation.

The objective in this phase was to help the participants to find solutions to the contradictions and to analyze them. The researcher invited them to take part in thought experiments in which they would *model and examine a possible new system of mail-delivery work* that would resolve the contradictions found in the current delivery practice.

The researcher gave the Change Laboratory groups material on the team experiments with delivery work that had recently been conducted in two Finnish post offices, and on the practice in Swedish post offices. He asked the participants to familiarize themselves with this material and to analyze the solutions offered. Their observations were written on the Mirror/Future surface. This was followed by a discussion about the advantages and disadvantages of the various team solutions, and the results were filed on the Ideas/Future surface. The reactions of the *Turku 52* participants were very critical. Although they considered the experiments "interesting", their immediate response was "It's nothing. Bullshit!" They thought the examples were threatening rather than promising (*Turku 52, Change Laboratory discussion, April 11th 1996*).

The reactions were not totally negative, however. One deliverer thought the experiments had clearly illustrated how the work should *not* be done. Another thought that some experiments, such as piecework remuneration, could perhaps be taken up. A third deliverer supported the idea that a new kind of division of labor regulated from the shop floor could replace team work.. This would require "some kind of cells", although he thought that the groups mentioned in the example were too large (*Turku 52 Change Laboratory discussion, March 11th 1996*)

The researcher then asked the participants to imagine and write down a story in which the contradictions in the activity system would be resolved in the near future. These stories were written separately for each element of the system. The ideas were collected on the Idea/Future surface and the participants were asked to summarize the contents of their story in a few words that were then inserted into each element on the Model/Future surface.

After this, the researcher asked the participants to suggest concrete solutions in small groups. He also asked them what they thought should be the first step toward the planned vision. All ideas were filed on the Idea/Future surface.

As another task aiming at modelling the future form of the activity the researcher asked each deliverer to take five minutes to come up with some concrete solutions to the contradictions found in the analysis, to consider how the object of work could be expanded and what the consequences should be. This produced many ideas for improvement.

The Turku 52 mail carriers put forward an idea for a new service, which they called "A security service for the elderly". To give an example of the modelling discussions in the Laboratories I will in the following describe the evolution of this idea.

Mail deliverer G came up with the new product idea. He considered the elderly to be a target group that required extra services: "I thought that some kind of help for the elderly would be useful. And it involves all kinds of things. There are a lot of elderly people on the route who need help." Mail deliverer B asked if they could take on the home-help's work as a sideline. The idea was to combine the work of the home-help and the mail carrier. G believed that if the post office advertised their services for the elderly, people would seize the opportunity.

Deliverer C said that he was not a home-help, and did not have the necessary training for it either. Mail deliverer A also resisted the idea: "It's difficult to imagine a delivery firm doing the work of a welfare worker." The researcher suggested that some of the tasks that home-helps did could be done by the mail carriers because "you go to the door daily". Mail deliverer A responded that the home-help's work was not suitable for a delivery organization or compatible with the company's license.

A: So I would just say that Finland Post Ltd. is a delivery organization like any other that has trailers, delivering stuff, or a ship that transports stuff or people. On ships you have other things, I know, but it's quite difficult to imagine a delivery firm performing welfare workers' tasks. It's not even compatible with our company's license.

Mail deliverer G, who had originally made the suggestion about starting a service for the elderly mentioned that nothing was said about combining anything in the conversations.

G: It wasn't said that anyone had to be a home-help, but that we would think of some little jobs that we could do ...

There were two suggestions put forward in the discussions that concretized the original idea and were written on the Change Laboratory's board in an attempt to bring the focus back to solutions that were compatible with delivery work: "charging for deliveries home" or "if someone receives some sort of money and can't come and fetch it, to draw it and deliver the money".

L referred to firemen who go and collect the corpses of elderly people who have been dead for a long time, and produced the first new service idea: "The idea is that the deliverer goes there daily." Mail deliverer A gave the service a name and asked for it to be recorded on the Change Laboratory board: "Hey, put the words *security service*." L repeated: "Yeah, hey, a security service!" The researcher only managed to

repeat half of the term: "Yeah, security..." when the excited A interrupted: "Yeah security, security service in that the mail worker visits daily."

The next step was to implement the idea and expand it. Mail deliverer A described the procedure: "The mail worker rings the doorbell daily and says hello". They thought that close relatives might also approve of the service when "the mother is living all by herself and a "mail boy" visits her on weekdays and rings the doorbell".

Other ideas for expansion were pondered on and discussed, but the security service was brought up again from time to time. The mail carriers kept elaborating on the new service and considering the possible obstacles. They also thought about the possibilities of applying the same idea to customers other than the elderly.

In the process of designing a new course of action the Change Laboratory groups developed *models of an ideal post office*, which were very similar in different groups. They all emphasized the responsibility of the deliverer and the independent functioning of the post office. The idea of expanding the object of work by creating new services and by broadening the scope of the basic delivery task and the new local deliveries was also common in the visions.

The object: *The customer who receives and sends*. Customers are noticeably more demanding nowadays (competition). Postal services have become versatile and the mail-order proportion has increased. Firms are being offered tailored and directed post-office services. Malmi post office is capable of separating Lada drivers and dog owners so our customers can direct their advertising. Services to private customers (receivers) have also improved: the boxes come where the customers want them. Customers are no longer given orders. (Malmi Change Laboratory report May 3rd 1996)

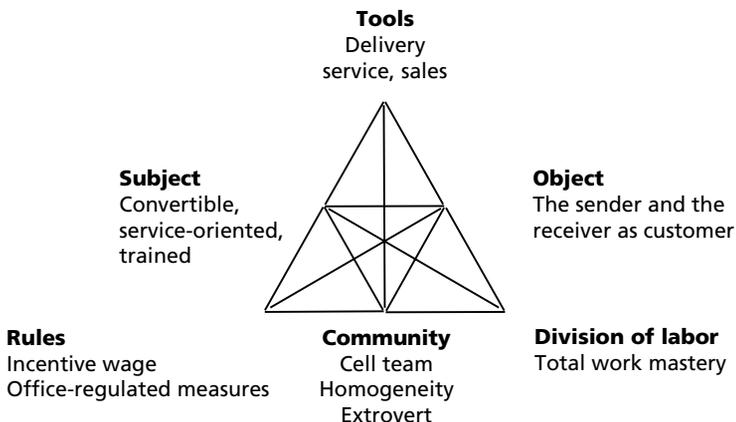


Figure 10.3 Turku 52's model of the future post office

The mail carriers said that their future work would involve intensive collaboration with customer companies and would be based on information and communication technology.

Three delivery drivers are starting their first round of the day. Rush starts downstairs because we are starting to run out of spring-season materials. But there is no cause for alarm since we can order the products straight from the biggest mail-order firms because of the amazing EDP connections. (Hervanta Change Laboratory group report, May 3rd 1996)

The Change Laboratory groups' future vision depicted post offices as independent profit centers in which self-directed teams of mail carriers operated a messenger service by delivering incoming mail and offering new services to business and private customers.

The next stage in the Change Laboratory process was *to agree on the kind of reforms that were necessary for realizing the future visions and to decide what would be the first steps* that the post office would take to implement the new activity model. Two of the five units, Turku 52 and Outokumpu, experimented with teamwork and new service products, and another two at Malmi and Hätilä, concentrated on developing new service products and overcoming the bottlenecks between production lines. The fifth unit, Hervanta, decided to try out teamwork.

The employees in *Hervanta* wanted to see whether they could improve the mail flow and reduce overlap between Paper and Delivery and Transportation Services. The test team consisted of four mail carriers who would jointly take care of sorting, transportation and delivery in two business areas and one suburban area for two weeks. The employees wanted to test customer reactions by conducting a survey among the businesses in the area.

The *Malmi* mail carriers discussed the purpose of the experiments, suspecting that the resulting changes would be minor. They were enthusiastic about their own local vision but not necessarily about the experiments. Eventually, "after Pihlaja persuaded us", they ended up carrying out six different experiments.

The purpose of *delivering registered letters in connection with basic deliveries* was to improve the service standards at a reasonable price. The mail carriers planned this service to benefit small and medium-sized businesses in the area. The purpose of *combining local transportation and delivery services* was to cut out the overlap of two parallel production lines. The Malmi mail carriers wanted to advertise the local firms and companies on the delivery routes. *Advertisement deliveries* would be offered to local advertisers at a reasonable price, thus introducing regional competition. As part of the *advertising campaign*, post-office products would be advertised on the delivery carts, which would be made more visible. The introduction

of *mail carriers as stamp sellers* would give them experience of creating customer contacts and sales work. Finally, starting an *export service for businesses in addition to basic deliveries* would reduce the overlap between business groups.

Outokumpu planned a *teamwork* experiment in the centre and the surrounding area. The team would consist of two persons and would work in sorting and delivery work. Four mail carriers in the surrounding area would form a team that would do the sorting together. The aim of the *shop and pharmacy experiments* was to offer a delivery service to the inhabitants of the surrounding area and people in their summer cottages. The mail carriers also planned to offer additional *export and import services to businesses* and to change the delivery routes accordingly. They hoped to be able to price these services competitively, and planned to start the experiment at the same time as three mail carriers from the neighboring locality were transferred to their office.

The *Hättilä* mail carriers planned a special *home-delivery service for non standard shaped packages*. A flyer would be sent to customers telling them they could ring the post office and order the service. Small entrepreneurs were also to be offered the chance *to get their advertisements delivered* to their areas of choice, *in connection with the normal mail delivery*. There were also plans to *sell, install and label* mailboxes for the customers in the area. The new product idea was that the mail carriers *would be assisting the residents of the old people's homes in the area* with their mail matters and would sell them stamps, postcards and packing materials once a week. Another idea was to try an express-delivery collection service in conjunction with the normal mail service.

The *Turku 52* mail carriers planned to make changes in the *division of labor*. They would form two delivery *teams*, which would make their work more flexible. The aim was to balance the workload, develop professionalism, learn a way of taking responsibility, and work at peak periods. The idea behind *selling stamps* was to increase revenue, create customer contacts and improve the image of the post office. The *security service* for the elderly was the new product that was meant to increase post-office revenue. It was aimed at elderly people who did not have daily support because their families lived far away. The mail carriers assumed that the families would want someone to visit elderly people on a daily basis, or at least weekly. The aim of the *internal work-guidance* project was to train new and old employees in special tasks.

Implementing the new activity model and reflecting on it

The researcher's role was small in the implementation phase. The mail carriers were asked to report any problems and achievements connected with the experiments, and to analyze how the goals had been realized and how they wanted to

continue the experiments. The role of the project leaders became more prominent during this phase.

The Hervanta mail carriers carried on their teamwork experiment for three weeks. They thought that the best outcome was that businesses received their mail earlier. They sent enquiries about the effects of earlier deliveries to companies. 70 companies replied, and most of them, 63, thought that earlier deliveries were positive.

These mail carriers considered a good team spirit and the possibility to vary their tasks daily to be the benefits of teamwork. The delivery part of the work went well and they were satisfied with it, as they were with the bunch deliveries managed by the team. The biggest problem was the big workload in sorting. The amount of work amazed them, but they could not say why they felt there was so much more work to do:

We still weren't able to figure out why there seemed to be an endless amount of sorting and putting the deliveries in order in the mornings. And if we'd counted the working hours from the work that was done, this kind of situation would never have arisen. We're still trying to work it out ... (Hervanta Change Laboratory's final report, 7.6.1996)

The supervisory group considered the Hervanta team experiment partly successful. In particular, the results of the customer survey were considered useful. The group thought that the Hervanta work community was capable of analyzing the problems and shortcomings brought up in the experiments, and wanted to continue with the group. However, the narrow scope was seen as a disadvantage: only one team had taken part in the experiment even though the whole work community followed it closely.

All of the development ideas in *Malmi* required elaborating. The mail carriers worked in small groups developing each product, and the new procedures were supposed to start in September of that year. However, the carriers were still suspicious about the success of the experiment and demanded more extensive changes.

Deliverer M: I would say that they're O.K. but they're still just a scratch on the surface because the establishment needs bigger changes that are impossible within the scope of this project.

Interviewer: What kind of changes?

Deliverer M: To eliminate the bottlenecks between the production lines for example.

(Interview with a deliverer, 30.5.1996)

The supervisory group thought that *the Malmi* mail carriers had transformed their product ideas into product concepts well. A weakness in the planning was the failure to address the problem of the internal division of labor, which still often came up in the discussion.

What complicated the implementation of the Outokumpu plan was a dispute between the management and representatives of the employees about how to carry out the reforms. The mail carriers had planned to try out teamwork at the time when the deliveries handled by Viinijärvi were to be transferred to Outokumpu under the management's plan. Teamwork required rearranging the routes and jobs in the whole post office. The mail carriers made this complicated arrangement themselves, which was exceptional because this work was usually done by production designers.

The teamwork was as extensive as it could have been in the circumstances. The export and collecting services were absorbed into the normal deliveries. The route changes eliminated the overlapping of the Paper and Delivery and Export Services. After one week, the employees found the results of the experiments to be good.

The Outokumpu mail carriers also tried stamp selling. This had been done previously in isolated areas but it was now being tried out in the population centre. The mail carriers themselves advertised this service. The product designers criticized the advertisement later because it did not reach the usual standards of Finland Post Ltd., but in any case the stamp selling produced a profit.

Before launching the shopping and pharmacy service the mail carriers conducted a customer survey. Only 5% of the people contacted replied, and of those only a few positively. Soon the sales dried up because a local entrepreneur had the idea of starting his own delivery service. The post-office mail carriers thought that the obstacles they had encountered brought out the overlapping aspects of their unit's activities and the organizations' inability to respond to the challenges of competition:

What can we do when there's so many obstacles and overlapping in the organization? Our competitors take post-office customers and they will carry on doing so if we are not able to respond to the challenges. (Outokumpu Change Laboratory group report, 7.6.1996)

The supervisory group thought that the Outokumpu team achieved promising results in spite of the short experimentation time and the fact that the mail carriers' work had turned out to be more versatile. The mail carriers had come up with inventively good ideas and had conducted customer surveys related to them. The group also appreciated the mail carriers' commitment to development.

With a view to bringing the product ideas of the *Hättilä* mail carriers in Hämeenlinna to fruition, five groups were formed and experts were called in from

selected area offices. Only one of the experts called his small group together in time. As a result, the mail carriers lost interest. They saw the experiments as a challenge, but they doubted that they would ever be carried through as the following excerpt illustrates.

Deliverer: I think that some of them might be realised, I don't doubt that, but there are also disputes between the production lines. Feels like that. (Interview with the Hätilä mail carriers 6.6.1996)

The reluctance of the area representatives to design product concepts stopped the design work. As a result, the mail carriers did not write the report themselves. Instead, the area office employees, who claimed that they were too busy to participate in the small-group working in the Hämeenlinna pilot post office, did it. The Supervisor group decided that the Hätilä post office would carry out the experiments with the support of the area unit. Both were told to improve their cooperation and to carry out the experiments during that autumn.

Turku 52 experimented with a new kind of division of labor. The eight mail carriers formed two teams, which they called "cell-teams". The teams cut down on their working hours and improved customer service. Business customers received their mail one-and-a-half hours earlier than before, and export services were carried out in the promised time, in practice one hour earlier than before.

The experiment activated the whole group. The workload was divided equally among all people in the cell and the working hours did not increase. Because of the rotation the professionalism of the mail carriers increased. (The *Turku 52* Change Laboratory group's report, June 7th 1996)

The mail carriers wanted to have more time for the experiments so that they would become familiar with most of the work tasks. They said in the interviews on May 5th 1996 that working in cells "brought up some mutual understanding and cooperation", and that the experiments "brought some new color to the work" and "a spirit of solidarity developed without us even noticing."

In one of the experiments the mail carriers started to sell stamps, which they publicized by distributing information about the new service in their area. As a result of negotiations with the area leaders, they were given money belts and price lists. The customers ordered stamps from them en route or by phone and received them the next day. In less than three weeks stamp sales on four routes made FIM 3,300 profit. The mail carriers were enthusiastic about the results of the experiment.

The results and the goodwill generated after such a short time and a little advertising exceeded all expectations. The mail carriers thought that the experiments should definitely continue. The method worked and did not increase job stress. (...) The profit from selling stamps could be distributed to the deliverer or to the post office as a bonus. (Turku 52 Change Laboratory group report, June 7th 1996)

In the context of internal work guidance, the mail carriers suggested that training in product knowledge and the use of the delivery-order directory should be given to fourteen new employees. They produced the training materials themselves. All the permanent workers in the post office gave practical guidance to all newcomers. The mail carriers felt that the experiment was a success and suggested that it should be continued.

They also produced an action plan for the security service for the elderly. The experiment was agreed with the city social services of the city. It started in September of the same year and was given a warm welcome. It received wide publicity and was established as a regular post-office service. This service expansion became a topic of discussion in Turku and other cities.

The employees in the Turku post office also visited other post offices and brought back some new ideas and working methods.

We found this to be a cheap and a pleasant way to develop and consolidate the working methods in the delivery. (Turku 52's Change Laboratory group report, June 7th 1996)

The supervisory group considered Turku 52's experiments very successful. The post office functioned very independently during the whole process, held meetings when necessary, contacted management to help with the organization, and bravely started using the new models in their work.

The group suggested in their meeting that the Turku 52, Outokumpu, and Malmi post offices could operate as "experimental aquariums", which would function as pioneers and set examples to other post offices during the next stage of the project. The same opportunity was also given to Hervanta "if it could clarify its visions and find a way of continuing the team experiment". The development of the Hätilä post office was left to the area management.

After the experiments had been carried out, the researcher asked the employees to estimate the good and bad sides of the solutions. The observations were written on the Mirror/Future surface. The researcher then asked the employees to think about which contradictions in the current practice could be resolved with each experiment and to analyse how the experiments had worked and how they might continue.

Reflecting the results in the final seminar

The Delivery 2000 project was motivated by the Publication and Delivery Services management's concern about the tougher competition. The business-group leader considered competition still to be a challenge when he spoke in the final seminar:

I'm more convinced, after these past five months, that the road we are walking on now is a substantial factor in how Finland Post Ltd. will hold up in the future. So my faith has become stronger in this Delivery 2000 project that we are really genuinely looking for development from the grass roots. I'm not saying it's the only way but I believe it's the best way to get through the competition situation and challenges that will come along. (business group leader, August 10th 1996)

The supervisory group thought that the experiments highlighted opportunities for increasing productivity and employee well-being, and demonstrated a new kind of enthusiasm among the mail carriers for developing their work. The management's attitude comes out well in the following extract in which a deliverer from Turku asked about the significance of the experiments and the new ideas:

Deliverer from Turku: Are the ideas we've brought up worth anything? These are awkward questions. But if we don't get an answer it's hard for us to know whether to continue or not.

Business group leader: I think this is a philosophical question. If this kind of question is being asked, I sure will answer. The ideas presented here are good and they should be continued. If I were to say anything else I would wreck the whole project at once. I don't want to do that. This Finland Post Ltd. is full of experts with different opinions, but from my point of view the work that has been done in these pilot offices give us a method for dealing with the competition. We won't deal with it by having a few wise experts at head office; they never could take care of it. They can create models and intelligent strategies but they can't put them into practice. And that's what I'm counting on in this project; that what you have done, you can also do in practice as long as you're given the right tools, because this comes from your own motivation. (Discussion in the final seminar 10.8.1996)

After the final seminar the supervisory group decided to expand and support the project. Some of the experiments in the local post offices changed shape, however, and were consolidated in a different way at the same time as the Change Labora-

tory project was expanded. The success of the innovations developed during the project indicated that the new activity concept could be expanded. In the following I will first describe how the experiments were consolidated in each post office, and then, I will summarize how these developments were connected to the contradictions of the current delivery activity.

Consolidating the improvements

The *Hervanta* mail carriers did not continue with the teamwork after the experimental phase, but they did start negotiating with the Tampere Export and Delivery Services about taking care of special deliveries from the Hervanta office. After some teething troubles the service began to function.

Pair work replaced the team experiment, one of them taking the key van route and the other a walking route in turns. This helped to increase their route knowledge, the work became more varied, and replacements were easily found for the key van routes. Thus the pair work increased flexibility and special deliveries could be made on time. This kind of work was becoming more common in Tampere:

This Delivery 2000 did have an effect in that we started planning things more independently and taking on more work. It's impossible to imagine that happening before. (Interview with a deliverer, January 1998)

The *Hättilä* post office area manager decided to start the export of special deliveries that the Change Laboratory had suggested in connection with bunch service simultaneously in the whole Hämeenlinna area. This changed the van mail carriers' work contribution in a positive direction.

When we discussed the experiment we decided to start it in the whole city. So we think that our project had some sort of consequences. (*Hättilä* Change Laboratory group report, November 15th 1996)

The Export and import service experiment was abandoned because the representatives of the transport and delivery service wanted to keep it in their own business group. The delivery service for non-standard shaped packages started in September 1996, but there was not enough demand for it. The mailbox installation and labeling service attracted a lot of attention at first, and around 50 mailboxes were labelled over the two weeks. After that, customer interest declined. There was no interest in the installation service. The advertisement delivery service offered to small entrepreneurs did not arouse interest either: only a few of them responded to the survey. According to the local representatives of the Business Service group,

these kinds of services were not compatible with the activities of the Publication and Delivery Services group. The Hätilä mail carriers still advertised the service experiments in their areas and also received some publicity in local television and radio programs.

Turku 52 succeeded in implementing four new improvements in the following spring. Teamwork, selling stamps, and in-house training were established procedures that were still being followed at the beginning of 1998. The cell teams were still being used particularly to ease backlogs at peak periods. Stamp selling gave a steady yearly profit. There have been no further visits to or from other post offices.

The mail carriers agreed with the social-welfare services to offer a security service for the elderly without charge for six months. This gave the home helps more time to spend with their elderly clients. The mail carriers on the three routes involved visited over 20 elderly people during the experiment. The service made the news on national television and the local television and radio channels made several programs about it. It also featured in local and national newspapers. The service became established in the post office and the time spent on it by the mail carriers is made up as holiday days. A few other post offices started up a similar service. The *Turku 52* mail carriers won an award of FIM 15,000 for this service in the 1997 quality competition organized by Finland Post Ltd.

The *Malmi* mail carriers in Helsinki began their experiments in autumn 1996, although only half of them had been started up by October. The first one to get off the ground involved the sale of stamps, which customers could buy directly from the deliverer or order by telephone. Sales were high during the first month but then fell a little. Nevertheless, the service became established and the mail carriers receive a special payment.

Experiments to cut out the overlap of delivery and transport work started up at the turn of September-October 1996. There were a lot of problems with the selling and advertising campaign. The intention was to paint the delivery carts yellow and to fit plastic pockets on them to advertise postal products. The painting was clearly a challenge:

Lappeenranta post office said that the carts couldn't be painted, that the paint would come off. But we suspected that they just wanted an easy life. Painting the carts hasn't been tried anywhere yet but the deliverer A used to be a professional painter and he thinks we could do it, paint one first to try it out. Modern paints are quite good. (Deliverer interview, August 26th 1996)

Painting the delivery carts became a question of principle regarding the whole development project. The delivers would have wanted the supervisor to make a more determined effort to carry it out: the painting became symbolic "because the

idea was completely ours” (Deliverer interview, August 26th 1996). The carts were eventually painted and were also fitted with plastic pockets for the advertisements. The advertising space was being well used in the autumn.

The main achievement in Malmi was to combine delivery and transport work. At first the van drivers offered export services to some businesses in the area, as the mail carriers had planned. The drivers’ work was more versatile, but the mornings became really busy. The arrangement was changed so that one deliverer helped the drivers during the morning rush.

The mail carriers’ request for compensation for the new duties was put on hold.

The whole thing will dry up if the money doesn’t start running! (Malmi Change Laboratory group report, October 27th 1996)

The mail carriers expanded the experiment in autumn 1997. A team of six or seven people comprising van drivers and mail carriers were involved in the experiment on a daily basis.

This shift to combine transport and delivery was apparently successful and an exceptional development, and heralded the combining of the Delivery and Transport business groups a year later. In 1997, the Malmi mail carriers received the first prize of FIM 30,000 for their invention in the ”quality Act” organized by Finland Post Ltd.

When the experimental phase started in Malmi in August, the mail carriers thought the developments were makeshift and that they would not take the business in the right direction. In the opinion of one of them at the beginning of 1998, they had given up their development ideals. Did the connection between the experiments and the visions still exist?

Well, in a way it annoys me that we haven’t succeeded with the experiment as we planned: in the Malmi Post Office Ltd direction. People think this might not be our own operation at all. We could have rotated our own people in those duties. Our own deliverer became a substitute. Their expertise could very well have been used. (Deliverer interview, February 26th 1998)

The Outokumpu mail carriers continued with their special deliveries, export and import services and stamp selling after the experimentation period.⁵⁰ Special deliveries as well as exports and imports were managed by introducing a new work-

⁵⁰ The Post Office management group decided in autumn 1996 that the mail carriers would sell Christmas stamps on their routes throughout the country – a result of the experiments carried out in the city of Salo and the Change Laboratory project. The service was profitable and it was offered again in 1997.

ing procedure. Stamps and postcards were also sold at summer events and in a local old people's home. Businesses and private customers have become used to buying stamps from the mail carriers. Selling activities are increased during the Christmas period, around Valentine's Day and before Easter. The 1997 sales target was reached in half a year. What the mail carriers still considered to be a problem was that they were not getting compensated for the selling.

The three delivery teams continued operating in the spring. Given the spread of the population, teamwork meant increased cooperation in the sorting. If someone noticed that the normal time for beginning the delivery round has passed he or she lent a hand.

In the spring of 1997, the mail carriers decided to break down the two- and three-person teams in the central city area. They had decided to continue sector sorting and did not return to individual route sorting. In conjunction with breaking down the teams they planned new delivery routes. Four cart routes were changed to bicycle routes, which also increased van use. The division of labor in the sorting office was also changed.

The mail carriers planned the new routes completely independently and announced their plans only to the product designers: a new practice began to develop.

Interviewer: How did this planning get started?

Supervisor: We took a map and started from there.

Interviewer: Did you invite the team separately in order to do the planning?

Supervisor: No. First we did the routes. The van drivers drew theirs, then the center mail carriers. We had that map there on the table at least a week.

(...)

Interviewer: How did the production designer feel about his change?

Supervisor: He didn't say. He didn't really say anything about it. I seem to remember we asked him to come by. He gave us a tip about working hours according to how we had planned the routes. We haven't measured it any more accurately since then.

Interviewer: Have the delivers complained that the measurement is bad or that it should be checked?

Supervisor: No they haven't. We've had some discussions about how we should take the measurement. Well then they said there was no need, that it was fine with them. Everything's quite all right according to them. (Supervisor interview, February 26th 1998)

The relationship of the experiments to the developmental contradictions of the work activity

Given the later progress, the developments that came out in the Change Laboratory fell into five categories: 1) those that never went beyond the idea stage, 2) those that were abandoned after the experimental stage, 3) those that became established, 4) those that extended within and outside the post office, and 5) follow-up developments that were put forward as solutions to the problems encountered in the experiments. Table 10.2 includes details of what happened to the developments and an interpretation of which contradictions were meant to resolve.

The four-month Change Laboratory process produced in all 23 ideas, 13 of which became established. Five of these stayed in their original form, five were extended and three resulted from follow-up developments.

Table 10.1 Contradictions in the delivery work and the experiments as solutions.

An element of the activity system	The contradiction				Number of experiments
	Object: expansion or improving the present	Internal division of labor: collaborative or solo work	External division of labor: the borders or collaboration between the production lines	Rules: workplace regulated or centralized norms and measures	
The development of the experiment					
Remained an idea	Outokumpu: shop and pharmacy service Malmi: registered letters to firms		Hättilä: export and import service		3
Abandoned	Turku 52 Visits to the other offices Hättilä a. postal service for elderly people b. customized advertisement delivery c. delivery of non standard shaped packages d. mail box service	Outokumpu Center area team Hervanta team			7
Established	Malmi a. stamp selling b. sales and advertisement campaign Turku 52 in-house training	Outokumpu district area team Turku 52 cell team			5
Extended	Turku 52 a. security service for elderly people b. stamp selling Outokumpu Stamp selling		Malmi The combination of delivery and transport services Hättilä Express letter export		5
Followed-up		Hervanta work pair rotation	Hervanta Express export and import service	Outokumpu Route planning	3
Realized and not realized	11+2=13	5+0=5	3+1=4	1+0=1	20+3=23

Three ideas were not tried out at all, two of which were connected with the object of the work and one with the division of labor. The suggestion about registered letters at Malmi was abandoned because of disagreements between the post office and the head of Finland Post Ltd.; the other two were abandoned because of disagreements between business groups.

Seven ideas were given up after the experimental phase. Five of these concerned the object of the work and two the division of labor. The plan to extend the object of work was given up because the new services proved to be unprofitable and customer interest in them declined after their initial enthusiasm. The abandoned ideas of teamwork concerned the internal division of labor and they proved not to function well. Even though the team experiments were not continued in either of the cases, the mail carriers did not return back to the individual work model but created new forms of cooperation.

The five improvements that had become established as permanent elements of work aimed at changing the object of activity and division of labor. Two of them involved the introduction of teamwork in which the mail carriers' strengths were utilized in terms of sorting and levelling peak-time loads. The establishment of these new services was problematic and the employees suspected that the experiment that had started out so well was now in danger because of the lack of a support system.

Five improvements were extended after the experimental stage. Three of these had to do with the object of work and two with the external division of labor. The stamp-selling experiment had its effect on a national scale. The security service for the elderly became established and there were plans to try it in Turku and other parts of Finland. Cooperation between transport and delivery services has gradually improved in the Malmi Post Office. It was expected that it could be extended.

Two of the follow-up improvements concerned the internal division of labor, new pair-work models, and a new kind of work rule involving route planning. The new services led to increased productivity in delivery work, and especially to increased cooperation between transport and delivery services. This new cooperation appeared to require a new kind of pair work and teamwork among the mail carriers, as well as a new kind of work planning in the post office.

The improvements set out in Table 10.1 are simplified. In reality they were more varied and included many changes in various parts of the work. However, the table does show the progress of the developments that arose from the Change Laboratories.

The mail carriers saw the possibility of developing their work by extending the object of their activity. In connection with this they came up with a suggestion regarding the division of labor, which needed follow-up in the work communities and discussions with the area management, designers and representatives of other

business groups. This led to attempts to devise new, more independent rules for local offices.

10.4 Assessing the experiment

The Change Laboratory experiment in Finland Post Ltd. showed the surprisingly creative nature of the conceptualization of a new system. It demonstrated that it was possible to implement a new system starting with small experiments that could be developed and diffused. It also showed the increase in initiatives among mail carriers and new collaborative possibilities between top management and workers on the shop floor.

The experiments and new ideas produced in the Change Laboratory project were based on the mail carriers' analysis of the threat posed by a reduction in the amount of the work. This threat could be interpreted as a consequence of two big changes caused by the IT revolution in the Finnish Post's markets. The first of these occurred during the economic depression in 1990 when part of the Post Corporation focused on the development of new services based on new information technology. Delivery as a traditional postal activity had to survive economically independently without support from the new services. The second change appeared five years later when the volume of the main product of Finland Post Ltd., the letter, had begun to decrease. Two years after the Change Laboratory project Nikali (1998, p. 156) showed in his dissertation that the 360-year-old tradition of mail delivery as the main service and source of income at Finland Post Ltd., with its constant increase in volume had begun to fail because of the increased use of new information technology. E-mail had begun to replace customary mail, and there has been a consist decrease in the number of delivered letters since 1996⁵¹. The saturation point of letter-mail development was reached in the same year in which the Change Laboratory experiment was carried out in Finland Post Ltd. The mail carriers understood this development and they were worried about their jobs. The tools and processes of learning through which they designed new services, experimented with them and reorganized their work were, in my interpretation, attempts to resolve this crisis. In hindsight their analysis of the dilemma between improving traditional work patterns and expanding the work still seems relevant.

The mail carriers raised two questions: *what kind* of services Finland Post Ltd. could produce locally, and *how* this could be done. Answering these questions lead to experiments that generated *new variation* in the delivery work. Some of the new

⁵¹ In recent years the increased number of bills from telecommunications companies to their customers have, paradoxically, caused a delay in this development.

forms of work resembled semi-autonomous team solutions, but the core of the new services could be seen as an attempt to customize the services according to the needs of the local customers. These experiments could be seen as the seeds of new, mass-customized delivery work, with some of the marketing and product design being carried out on the shop-floor level with the support of centralized product development. The new ways of independently dividing, planning and standardizing the work on the shop-floor supported this concept.

It is interesting to note that the new activity concept went beyond the project's original starting points, which highlighted in-house entrepreneurship, the possibility to rationalize and develop the work on the shop-floor level, responsibility taking on the individual and community levels, and the opportunity to develop teamwork in the delivery service. The managers and union leaders set these goals, but the way in which the objectives could be met was a mystery to them. The project came up with a much more radical suggestion: a vision to expand the object of delivery work. The original goals of the project were included in the vision but they were only a part of the more radical concept.

One reason why the project started was that management was disappointed in the results of the "good delivery" project carried out before the Change Laboratory. "Good delivery" was a homemade combination of several participatory developmental techniques (such as double teams) that are widely used in socio-technical-design projects. The Change Laboratory achieved better results.

The Finland Post Ltd. case showed that it was possible to produce expansive learning actions within the Change Laboratory. The main result of these actions was a new concept concerning the object of the delivery work. While customers had previously been seen mainly as receivers, the mail carriers began to view them also as senders. Given this new concept they could direct their developmental work: model a new kind of activity system, invent new product ideas and experiment with them. The experiments succeeded in increasing the profitability of the post offices as well as improving employee well-being. The Change Laboratory also improved the collaboration between workers and top managers. In some cases, but not all, the middle managers, designers and union representatives also supported the Change Laboratory work.

As a result of the later development of the Change Laboratory project a large work group including union and management representatives (see page 197) produced a concept⁵² of mass-customized mail-delivery work that was approved by

⁵² Helenius, Heikkinen, Kaatrakoski, Niemi, Palmolahti, Palonen, Peltoniemi, Pihlaja, Rantala & Saarinen: Luonnos jakelutyön uudeksi toimintamalliksi, [Outline for new activity model of delivery work] Suomen Posti Oy, 1997.

the management of the business group and union leaders on 8.8.1997. The concept summarized the results of the project and suggested ways of customizing the services and making them more flexible. The management did not put the concept into practice, however. Because of this, too, the new kinds of learning actions the carriers took did not develop into a new form of activity, i.e. into a sustained learning activity connected to the new delivery activity. There appear to be three main reasons for this.

The first reason is connected to the diffusion processes that followed the first Change Laboratory wave. Although these processes are not the object of my study, I offer some observations here. It turned out that the majority of management and trade union representatives did not approve of the direction in which the Change Laboratory project was heading, although it had been formally approved.

The second reason lay in the way in which the process of the first Change Laboratory wave was carried out. Although the common seminars improved the interaction between the workers and the top managers of the business group, some production designers, product designers and other middle managers resisted the mail carriers' implementation actions. This resistance could be interpreted as a contradiction between the prevalent activity concept and the new one the carriers were attempting to implement. The key actors, the production designers⁵³, planned and standardized the routes of each deliverer in the post office. They analyzed the daily variations in each mail carrier's work tasks using videotaped data and computerized information on the variation in mail quantities. Although they had access to more and more advanced technology, they applied the same abstract-empirical system of generalizing that Taylor once advocated. This system has a long tradition in the Postal Service. It provides a basis for the collective bargaining with which it is associated and on the other hand it enables the parties to negotiate the extent of the routes, for example. The negotiators have to be able to use it and to change it. The product designers and middle managers⁵⁴ work was also organized to support this system and to keep development separate from delivery work.

When the deliverers engaged in the Change Laboratory project began to implement the ideas that were products of the theoretical-genetic generalizing, the new and the old ways of producing generalizations collided. The implementation of the new product ideas, such as stamp selling, a sales and advertisement campaign, the delivery of non-standard-shaped packages, the mail-box service, the shop and

⁵³ There were over 60 production designers working in Finland Post Ltd.

⁵⁴ Following the project, in 1998–1999, two coaches from second phase, Anu Rantala and Olli Palonen, carried out a large project for foremen using the tools of developmental work research. This project produced a team organization for foremen that is still in use in Finnish Post Ltd.

pharmacy service and customized advertisement delivery, started to *aggravate* the contradictions. The reactions to the improvement suggestions among the middle managers and union leaders could be seen as a sign that there were later disagreements about the direction of the new development of the business activity.

This raises an important question concerning the Change Laboratory method as an alternative way of producing generalizations and of changing the bifurcated system of generalizing typical of mass production. I demonstrated in Chapters 5 and 8 that the central subject of the distributed system of generalizing in the Taylor system was the designer. The developmental method applied in the Change Laboratory emphasizes learning on the shop floor with the support of top managers. The empirical case highlighted the central role of the planners and designers, however, who resisted the new form of learning. The question thus remains of how to engage the designers in these kinds of projects. To what extent would it be possible to carry out the cycle of expansive learning in delivery work without changing the other related activities at the same time? If it is possible to produce the kinds of innovation and collaboration discussed above within the Change Laboratory, where in the larger organization and by whom should the change be initiated, and how could the results be integrated into the established practices?

The third reason why the new type of learning did not develop into a sustained system in the delivery work was that the expected competition did not materialize. The "real" reason for starting the project was the expected market situation that a new competitor would trigger. Because the Finnish Government did not give one large delivery company permission to enter the markets during the Change Laboratory project, one of the motives behind the project disappeared. The project's analyses indicated that postal delivery work was in a need state. The contradictions had not yet developed into second-order contradictions that would manifest themselves as individual worker's double-bind situations, to which radical change would have been the only solution. The solutions that were produced were solutions to the first-order contradictions, such as between "receiver" and "sender" within the object of the activity system. According to the theory of expansive learning, such solutions are necessarily much more hypothetical than ones based on second-order contradictions. This is also why their affect on the direction of the development is smaller than that of the solutions of second-order contradictions (Engeström, 1995, pp. 88–90).

The challenge that the carriers' solutions raised seemed very demanding. The experiments they planned and carried out brought out the need for more flexible use of standards and the local customization of services. It is possible to interpret this to suggest that the project brought out the need in Finland Post Ltd. to take radical steps in two directions at the same time: that of mass customization because of the radical change in the object, and that of flexible standardization,

which according to Victor and Boynton's theory is a precondition for mass customization.

On the other hand, in the spirit of self-criticism, we might think that while "the sender" of post as a new hypothetical object of activity began to affect the developmental project, the other side, "the receiver", was left without sufficient consideration. The increase in delivery efficiency, however, probably also fell within the zone of proximal development of the activity. It could be that the new concept affected the project to the extent that the developmental work was locked in a one-sided vision.

The implementation of the Change Laboratory nevertheless showed the need to break away from mass production and its distributed system of generalizing. The strong tradition of abstract-empirical generalizing dominated the daily routines, work instructions, collective bargaining, union leadership, management, production design, and many other organizational and professional structures. In the historical part of this study I only analyzed the original forms of learning in and for production. The distributed system of abstract-empirical generalizing was institutionalized in Finland Post Ltd. and embedded in the structure and mediators of the production activity. Developmental efforts that do not correspond to this model are easily regarded as invalid or only as solutions to personnel motivation problems, and projects that suggest radically different concepts of productivity are easily considered "bumbling". The strong tradition of and confidence in the omnipotence of the abstract-empirical system of generalizing may affect the way the production is considered and performed so strongly that, although productivity could be increased by using other methods, or other systems of generalizing, such solutions are rejected as inappropriate. This is also a challenge for the methodologies aimed at triggering new forms of theoretical-genetic generalization in and for production.

11 Summary and discussion of the results of the study

The objective of my research was to find a way to conceptualize learning in and for production so as to allow for the analysis of its historical change. My basic assumption was that forms of learning are connected to forms of production, and that they should be studied as historically changing.

My first research question was: "How can the ongoing qualitative transformation of the content and institutional forms of learning in and for production be conceptualized and located historically?" In seeking an answer I had to ask a more profound methodological question concerning how to conceptualize the phenomenon in order to make possible the study of its historical development. As answer I would say that if we are to understand learning as a changing phenomenon we should see it as the adoption, application and development of generalized operations, the carrying out of which is mediated through tools and concepts, i.e. artifacts used in production.

The artifacts objectify externally a generalized representation of reality that is important in performing a specific operation. More specifically, learning in and for production could be understood as an artifact-mediated process of generalizing what is essential for accomplishing an action or a joint activity with the help of earlier generalizations. The artifacts that mediate the production activity, and which vary in different types of production, thus become crucial in the analysis of production-related learning in that they objectify the generalizations and mediate the resulting new operations.

Relying on Freeman and Louçã's theory of techno-economic paradigms, I first located the current change in learning in and for production in the transition from the mass-production-dominated techno-economic paradigm of the motorization-based long wave of economic development to the new techno-economic paradigm of the new wave based on ICT technology. This transition started in the 1990s. I also came to the conclusion that the main models of mass production

are embodied in the Fordist-Taylorist model, the socio-technical model and the model of flexible manufacturing.

In order to be able to conceptualize the nature of the change I had to answer my second research question: "What were the principles and general structures of the dominant forms of learning in and for production preceding the ICT revolution?" In doing this, and with a view to mastering the huge body of historical material on the development of production, I decided to search for the "ancestors" of the basic variants of mass production. Instead of just describing the generalized solution, the new model of production in its final form, I analyzed the processes through which it was formed following Leont'ev's principle that the true nature of a generalization is not apparent in the outcome and can only be revealed by analyzing the process that produced it. In this case the generalization to be understood was a specific model of production and the related system of learning in and for production.

In analyzing the processes of how the "ancestors" created the main variants of the model of mass production I relied on the reports and descriptions of the initial series of experiments that led to the first version of the new form of mass production and the related system of generalization. In chapters 5–7 I analyzed the processes through which Taylor's system, the system of semiautonomous teams and socio-technical work design, and the flexible production system were created.

As a result, I could state that the Taylorist system of generalization evolved as a solution to the contradiction between traditional forms of generalizing developed in craft work and the new requirements based on enormous growth in production capacity through the introduction of electrified mechanical machines. In my analysis, the "ancestor" of the various forms of learning in and for mass production was the new distributed system of optimizing the methods for performing repeated tasks. The variation that was necessary for this type of generalizing consisted of the various ways individuals had developed for performing the task. This variation was analyzed by specialized planning officers with the help of time-and-motion study, and objectified in a new type of secondary artifact, the work standard that comprised the "one best method" to perform the task. The generalized operations embedded in the standard were thus results of empirical generalization through comparison. The process of creating new generalized operations was divided into two main parts: the research and design of the method by the planners, and the workers' appropriation and learning to carry out the designed operations.

Algorithmic generalizations describing the correct way of performing a task require that the task, incorporating the material, the relevant conditions, the objectives, the tools and other components of the activity, remains the same. The new system created problems of motivation and morale, which in turn became an object of intensive research and development. A new form of production was de-

veloped only when contradiction between the rigid form of generalization and the varying object of the activity also aggravated within production activities. The development and extensive diffusion of Socio-Technical Systems Design was based on this contradiction of Taylor-type production. The system of semiautonomous work teams resolved it by creating space for craft-type experiential generalizing within the context of mass production. The same basic contradiction between the rigid form of generalizing and the varying object of production was resolved in an entirely different way in the flexible manufacturing system by broadening further the object of attention of the workers and creating dialogue between teams of planners and doers.

My analysis revealed four dominant forms of learning in and for production that have preceded the ICT revolution: craft-type learning based on perceptual-functional generalizing in which the generalized operations are mainly preserved as social practices and forms of primary artifacts, and three variants of distributed systems of learning in and for mass production that are all based on:

- *the division of labor in producing production-relevant generalizations*
- *the use of secondary artifacts as a means of preserving the generalizations and exchanging partial results between the parties in the distributed process*
- *an abstract empirical method of generalization that is fundamentally based on the comparison of cases.*

The object of generalization expanded in Socio-Technical Systems Design and the flexible manufacturing system, and the interaction between the related parties has changed from unilateral control in Taylor's system through peaceful coexistence in the socio-technical system to creative dialogue in the flexible manufacturing system.

My third research question concerned the possible contradiction between mass-production-type systems of learning in and for production and the emerging new structures and production dynamics of the ICT era. As I pointed out in the introduction of this study, there is much evidence of a lack of mastery of the necessary transformations in production. My analysis suggests one hypothesis concerning the root cause of the problems in managing change. The forms of empirical generalization on which the distributed systems of generalizing in and for mass production are based do not allow one to master historical change and new kinds of variation in the elements of production. The potential new layer of generalizing in and for production could thus consist of the theoretical-genetic forms of generalizing.

In chapters 9 and 10 I explained Developmental Work Research methodology and the Change Laboratory method of supporting a collaborative process of

theoretical-genetic generalization in the form of expansive learning activity, which is required for the practitioners' involvement in an expansive reconceptualization and remediation of activity. The experimental application of the Change Laboratory in Finnish Post Ltd. demonstrated that, with the help of an external interventionist, the post carriers were able to institute a theoretical-genetic process of generalization concerning the principle of their activity. This process produced a viable new model for the post delivery activity. On the other hand, the new form of learning did not become a stabilized practice, but succumbed to the strong infrastructure of the mass-production-type distributed system of generalizing.

As an individual case the Change Laboratory provides an example of the implementation of theoretical-genetic generalizing, and demonstrated the difficulty of changing the system of generalizing. The new form of generalizing in and for production contradicted the established abstract-empirical form of generalizing. As I see it, the need for new form of generalizing was not strong enough to motivate the production designers and middle management to develop this new form of activity and learning. There was thus a remarkable move first towards theoretical-genetic generalizing and then reverting back to abstract-empirical generalizing. This contradiction could be seen as a methodological and practical challenge for further research and for the development of learning in and for production.

The significance and generalizability of the results of my study lie not in its empirical representativeness, but in the theoretical analysis. The main result is a conceptual scheme for analyzing learning in and for production as a historically developing phenomenon, a scheme that could be used in empirical studies on forms of such learning. The limitations in the applicability of the results are related to the theoretical ramifications of the object of the study. The concept of a distributed system of generalizing is based on the mass-production reality of single-organization production. Production is increasingly being carried out by coalitions of organizations, and new distributed systems of generalizing will also probably be increasingly distributed among a number of collaborating organizations. These new systems of learning are currently the object of intensive research. The limitation imposed by my unit of analysis does not make the results irrelevant. On the contrary, the findings help to identify the differences between the emerging new systems and the old ones. Understanding this difference is of enormous importance, because much of the emphasis in new information technologies and learning is still on applying new technology to old forms of learning instead of building qualitatively new forms.

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