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How do research institutes learn?

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How do research institutes learn?

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Abstract

The aim of this paper is to contribute to the theory of organisational learning (OL) by developing a middle range theory of how research institutes learn. Because of a research institute's specific division of labour in the organisation-environment interactions, the means of mediation between individual and organisational learning are of particular interest. To study these means, a secondary analysis of interviews with scientists of four newly founded East German research institutes was carried out. The early development of these institutes was determined by the necessity to learn as fast as possible in order to achieve quick integration into the German research landscape.

The results of the empirical analysis show (1) the importance of 'unconventional' OL by hiring West German scientists who are experienced in the relevant contexts in which the institute has to operate; (2) the close connection between the modes of 'loose coupling', on the one hand, and, on the other hand, the mediation between individual learning and OL; and (3) the need to enrich analyses of research institutes by introducing a variable describing the fragmentation of an institute's technical core, thus going beyond the classical variables for describing organisations' technologies (task uncertainty and complexity).

Zusammenfassung

Mit diesem Papier soll zu einer Theorie mittlerer Reichweite über das Organisationslernen (OL) von Forschungsinstituten beigetragen werden. Die in Forschungsinstituten auftretende besondere Arbeitsteilung in den Interaktionen der Organisation mit ihrer Umwelt läßt die Frage nach der Art und Weise der Vermittlung zwischen Individual- und Organisationslernen besonders interessant erscheinen. Diese Vermittlungsprozesse wurden in einer Sekundäranalyse von Interviews mit Wissenschaftlern aus vier neugegründeten ostdeutschen Forschungsinstituten untersucht. Um sich in die deutsche Wissenschaftslandschaft integrieren zu können, mußten diese Institute in ihrer ersten Entwicklungsphase so rasch wie möglich lernen.

Die Ergebnisse der empirischen Untersuchung zeigen (1) die Bedeutung des 'unkonventionellen' OL durch die Einstellung westdeutscher Wissenschaftler, die das notwendige Wissen über wichtige Umwelten haben, (2) den Zusammenhang zwischen den in Forschungsinstituten auftretenden Varianten einer losen Kopplung einerseits und der Vermittlung zwischen Individual- und Organisationslernen andererseits sowie (3) die Notwendigkeit, bei der Analyse von Forschungsinstituten die klassischen Variablen zur Beschreibung der Technologie (Aufgabenunsicherheit und Komplexität) durch eine Variable zu ergänzen, die die Fragmentierung des technologischen Kerns eines Forschungsinstitutes beschreibt.

1. Introduction

This paper¹ deals with organisational learning (OL) as a response to environmental changes. As several reviews of the growing body of literature show,² the field of research on OL is very heterogeneous. On the one hand, application oriented research on OL has little to do with attempts at theoretical integration (Wiesenthal 1995: 138). On the other hand, the theoretical discussion remains on the most abstract level. The different types of learning processes,³ the knowledge, culture or ideology which are seen as the result of learning, and the mechanisms of OL are discussed from a perspective which encompasses all organisations.⁴ Theoretical models of OL operate with metaphors from individual learning and with an understanding of organisations which allows no differentiation. However, a further accumulation of knowledge on OL on this abstract level is unlikely. What is needed are middle range theories which are able to explain the variation of OL between different types of organisations and the differences between learning processes on different subject matters. A middle range theory should allow us to find out

- how different types of organisations learn,
- whether the OL varies with the subject matter of learning and
- how a mediation between individual and organisational learning processes takes place.

We could thus develop our understanding of whether different types of organisations do learn in different ways. This paper tries to contribute to the research on OL by investigating the OL of a specific type of organisation (the research institute) in a special situation (early stage of development).

The OL of research institutes is studied using a special case that arose from German unification: In the course of unification, the former Academy of Sciences (AoS) of the GDR was dissolved and its institutes were evaluated by committees established by the Science Council (*Wissenschaftsrat*, a national board advising the government on science policy). As a result, it was recommended that more than 50 new research institutes of the different West German structural types be founded. About 40-50 % of the scientists who had formerly worked at the

¹ I am grateful to Grit Laudel and Renate Mayntz for their helpful comments on an earlier draft. Additionally, I would like to thank Katja Rolletschek for her technical assistance and Gabi Rosenstreich for saving readers from having to cope with my 'rough' English.

² For reviews see Levitt/ March (1988), Dodgson (1993) and Wiesenthal (1995).

³ As a rule, two types of learning can be distinguished: Simple or single-loop learning, which refers to the correct application of rules, and complex or double-loop learning, which refers to the adequacy of rules (Argyris 1976, 1982; Argyris/ Schön 1978; Fiol/ Lyles 1985; Dodgson 1993: 381, 383; Wiesenthal 1995: 139). As a third type, Argyris and Schön (1976) introduced deutero learning, which refers to an organisation's capability to learn.

⁴ See especially Duncan/ Weiss 1979, Finne 1991; Shrivasta 1983, Dunbar/ Dutton/ Torbert 1982, Daft/ Weick 1984, and Daft/ Huber 1987.

Academy of Sciences were re-employed in these new institutes (Meske 1993: 305, see also Mayntz 1994a, 1994b, Wolf 1994, 1996).

The early development of these institutes is of special interest to OL research for two reasons. Firstly, the institutes had to establish a stable position in the German research landscape, which was a new environment for them. Therefore, they had to cope with a situation analogous to a radical environmental change, and their attempts to integrate themselves into the German research landscape represent a special rapid learning process. This 'inverse perspective' on the organisation-environment disparity allows an investigation of 'speeded-up' learning processes. Secondly, the institutes began with very specific initial conditions regarding the organisational knowledge base. The scientists' experiences with the West German political environment and with the international scientific communities differed along the lines of their own backgrounds (GDR, respectively, FRG). Additionally, differences were found between the scientists from the GDR. Their opportunities to interact in their international scientific community during their work in the GDR differed, as did the intensity of individual learning processes within the time span between the fall of the wall (November 1989) and the foundation of the new institutes (January 1992).

Thus, the institutes were in an extreme situation regarding the necessity for OL and the disparity between their members' respective experience and knowledge. Under these conditions, the features of learning processes can be expected to be more discernible than in 'normal' cases of OL. Among these features, the means of mediation between individual and organisational learning merit special attention. Being a highly individualised enterprise, research is generally expected to involve special demands for the mediation between individual and organisational actions. In our case, these demands are intensified by the necessity to mediate the actions of scientists coming from different cultures. Therefore, the means of mediation between individual and organisational learning can be expected to be crucial for the institute's successful early development. *The aim of this paper is to investigate how and by which means a mediation between individual and organisational learning takes place in research institutes.*

To analyse the OL of research institutes, it is first necessary to develop theoretical assumptions which enable us to categorise research institutes as a special type of organisation (Section 2) This can be done on the basis of the technological paradigm of organisation research, on the one hand, and by using some of the sociology of science's findings about research processes and scientific communities, on the other.

One source of information on OL was an ongoing research project on the integration processes and the emerging specific paths of organisational development of four newly founded institutes. Although OL is not the main focus of the project, it has been revealed to be a key process in the integration of the institutes into the German research landscape. Therefore, some of the project's preliminary results could be used. Additionally, a computer-aided qualitative content analysis

focusing on OL was carried out as a secondary analysis of part of the empirical data. Section 3 of this paper describes the methodology of the empirical investigation and the material used.

In Section 4, the results of the empirical investigation are presented. These results concern OL in different organisational environments and the organisational means which are used to mediate between individual and organisational learning. The interpretation of the empirical results leads to contributions to a middle range theory of how research institutes learn (Section 5).

2. The research institute as a special type of organisation

The investigation of the OL of research institutes strikes the problem that no methodology exists for the development of middle range theories of specific types of organisations. Therefore, a theoretical discussion is necessary to provide a background for adapting concepts of organisation research to research institutes.

The research institute is treated as special type of organisation on the basis of the "technological paradigm" of organisation research. This paradigm was developed by Woodward (1965), Thompson (1967), Perrow (1967) and others and played an important role in the work of the Aston group (see Pugh 1981; Perrow 1986: 140-146, and Scott 1986: 281-314 for overviews). It has recently been referred to in studies on the role of new technologies in organisations (Weick 1990). Despite all the discussions on how closely the organisational structure follows the technology, the basic message of the technological paradigm is that technology matters, i.e. that it makes sense to differentiate between organisations with respect to their specific "technical cores" (Thompson 1967). However, the key problem of how to describe and classify technologies remains unsolved. Scott's (1986: 282-287) analysis shows three variables to be the most important for describing technologies: complexity or diversity, uncertainty or unpredictability, and interdependence. Nevertheless, as Perrow (1986: 143) states, the problem of "measurement (and thus the definition of technology itself)" remains unsolved.

The reference to the technical core of an organisation allows a basic analytical distinction between two types of actions. All the actions which are part of the technical core, i.e. of the transformation process, and deal with the subject matter of this transformation, are here called technological actions. All the actions which are carried out to maintain the social conditions for the technological actions are called strategic actions⁵. Obviously, this distinction is only an analytical one because at least some actions contain moments of both types. However, most of an organisation's environmental actions are strategic ones. Exceptions emerge when organisations have an interorganisational division of labour with respect to their technical core.

⁵ For the science system, a similar analytical distinction (research activities cf. scientific activities) is made by Krohn and Küppers (1990).

With respect to the organisation-environment relations, organisations are seen as corporate actors, i.e. as social entities which are capable of acting and therefore of partially shaping their environments. The plural "environments" is used here to introduce a basic differentiation of the external conditions of organisational actions⁶. As a rule, organisations are confronted with different types of actors and institutional settings, such as markets, state actors, professional organisations, etc.

To establish an analytical framework for the investigation of organisations, a differentiation of aspects of an actor's situation is used here that was developed for empirical investigations of actions.⁷ The application of the analytical frame to organisations and their environments is described in table 2-1⁸.

Aspect of analysis	intraorganisational conditions of action	Environments: external conditions of individual and organisational action
functional aspect	technical core, division of labour	organisational domains, division of labour with other organisations
economic aspect	exchange processes, collaboration	exchange processes, collaboration
sociostructural aspect	membership of social groups, stratification, roles	membership of social groups (e.g. professions), stratification, roles
institutional aspect ⁹	institutional framework	institutions in the organisation's environments
cultural aspect ¹⁰	identity ¹¹ (simplified self-image of the organisation), values, beliefs	perception and evaluation of the organisation by its environments, values, beliefs in the environments which are relevant to the members of the organisation

Table 2-1 Analytical differentiation of an organisation's conditions of action

⁶ Within the approach described here, the concept 'environment' is used solely to refer to the external environments. Since organisations are understood as entities which include the members and not as pure structures or communication systems, the concept "internal environment of the organisation" is of no use here.

⁷ See Hager (1988: 89), Gläser (1990: 23-28) and Gläser et al. (1993: 138). For similar approaches, see Mayntz (1988: 10) and Schneider (1989: 31-34).

⁸ Of course, many empirical phenomena cannot be assigned to one special aspect of analysis. The proposed differentiation is a tool for analysis and not a scheme for the categorisation of empirical phenomena.

⁹ Institutions are seen here as informal and formal rules governing the actions of individual and corporate actors (Mayntz/ Scharpf 1995: 47-48; North 1990: 364). This understanding, which is narrower than others, e.g. than the cultural approaches, is used to enable an empirical identification of institutions and to differentiate between institutions and knowledge.

¹⁰ The concept of organisational culture is reduced here to cognitive aspects to make clear distinctions between knowledge and actions. Actions (routines, habits) are generally understood here as *expressing* a certain culture rather than *being part* of the culture (see Schein 1985: 9).

¹¹ The identity of the organisation is understood as a simplified self-image (cf. Mayntz/ Scharpf 1995: 56).

Although organisations are one of the most widespread social realities of our time, the role of organisations in science is a significant blind spot within both organisational sociology and the sociology of science¹². Questions of what formal organisation means for research processes and how research influences the form of organisations are not dealt with in organisational studies. The sociology of science traditionally deals with the social structures which emerge in research and in scientific communities and influence knowledge production (Zuckerman 1988). For this reason, only a few studies on the institutionalisation of modern sciences, on the emergence and development of state research programmes and on individual research projects tackle questions of formal organisation. An attempt by Whitley (1984) to systematically apply the technological paradigm of organisational sociology to the study of scientific fields is of particular interest here. Using parameters of the technological paradigm, Whitley describes the relationships between uncertainty and mutual interdependence in a scientific field, on the one hand, and social structures of the scientific community, on the other hand. Whitley's study is of great importance since he insists that in science "technology" matters too.¹³

The lack of knowledge about the role of formal organisations in science is surprising since organisations are important structures in modern research and, therefore, merit more attention than has been paid so far. Since there is no common ground in the literature, some theoretical assumptions are necessary regarding specific characteristics of the research institute as a special type of organisation (universities and R&D labs are excluded here).

Functional aspect: The first task is to describe the technical core of a research institute - that is: research. We define research here as the systematic usage of existing scientific knowledge to produce new scientific knowledge (for a similar definition, see Whitley 1983: 711). The attributes "systematic" and "scientific" indicate that the knowledge must be produced in a way that is intersubjectively reproducible and must relate to the existing body of knowledge. Some key features of research can be derived directly from this definition:

- Research is a creative process: Despite the emergence of routines as a consequence of the division of labour, the production of new knowledge always requires *creativity*. Therefore, *spontaneity* and *uncertainty concerning the kind of solution, time and resources needed* are inherent features of research. Moreover, creativity implies that *individualised production*

¹² Some exceptions, however, should be mentioned. For organisational sociology see Blau (1973) Geser (1975), Clark (1983), Mayntz (1985), Alpert (1985), and Wolf (1994, 1996). Some science policy studies are also based on organisational sociology (e.g. Hohn/ Schimank 1990; Mayntz 1994a; Schimank 1995; Braun 1997). For studies which deal directly with the role of organisations in science, see Gläser/ Meske (1996) regarding the AoS of the GDR and Hasse (1996) about the organising of cell genetics research.

¹³ This consideration was neglected in the 1980s as a result of the boom in laboratory studies. The influence of materials, apparatus and cognitive structures on research processes was observed by the laboratory studies as well (Pickering 1993). Since it can also be observed that the constructivist paradigm is beginning to be worn out, it seems useful to re-examine the work which was done on cognitive structures by Whitley and others in the 70s (Gläser/ Laudel 1996).

processes take place. Since creativity leads to new knowledge and thus corresponds to the understanding of learning, a *continuous learning process* occurs in the technical core of a research institute.

- Research is translocal: Since it relates recent action to the existing body of knowledge on the subject and thus to the research which is done simultaneously all over the world, the locus of knowledge production is the scientific community. Therefore, the technical core of a research institute is always integrated into the larger technical core of a scientific community, i.e. it *spans boundaries*.
- Research is heterogeneous: Since research is organised around varying subject matters and this scientific knowledge is not necessarily integrated, it is possible that *more than one technical core exists within a research institute*. This aspect of a research institute's structure seems to be most important because it means that there are two types of research institutes: those with a fragmented technical core and those with a homogenous technical core. Both the many individualised research processes and the existence of more than one technical core are causes for the loose coupling in research organisations.¹⁴

To synthesise the features of an institute's technical core(s), we use the variable research profile which describes

- the institute's domains, i.e. the fields of research and potential applications which are dealt with by the institute's technical core(s), and
- general features of the institute's research, such as the basic or applied orientation, the homogeneity, theoretical or experimental character, degree of complexity and time characteristics (long-term cf. short-term research).

This short discussion does not try to ignore the classical variables complexity, uncertainty and interdependence. However, it seems fruitful to analyse the composition of a research institute's technology before using these variables. For example, whereas the mutual interdependence within one technical core is likely to be high, the existence of different technical cores within an organisation does not necessarily imply a low mutual interdependence. Therefore, the structural aspect 'number of technical cores' can not be reduced to the variable 'mutual interdependence'.

Economic aspect: Within a single technical core, a division of labour and a close collaboration are natural. However, the existence of more than one technical core does not imply a low level of collaboration between them. Since different technical cores are often combined in a research institute to benefit from the possibilities of collaboration, this can be more intensive than the collaboration within individual technical cores. Processes of collaboration and the attempt to integrate an institute's technical cores can lead to a fusion of technical cores (for a more compre-

¹⁴ For the loose coupling perspective see Weick (1982) and Orton/ Weick (1990); for loose coupling in research organisations see Clark (1983: 16) and Gläser/ Meske (1996: 209-210).

hensive discussion, see Gläser/ Meske 1996: 201-206). Within the scientific communities, a continuous formal and informal exchange of information takes place which follows specific rules.

Sociostructural aspect: A scientist's integration into a scientific community is based on interconnected work mediated by the scientific knowledge and often also on collaborative work. Therefore, the influence of a scientific community on the intraorganisational social structures is much stronger than that exerted by the 'peer communities' of 'normal' professions. If an institute comprises technical cores from different fields, the organisation consists of organisational subsets of different scientific communities (Diagram 2-1). Each of the subsets is expected to have its own internal stratification and local leading scientists; a social structure which is often projected onto the organisation's formal hierarchy. The intraorganisational stratification is externally determined insofar it is part of the stratification within the scientific community.

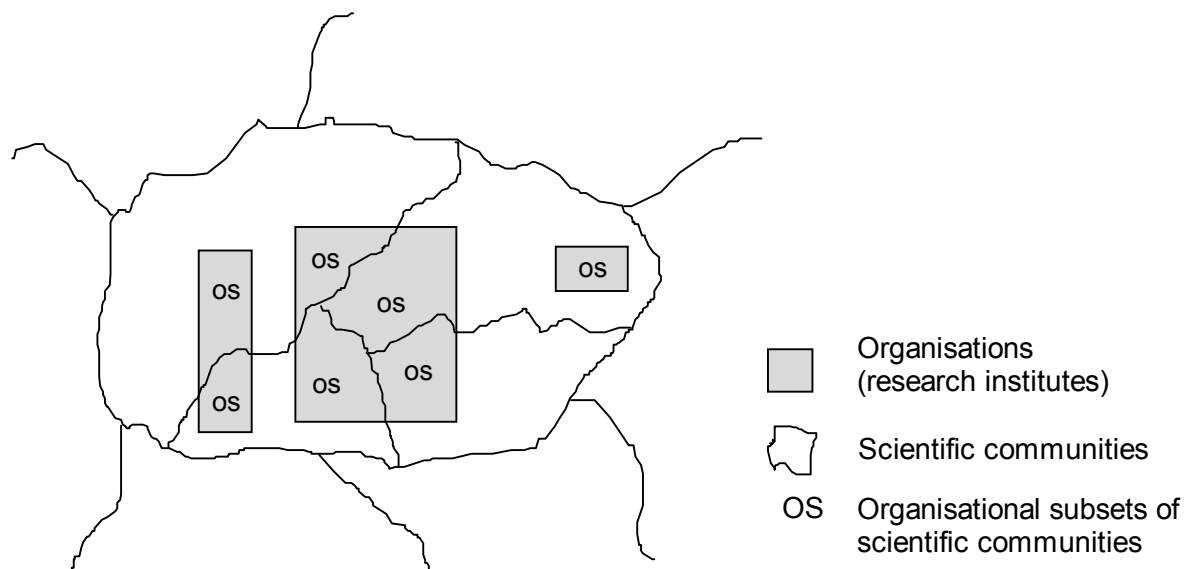


Diagram 2-1: Relationship between scientific communities and research institutes

(Source: Gläser/ Meske 1996: 203)

Institutional aspect: Since there is a high degree of task uncertainty, the institutional rules within the organisation are of a highly informal character (Scott 1990: 114). However, this does not mean that hierarchies cannot exist. Stratification-based hierarchies exist within organisational subsets of scientific communities. These are projected onto the formal structure of the institute, with the leading scientists being heads of departments, etc. If more than one subset exists in the institute, a decentralisation of decision-making and power is necessary because most of the decisions can be made only within the subsets. Generally, the existence of more than one technical core results in a loose coupling between the respective organisational subsets of scientific communities in the organisation.

Cultural aspect: An institute's identity should, at least, refer to the field(s) the technical core(s) belong(s) to, to the basic/ applied nature of the research and to the quality of the research. Additionally, the actor constellations in the institutes' environments are part of the identity because they refer to the legitimacy and the power of the institute. If two or more subsets exist, their specific cultures, including identities, develop as an institute's subcultures. Thus, it is possible that problems of communication and collaboration between different disciplinary cultures emerge.

Environments: Adopting a model by Krohn and Küppers (1990), four environments can be distinguished for a research institute: the scientific communities, science policy, the economy and the public sphere. The organisation-environment interactions are characterised by a specific division of labour with regard to the different environments. Table 2-2 shows the main actors in the organisation-environment interactions.

Environment	Main actors
scientific communities	research actions: scientists strategic actions: leading scientists within the subset
economy	leading scientists within the subset, strategic apex of the institute
science policy	strategic apex of the institute
public sphere	strategic apex of the institute, leading scientists within the subset

Table 2-2: Main actors in the different organisation-environment interactions

As table 2-2 shows, important differences are to be expected between institutes with only one and those with more than one technical core. In institutes comprising one technical core, it is very likely that the subset's leading scientists and the institute's strategic apex are identical and thus the division of labour is reduced to that between leading and other scientists. The other case produces a very sophisticated division of labour which requires additional means of mediation between the different actions. This holds true for the specific learning actions which are dealt with in this paper.

3. Methodology

To provide a basis for the qualitative content analysis, a precise definition of the key concepts of OL was necessary. At first glance, the existing definitions of organisational learning seem to differ widely. For example, Shrivasta (1983) distinguishes four perspectives on organisational learning, and Krebsbach-Gnath (1996) cites no less than 15 definitions of OL that she found in the literature. However, this diversity is caused by the idiosyncratic terminologies rather than by theoretical differences. Upon closer examination of the different approaches and definitions, a great number of similarities can be detected. Most of the definitions refer implicitly or explicitly to OL as

- being caused by environmental changes (Argyris 1976: 365; Argyris/ Schön 1978: 19; Kahn 1982: 427, Dodgson 1993: 387),
- a system of intraorganisational actions (Duncan/ Weiss 1979: 87-89; Argyris 1982: 48; Dodgson 1993: 377-378, 388)
- changing the organisational knowledge (Duncan/ Weiss 1979: 84-85; Hedberg 1981: 3; Daft/ Weick 1984: 285; Dodgson 1993: 377, 382-383) and
- resulting in changed organisational actions (Argyris 1982: 49; Dodgson 1993: 377)

As a basis for empirical analysis, the following definition is used: *Organisational learning is a system of intraorganisational actions by which knowledge about action-outcome relationships and the effect of the environment on these relationships is changed.* This definition is analogous to that of Duncan and Weiss (1979: 84), but instead of their more general term "process" the more precise term "system of actions" is introduced.

Organisational knowledge is "knowledge which is available to organisational decision makers and which is relevant to organisational activities". It is:

- "communicable - capable of being stated in terms that are, in principle, understandable to other members of the organisation",
- consensual - "there is an acceptance of this knowledge among members of the organisation and agreement concerning the validity and utility of this knowledge",
- integrated - the organisational knowledge is "a set of interrelated statements of action-outcome relationships" (Duncan/ Weiss 1979: 86).¹⁵

Thus, organisational knowledge is a feature of the organisation as a whole and therefore expresses the difference between individual and organisational learning (Wiesenthal 1995: 143). Whereas individual learning results in changed individual knowledge, OL results in changed

¹⁵ This definition distinguishes organisational knowledge from other concepts used to describe cognitive features of the organisation, such as the concept of organisational culture (Schein 1985). The narrow definition, however, supports the empirical identification of elements of organisational knowledge.

organisational knowledge. Mediation between individual and organisational learning ensures that at least a part of the new individual knowledge acquired in individual learning processes can be integrated into the organisational knowledge.

Since organisational knowledge is knowledge about action-outcome relationships, it is possible to differentiate the knowledge with regard to its subject matter. Knowledge about action-outcome relationships can refer to the following different types of actions taken by a research institute (see Section 2):

- the technical core of the organisation, i.e. the research actions,
- intraorganisational strategic actions which maintain the technical core (communication, decision making, resource distribution),
- organisation-environment interactions which are research actions based upon a division of labour,
- organisation-environment interactions which ensure the maintenance of the organisation and thus the existence of the technical core.

As a rule, OL is seen as a reaction to the perception of environmental changes to which the organisation must respond. However, it is more precise to say that the perception or anticipation of a "performance gap" (Downs 1966: 191), i.e. a gap between the real and the desired performance of an organisation, initiates OL (Duncan and Weiss 1979: 92). This description emphasises, firstly, that it is the perception of the organisation's members that induces organisational learning processes. These perceptions can differ from the actual environmental changes. The reference to the organisation's performance implies, secondly, that OL can occur not only as a response to environmental changes, but also as a consequence of strategy making, e.g. in connection with prognoses regarding an organisation's development.

The most important indicator of whether a learning process took place is a change in organisational actions. However, OL need not result in new or changed actions immediately. Since the application of the results of OL depends on situational opportunities, it is possible that the organisational knowledge is developed independently of its application.

Being a feature of the organisation as a whole, OL must be more than the sum of individual learning processes within the organisation. Organisations themselves, however, do not act. Organisational action is itself a model which indicates that individuals act as representatives of their organisation. Given the understanding of OL as a system of actions on the part of the organisation's members, one has to look for the mechanisms which (1) integrate individual actions into a system which develops organisational knowledge and (2) ensure that the results of OL influence the actions of individual members. References to at least two important means of mediation between individual and organisational action can be found in the literature. Firstly, the organisational knowledge itself mediates between individual and organisational actions because it functions as a store of information which is filled by all members and can be made accessible

to all members of the organisation (Duncan and Weiss 1979: 87-88). Secondly, the institutional framework (the system of organisational rules governing the actions of the members) mediates between learning on the organisational level and changed individual actions (Argyris/ Schön 1978; Zhou 1993: 1137-1139).

As is shown in Section 2, the 'individual action - organisational action' problem is especially important for research institutes because of their sophisticated division of labour within the environmental actions. Therefore, an empirical analysis was carried out to prove *whether and under what conditions the two means mentioned above mediate between individual actions and organisational learning*. The variables that guided both the analysis of the preliminary results of the research project and the secondary analysis of some of the interviews were selected on the basis of these theoretical assumptions on OL (Diagram 3-1). The secondary analysis was then carried out as a computer-based qualitative content analysis which used the variables to extract information on OL from the interview transcripts.

As a result of the content analysis, the learning processes described in the interviews could be reconstructed. These reconstructions were compared with regard to the means of mediation which were used in the different learning processes.

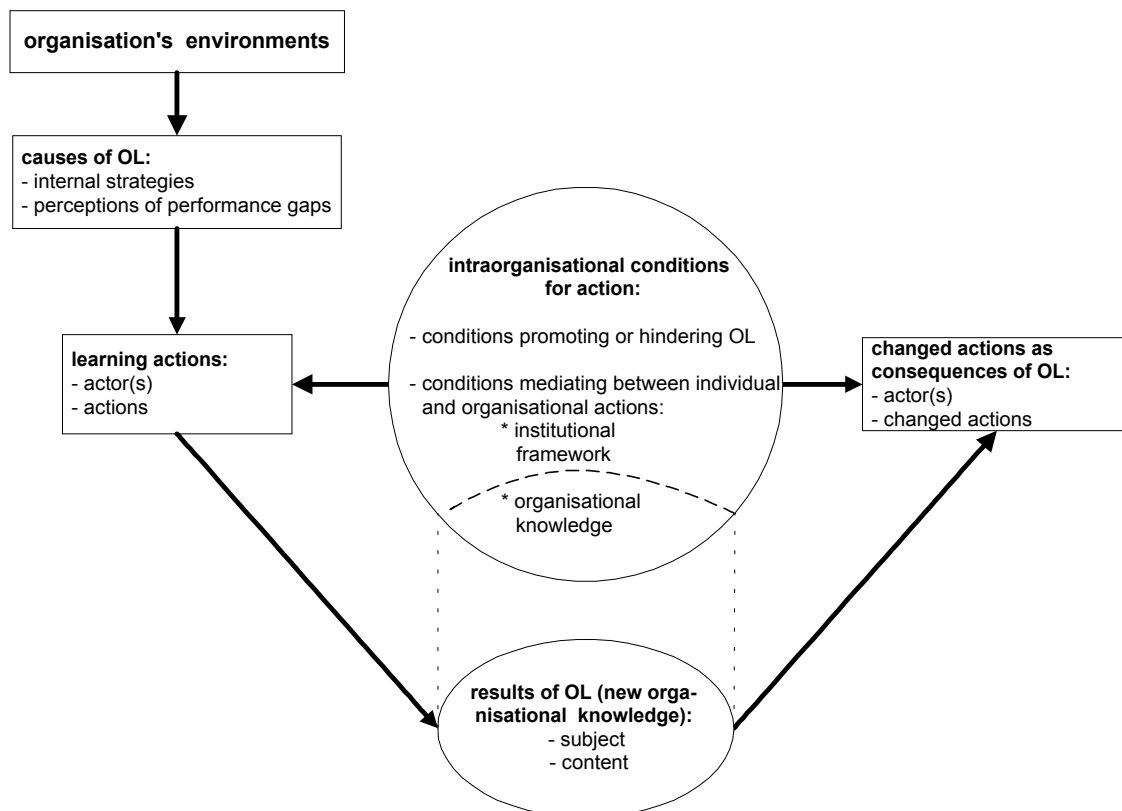


Diagram 3-1: Variables and assumptions on causal relations which guided the empirical investigation

4. Empirical results

In this section, the empirical findings on the OL of four newly founded East German research institutes are presented. As has already been mentioned, the perspective on OL underlying the analysis is unusual in some respects: In the case of the newly founded institutes, the disparity between the actual state of the organisation and the organisation's environment is not caused by a rapid environmental change but by the creation of institutes which are not adapted to their environment. To provide a basis for the discussion of OL processes, an overview of the founding process and the institutes' initial conditions is necessary (Section 4.1). This description encompasses both the conditions which are common to all four institutes and differences in their initial conditions. It is based on the empirical study mentioned above (Gläser et al. 1995). The special conditions that caused OL by producing perceptions of performance gaps and the learning processes in the four institutes are described on the basis of a secondary analysis of about 10 interviews with scientists (directors, heads of departments, research fellows) from each institute (Section 4.2).

4.1 Initial conditions: big newcomers

The initial conditions under which the new institutes existed were shaped by founding processes which were unusual at the very least. As a rule, the plans to found a research institute begin with ideas about its research programme and the scientist(s) who are to head the institute. After being founded with a small staff, the institute grows by hiring scientists who work in the field of the institute's research programme. In the case of the East German research landscape, the task was to maintain capable research potential in a double sense: Firstly, attractive lines of research were to be continued in the new institutes. Secondly, capable research personnel from the AoS' institutes were to be re-employed in the new institutes. Whereas much leeway was given concerning the scientific fields selected for the institutes, the selection of a field effectively dictated the new institute's future staff. Most of the personnel had to come from the former AoS' institute(s) whose research had been recommended for continuation. A certain amount of selection was possible because there were significantly fewer jobs now available in the new institutes. Additionally, the Federal Ministry of Research and Technology recommended reserving 10 % of the positions for West German scientists in order to obtain a "mixture" in the institutes.

The four institutes faced both common and specific initial conditions which are briefly described in the following.

Common initial conditions

Functional aspect: The new institutes' technical cores were determined in several steps. The process began with the AoS institutes' ideas regarding their further existence. These ideas had been contained in reports which the former AoS institutes were required to present as a basis for

their evaluation by the committee appointed by the Science Council. As a result of the evaluation, the committee proposed the preservation of certain research fields and the foundation of a new institute whose technical core(s) and domains were roughly described. On the basis of these recommendations, a founding committee was formed which developed a more precise conception of the institutes' research, appointed a founding director and hired personnel for the new institute. The institutes' director had the opportunity to change the research programme too. Despite the differences between the ideas originally developed by the AoS institutes and the final research programme implemented by the new institutes, all new institutes were founded on the basis of a positive evaluation of both research results and personnel. Since the technical basis of research was generally very bad, all institutes got new, excellent technical equipment.

Economic aspect: The institutes analysed here belong to the so-called 'Blue List'; a group of institutes which were co-financed equally by the Federal Ministry of Research and Technology and the respective federal state (*Bundesland*). At the time of their foundation, the institutes' size and financing was the same as is usual for long-standing West German research institutes.

Sociostructural aspect: The transition of scientists from the old to the new institutes led to unusual social structures. In order to achieve flexibility, the Science Council recommended that a significant share of positions have fixed-term contracts. This recommendation was in conflict with the curriculum vitae and the expectations of most of the East German scientists, who had all had permanent contracts with their AoS institutes. About two thirds of the pool of scientists available for the positions in the new institutes were too old to integrate themselves into the West German career pattern. This is characterised by series of fixed-term contracts up to an age of about forty years, a postdoctoral research and lecturing qualification ("Habilitation") being attained during this time and the hope of a professorship for the time thereafter. Particularly the scientists over 45 years old might not expect to get a job on the German scientists' labour market. For these reasons, there was a strong pressure exerted in the foundation process for the scientists to receive permanent contracts. In all of the four institutes analysed, the proportion of fixed-term contracts recommended by the Science Council was ignored or undercut. As a rule, all the older scientists (in at least one institute, all scientists older than 40) received permanent contracts. In addition to the comparatively small number of East German scientists with fixed-term contracts holding the institutes' budget positions, many East German scientists received fixed-term contracts on the basis of project funding.

Because of the political and financial restrictions on GDR science, most of the East German scientists were unknown in the international scientific community and had no personal contacts to scientists in the Western world. The demand to reserve 10 % of the positions for West German scientists may be seen as a response to this situation. Since the West German scientists fitted into the usual career pattern, a significant internal differentiation of the social structure emerged in the institutes (table 4-1).

	East German scientists' mean age	West German scientists' mean age
with fixed-term contracts	41,0	34,0
with permanent contracts	48,4	40,5

Table 4-1: Mean age and contract status of scientists in four new institutes in 1992

Some scientists from the AoS institutes took part in the founding process and influenced both the research planning and the hiring procedures. Being leading scientists in their fields (although not necessarily in leading positions in the AoS institutes), these scientists wrote conceptions for the new institutes which were at least partially used in the founding process. They were asked to take part in the decision-making process regarding technical cores and hiring and were often appointed to key positions in the new institutes. However, the directors' positions at the new institutes were advertised and West German scientists appointed. Approximately 10 % of the vacancies for scientists were reserved for the director to fill as s/he saw fit.

Institutional aspect: The formal structure of the institutes corresponded to the model which was established by the West German institutes. All four institutes were given a two level structure and were divided into departments. Each was assigned a scientific advisory board to regularly evaluate the institutes' development and advise the director in strategic decision-making. The founding committees delegated some decisions which were crucial for the future development of the institutes to the directors. They had the opportunity to bring scientists from West Germany to fill the reserved vacant positions and to change the institute's research programme. A very important external condition was the fact that it was already announced that the next evaluation of the institutes would be carried out in the near future (about 1998).

Cultural aspect: With the "import" of West German scientists into the institutes, two different research cultures, produced by the two different science systems, clashed. Table 4-2 briefly describes the conditions for actions and the scientists' perceptions of the different orientations they produced or produce.

	GDR	FRG
conditions for action	permanent contracts with the experience of security, political and financial restrictions hindered international communication, little pressure to publish, little pressure of time	fixed-term contracts with the experience of insecurity, wide possibilities for international communication, great pressure to publish, great pressure of time
research orientations	depth, completeness, continuity less tendency to change the subject matter of research less tendency to publish less tendency to do research abroad	breadth, quick success, change less tendency to think in long-term research programmes

Table 4-2: Conditions for actions and the resulting orientations in the science systems of the GDR and the FRG

Varying initial conditions

Despite the common conditions which were produced by the similar structures of the founding processes, there were many differences in the initial conditions experienced by the four institutes. This created specific tensions with their environments. These differences were partly caused by the different recommendations made by the Science Council and were partly a result of disparity in the founding process. In the following, the differences which turned out to have a great influence on learning processes will be briefly addressed by describing the founding processes.

Because of its very special character, the founding process of Institute 4 shall be briefly described. The institute's predecessor received a very positive evaluation and its further existence was recommended. The ideas put forward by the institute's scientists about the future research profile were supported by the evaluation committee. The founding committee, however, came to a completely different evaluation of the institute's competencies.¹⁶ The technical core characterised as the field of the greatest competencies by the evaluation committee was severely criticised by the founding committee. The original plans for the new institute were discarded. Naturally, the scientists from the AoS institute lost all their influence in the founding process. The founding committee decided to delegate all important decisions to the new director. Therefore, neither a research programme nor a formal structure for the new institute were developed by the founding committee. The director's position was advertised and about 30 scientists applied. Surprisingly, none of them was selected. Instead of choosing one of the applicants, members of the founding committee began to approach other scientists (who had not applied). One of these 'special candidates' then submitted an application and was appointed to the position of founding director. However, he left the institute after a few months. Thereafter, one of the institute's scientists was selected to be acting director, with limited authority. Therefore, at the point of its foundation, the institute had more than sixty scientists, but no director, no recommended research profile and no structure. This institute's starting conditions were the worst we found in East Germany.

The new institutes differed with regard to the number of technical cores they comprised. In the case of Institute 1, only one technical core was originally planned. The plans for the institute were developed by scientists from its two predecessors. Their influence on the founding process, was, however, very small: The founding committee very quickly selected the new director who was given a great deal of power. He had the authority to choose scientists to fill 20 % of the available positions and to dictate the research programme. The institute received an additional research group from one of the preceding AoS institutes. The group was to have been transferred

¹⁶ One of the reasons for this discontinuity was the personal discontinuity between evaluation committee and founding committee. Whereas members of the former evaluation committee played an important role in many of the foundation committees, this was not the case in Institute 4.

to another new institute, which had, however, rejected this plan. Thus, Institute 1 had an additional small technical core.

In the case of Institute 2, the Science Council recommended establishing an institute with four technical cores which should collaborate closely with one another. This institute was to benefit from synergy effects between the technical cores. Institute 3 comprises one technical core, created by bringing together scientists who had formerly worked on the same subject matter, but in different AoS institutes. Institute 4 comprises two technical cores which had already existed in its predecessor.

The combination of the recommendations on the research orientation (basic vs. applied research) and on the scale and potential sources of external funding,¹⁷ led to a specific situation for each of the institutes. In the case of Institutes 1 and 2, the recommendations made regarding external funding were consistent with those regarding research orientation. This led to a comparatively high autonomy in their choice of research topics and funding sources. The recommendations made for Institute 3 were also consistent. The institute was designed to be an organisation carrying out applied research for industry. Thus, it was recommended that a large share of project funding come from the industrial sector. Therefore, in the founding process the institute's research profile had to be adapted to meet the concrete needs of industry. This process was successful and the institute received considerable external funding from the start but has been dependent on industry's interests since then. This funding made it possible for Institute 3 to use the subsidies to improve its equipment rather than to cover personnel costs. For Institute 4, recommendations were made which contradicted each other: The institute should devote itself to basic research and discard its connections to industry. On the other hand, a large proportion of external funding should be attained. Since most potential external funding sources support applied research, this is a contradiction; it characterised both the recommendations of the Science Council and the recommendations of the founding committee.

An overview of the differences in the initial conditions is given in Table 4-3.

¹⁷ In addition to this institutional funding, the Science Council recommended that in some of the institutes a certain number of employees should be financed with external funding. This is to be achieved over a transition period of five years. A temporary subsidy fund was created to compensate for the initial gap between the actual and the recommended external funding at a given point. Every year this fund was decreased by 20 % of the original sum and thus disappeared after five years.

Aspect of analysis	Institute 1	Institute 2	Institute 3	Institute 4
Functional aspect: number of technical cores basic vs. applied orientation differences between original recommendation and research profile of the institute stability of the research profile at the time of foundation	2 basic research few differences high	4 integration of basic and applied research no differences high	1 applied research few differences high	2 basic research considerable differences very low
Economic aspect: recommendations regarding external funding amount of preliminary subsidies	no recommendations: autonomy no subsidies	no recommendations: autonomy no subsidies	large share of project funding by industry: heteronomy high subsidies, but also initial high project funding	large share, but no source mentioned very high subsidies
Sociostructural aspect: role of East German scientists mediating the transition	low due to the very quick appointment of a West German director	very high: an East German scientist was acting director at the founding of the institute	high: an East German scientist was vice-director at the founding of the institute	very low
Institutional aspect: fixed internal structures	yes	yes	to a great extent	nothing fixed: no director, no departmental structure
Cultural aspect: fixed identity	yes	yes	yes	no

Table 4-3: Variation in the four institutes' initial conditions

4.2 Learning processes in the four institutes

Institute 1

From the beginning of its development, Institute 1 was characterised by its director's very strong position. He is a scientist who is highly respected in the international scientific community and benefits from widespread international contacts, especially with American and Japanese scientists. Being involved in the foundation process at a very early stage, he had a great influence on decision-making regarding the institute's research profile and technical equipment and was able to autonomously appoint about 20 % of the scientists, including one department head. Since the institute's foundation, the director has been both co-author of most of the institute's publications and the scientist who raised a great deal of the institute's external funding. It was commonly acknowledged in the new institute that its successful development largely depends on its director. Moreover, the director had a clear conception of how a successful institute has to behave.

For these reasons, the OL in Institute 1 was a process of transforming the individual knowledge held by the director and some other scientists into organisational knowledge and ensuing actions. OL was necessary because, despite the director's and other scientists' abilities and knowledge, performance gaps had existed. The main initial performance gaps perceived by institute members were:

- differences between the actual and the necessary (desired) output, i.e. publications, conference lectures etc.,
- a lack of international contacts and, therefore, of international recognition of the institute,
- differences between the institute's actual research profile and the research profile expected by the political environment.

As the main cause for the first and second initial performance gaps, the institute's director identified the different research experiences and cultures of East and West German scientists. In other words, the East German scientists had to learn what the organisation already knew. Therefore, he established some rules to mediate between organisational knowledge and individual learning:

- (1) All scientists must attain a publication output which is on par with the rest of the scientific community.
- (2) All publications must be read by a scientist from another department before being sent to a journal.
- (3) All conference lectures must be presented within the institute before being given at the conference.

(4) The institute's scientists, especially the younger scientists and the department heads, must do research abroad in order to gain international contacts and experience.

Whereas the second and third rules could be enforced using sanctions and were thus adhered to, the effects of the first and fourth rules were weaker. Only some of the scientists significantly increased their output and went abroad temporarily. However, the institute's overall performance has steadily increased.

The third performance gap mentioned above referred in particular to the institute's image as being homogenous with respect to the fields of research and the research orientation. The homogeneous image was challenged by the incorporation of a second technical core. Since, however, both the director and the head of the department comprising the second technical core forced an integration of the research, they initiated a process of assimilating the second technical core. The new department has gradually changed the subject matter of its research in order to work on problems which are relevant for the other technical core. Additionally, it lost nearly the half of its scientists because of a lack of external funding. Therefore, the second technical core is likely to be assimilated by its 'big brother' within the next few years.¹⁸ This process is indicative of the role that the institute's identity plays in determining research strategies. In the interviews, the head of the new department repeatedly referred to this identity and tried to show that the research done by his department is fully compatible with the institute's identity. With one exception, all departments behaved similarly.

The homogeneous image was also challenged by the variation in the institute's research orientations. The original mission of the institute was to do basic research. This idea was supported by those East German scientists who actively took part in the foundation process. The institute's director, however, was personally interested in applied aspects of his research field too. In addition, the German research landscape underwent a political change which resulted in significant pressure towards applications. This pressure also affected the basic research institutes. Having learned that the institute's original mission was nullified by the new political development, the director tried to change both the institute's research profile and image to one of 'basic research, but with an openness for applied aspects'. For example, the director modified a rule to allow the institute's yearly reports to also refer to applications. This gradual change in both the research orientation and the institute's image led to internal conflicts with one department head: He did not adopt the institute's new policy and thus showed a tendency to separate out as an independent technical core. This conflict resulted in the formal removal of the

¹⁸ In their interviews, both the director and the leading scientist in the second organisational subset tried to present the second technical core as already completely integrated. Since all independent indicators (co-authorship, publication media, internal collaboration), disprove this, the statements must be interpreted as attempts to save a certain image of the institute.

department head from his function and the authority over the department being transferred to the director.¹⁹

Since the scientists got new equipment and the fields of research partially differed from those of the preceding institutes, some OL on the level of research action was also necessary. With one exception, this OL within the research actions was described as "business as usual". The exception was the director's assessment that some of the East German scientists need to learn to develop attractive research ideas. This was not so important in the GDR because the bad technical basis limited creativity.

Institute 2

The main initial performance gap in Institute 2 was the difference between the research profile recommended by the founding committee and the institute's state. Because of its three different predecessors, the institute started with a very low level of integration of the four technical cores. Additionally, one of the technical cores had to change from completely applied to dominantly basic research.

Naturally, the OL focused on the development of the research profile. The institute's director, a scientist from one of the institute's predecessors and aged 62 at the time of founding, tried to support the integration of the technical cores by means of an "intensive communication". Since all institute scientists perceived the performance gap regarding the integration, a rule emerged that all new projects must be oriented to the institute's integrative research agenda. However, since neither the director nor the department heads penalised deviations, the rule had little effect. Although the scientists knew of the necessity to integrate the technical cores, i.e. had learned, they did not change their action because their choice of research problems took place within the frame of reference of their particular field. A second attempt to cross the boundaries between the technical cores was the institutionalisation of projects in which scientists from all technical cores were to collaborate. Since this was an additional measure which did not challenge the projects within individual fields, these projects were widely accepted and lead to a gradual approximation of the technical cores.

One technical core's research orientation needed to be changed since it had been exclusively application-oriented prior to its integration in the new institute. The necessity to shift to basic research was accepted by the scientists. However, their freedom in selecting research problems enabled some of the scientists to resist. Thus, the change has come slowly in this case too.

¹⁹ At the same time, the director removed a second department head and assumed authority over the department. The reasons for this second decision could not be ascertained.

Other performance gaps regarded to the institute's output. Three of the four technical cores started with a comparatively low publication output. Again, a disparity between learning processes and behaviour emerged: The scientists knew and accepted that they have to increase their publication output with regard to both quantity and quality (publication in highly acclaimed journals). However, the output has risen only slowly because the East Germans demonstrate less inclination to publish²⁰ and/ or the East Germans are disadvantaged in the competition for international publication.²¹ To increase the quality of publications, an internal evaluation rule was established: All publications must be read by the author's department head.²² In addition, papers submitted to important international conferences must first be presented within the department.

Finally, although no recommendations were made concerning the external funding of the institute as a whole, a performance gap was perceived with regard to the external funding of some departments. This perception emerged because the scientists learned that the amount of external funding was an important criterion in the evaluation of research. Despite this knowledge, only one of the departments attained significant levels of external funding.

As was the case in Institute 1, the new technical equipment led to learning actions among the scientists. No mention was made of problems with these learning actions.

The situation in Institute 2 changed after the new West German director was appointed. This director was in a position to compare the institute with similar West German research organisations. Furthermore, one of the first problems he became aware of in his new appointment was the massive threat of funding cuts to 'Blue List' institutes. As a consequence, he anticipated strong competition between research institutes and the institute's further existence being threatened. For example, he perceived that a 'Blue List' research institute always had to argue that its research must be conducted in a separate institute, i.e. that it cannot be carried out in a university. This is usually done by hinting at the complex and long-term character of the research, two features which were in fact not particularly pronounced due to the comparatively low integration within his new institute.

What the new director introduced into the organisational knowledge was not a new knowledge about performance gaps, but the knowledge about possible consequences of insufficient actions. Consequently, he changed the institutional framework mediating between organisational knowledge and the learning processes of the departments. A centralisation of power took place which was expressed by the following new rules:

²⁰ This reason was given by the new, West German director.

²¹ This reason was given by the scientists themselves.

²² In some cases, the publications were read by the institute's director as well.

(1) All project proposals must be publicly presented in the institute before they commence. The director decides together with the department heads whether the project should in fact be started. The prerequisites are (a) collaboration with other technical cores, (b) the quality of prior projects, measured by publications in SCI-journals, (c) the quality of the new project. If one of the prerequisites is not given, the project is discarded and the resources used for other projects.

(2) Vacant positions in a department come under the authority of the director. He decides together with the responsible department head who should be hired. The criteria are the same as described in the first rule. The new scientist's contribution to the integration of basic and applied research is an additional criterion.

(3) A co-ordination team is formed which consists of the director, the department heads and one representative from of each department, selected by the scientists. This team's task is to develop and apply an integrative research programme for the institute.

Since not enough time had passed between the introduction of these measures and the empirical investigation being carried out, it is difficult to evaluate the effects of the new rules. However, the rules were obviously applied and led to first results regarding the research programme, new projects and appointments. Thus, at least the speed of learning can be said to have increased.

Institute 3

In the case of Institute 3, the OL was much easier than in the other cases. Since all important performance gaps had to be anticipated and closed before founding the institute, the foundation process resulted in the institute's research profile fitting well with environment's expectations. This was confirmed by the amount of external funding reaching the level that had been recommended.

It is important to note here, that the institute's performance is measured by other parameters. Generally, the criteria research profile, output (publications) and external funding were applied to Institute 3 as well as to the other institutes. However, the institute's publication output was accorded lower priority than was the case in other institutes. The most important criterion for this institute was the amount of external funding which is given directly or mediated by industry.²³ Therefore, the institute's members mentioned the publications and conference lectures as being important but reduced their function to being a contribution to the institute's image for the partners in industry. Because of the importance of this image, it was ruled that

²³ In Germany, a very large share of external funding for applied research is given by the Federal Ministry of Education, Science, Research and Technology as project funding for both industrial enterprises and research institutes. To acquire such funds, the institutes need to collaborate with industrial enterprises or at least to find an enterprise which expresses its interest in the project.

publications must be read in advance by the department head and conference lectures must first be presented in the institute.

One other learning action was found which did not occur in the other institutes: In order to maintain a consistent institute image, only the director and department heads were allowed to give political and, in a wider sense, strategic statements regarding the institute. "This we learned from the firms", a department head explained.

The role of the institute's image was emphasised by all scientists interviewed. None of them could imagine a research project being selected which does not contribute to strengthening the institute's position on the external funding 'market'. This was the case although the institute has few formal rules governing the behaviour, i.e. the selection criteria used by its scientists. Obviously, the influence of institute identity on the scientists has the same effect as such rules. The identity was described as being the most important factor of influence in the everyday decisions made by the researchers.

With regard to the technical core, a learning process was described for the whole institute. The institute had to develop know-how about one of its technologies, which, although not new, was difficult to handle. Although the learning process was not research because the institute's competitors already possessed the relevant know-how, it was very important for the institute's further success in applied research.

Institute 4

In this institute, the learning processes were determined by the instability which had characterised its overall situation until mid-1996. The main cause of the instability was that the director's post could not be filled. Since foundation, four different directors had managed the institute for periods of several months respectively. In between were interludes in which the East German scientist who had already performed this function at the time of founding, officiated as acting-director. Because the founding committee (which acted as the institute's scientific advisory board after the formal foundation in 1992) delegated full authority over the research programme and the institute's formal structure to the future director, no formal structure was established. Consequently, there was only one department at the time of foundation. Two years later, one of the directors created a second department prior to returning to West Germany. Under these conditions, what the research groups in the institute learned was completely different to what was learned in the other three institutes. All ten research groups learned about the criteria of success, such as research profile, publications, external funding. All groups also perceived the respective performance gaps. Since a very large share of external funding was recommended by the founding committee and many positions were financed by the subsidies

mentioned in 4.1, the institute was perceived to be under particularly great pressure in this respect.

Thus, neither the performance gaps nor the subject matter of learning differed from the OL occurring in the other institutes. What differed was

- the level at which learning occurred (group level instead of organisation level) and
- the content of the theories on action-outcome relationships which were developed in the research groups.

All scientists and research groups learned that the organisation is not an environment relevant for their survival. Each research group learned that the best strategy is to maximise their own performance independently of the others and independently of the directors who occasionally appeared in the institute. For example, the head of one research group described how one of his projects was rejected by the director for no reason. Nevertheless, the project was started and led to a great scientific success. From this time, the research group ignored the strategic apex of the institute, when it happened to have one. Strictly speaking, no OL has taken place in this institute because no organisational knowledge existed which could be changed. Instead, group learning in a set of almost independent research groups developed and replaced OL.

Important consequences of this learning process were:

- the emergence of barriers between the institute's research groups and a very low level of collaboration,²⁴
- the research groups' refusal to contribute to the institute's common tasks by sharing resources,
- competition between the research groups regarding external funding,
- no intraorganisational rules to secure the quality of the institute's output.

The learning processes regarding publication, international contacts, external funding and the necessity to do research abroad took place within the research groups and led to a significant improvement in their performance. The institute was recognised in the scientific community as having both excellent technical equipment and highly qualified staff. Therefore, many scientists from other countries have visited the institute since its foundation.

With regard to the research action, a specific difficulty was mentioned which was produced by the founding process: Since the institute had to change some of its research fields, some of the older scientists had to switch fields altogether. However, this leads to the older scientists having to compete with their younger colleagues - who were much better prepared for this competition.

²⁴ As was the case in Institute 1, the director interviewed recognised the importance of integration for the institute's image and described the level of integration in the institute as very high. However, all other scientists expressed a contrary view.

4.3 Comparison of the mediation processes

The mode of OL implemented by the institute's founders involved importing scientists with the skills and experience necessary for the institute. Thus, the appointment of about 10 % West German scientists, including the director and some of the department heads, turned out to be the most important process of OL. Thereafter, the OL was a process of changing individual knowledge into organisational knowledge. This occurred

- through the establishment of rules governing the behaviour of both organisational subsets (if there is more than one) and scientists, and
- through the development of the institute's identity. This provided both organisational subsets and individual scientists with criteria for their decisions on new research projects.

If several technical cores exist, the question emerges which role the respective subsets play in OL. It is important to note here that although the institutes' formal structure was nearly identical, the departmental level and, therefore, the formal hierarchy, only played a role in institutes with several technical cores. The other institutes (Institute 3 and, to some extent, Institute 1) were characterised by the institutes' identities exerting a stronger influence. This difference is crucial for the mediation of OL in the institutes:

- In institutes with one technical core (Institute 3 and, to some extent, Institute 1), no rules are in place to govern the behaviour of organisational subsets. Some rules are established to ensure the quality of the scientists' output. The institute's identity plays an important role in decision-making about new research projects. The identity reflects the institute's research profile, i.e. the research fields and orientation (basic or applied). The identity then guides the selection of projects in keeping with the institute's research profile.
- In institutes with several technical cores, organisational rules are designed to govern both the subsets' contributions to the research profile and the quality of the scientists' output. Similar rules can be applied within organisational subsets. The influence of the institute's identity is comparatively low because a 'competing identity' exists within the organisational subsets and this is more likely to influence scientists' decisions.

The different situations in Institutes 2 and 4 enable us to compare the relationship between the degree of centralisation within institutes with several technical cores, on the one hand, and the modes of the different subsets' learning, on the other hand (table 4-4).

	Institute 2 since 1996	Institute 2 until 1996	Institute 4
Institutional framework	dynamic	stable	almost non-existent
Degree of centralisation	high	low	no centralisation
Organisational knowledge about requirements for the institute's existence	institute's existence is very dependent on subsets' performance and integration	institute's existence is not very dependent on subsets' performance and integration	none
Organisational knowledge about requirements for the subsets' existence	subsets' existence is very dependent on their contribution to the institute's performance	subsets' existence is not very dependent on their contribution to the institute's performance	subsets' existence depends only on their own performance
Consequences of learning	rapid increase in contributions to the institute's performance	slow increase in contributions to the institute's performance	contributions only to the subsets' own performance

Table 4-4: Institutional framework and OL in institutes with several technical cores

The differentiation between results and consequences of OL shows that although the learning process is finished, the change in behaviour is restrained by the internal dynamics of the subsets. An institute's strategic apex functions as an intermediate level between the environments' demands and the organisational subsets. A weak strategic apex and the subsequent low degree of centralisation therefore seem to prevent changes in actions by buffering external demands. In Institute 2, the changes in institutional rules led to a direct translation of external threats to the institute into intraorganisational threats to the subsets.

5. Discussion

The early development of the four institutes proved to be an unusual case of OL in three respects. Firstly, the OL was investigated from an 'inverse' perspective: The disparities between the organisations' environments and actual states emerged because of organisational changes rather than environmental changes. However, for the purposes of this study the way in which causes for OL emerged was not of primary concern. Secondly, the OL of the very first phase of the organisations' development was investigated. The advantage of this focus is twofold:

- It was possible to conduct a study of a phase of a research institute's development which can very seldom be observed. Furthermore, since the institutes were founded simultaneously under common general conditions, a comparative study could be carried out in which a relatively large number of variables could be regarded as constant.

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- The pressures of the institutes' start-up phase caused, at least in some cases, discernible *extreme OL processes*. This is a benefit which all studies of organisational responses to *radical* environmental changes have. However, in the case of research institutes these radical environmental changes are generally restricted to funding cuts. The East German institutes faced a much more complex disparity between their environment and state.

However, it must be admitted that the focus on the early phase of the institutes' development has disadvantages as well. In some cases we had to note incomplete founding processes and, therefore, an overlap between OL during the early development and after-effects of the founding processes.

The third unusual aspect of the OL study was the very special East German situation. The institutes were founded without a growth option. There was only a limited choice of personnel for the new institutes, and the cultural differences restrained internal integration.

Nevertheless, these factors did not hinder the study of OL undertaken for this paper. The investigation of both extreme and atypical learning processes contributes to the study of means mediation between individual action and organisational learning. To provide a clear picture of the findings, the following discussion is divided into a discussion of more concrete results on OL of the East German institutes (section 5.1), a discussion of general aspects of OL of research institutes (5.2), and some concluding remarks about the analytical framework which was implicitly tested by this study (5.3).

5.1 Organisational learning in the newly founded East German research institutes

The most important mode of OL in the new institutes was the 'import' of West German scientists whose individual knowledge about environmental needs was turned into organisational knowledge. This form of OL is described by Wiesenthal (1995: 145-146) as one variant on "unconventional organisational learning". It takes place when an organisation's environment has the right to determine its membership. This was the case in the founding processes of the East German institutes: The founding committees decided in advance that West German scientists should be appointed as directors, as most of the department heads and about 10 % of the scientists.²⁵

The import of West German scientists turned out to be crucial for OL because the institutes did not have enough time to learn through their own experiences. The institutes were confronted

²⁵ In the case of the directors and many department heads, the import of West German scientists was achieved by the posts being publicly advertised and the appointment criteria being applied which were usual in West Germany. Because of their different curriculum vitae, the East German scientists had only little chance of being appointed.

with the task of reaching their full performance level within five years. This task allowed no room for a "normal" learning process with slight changes to the organisational knowledge. Even the learning process which turned the imported individual knowledge into organisational knowledge took more than five years in some cases.²⁶

A general question which might emerge with regard to OL in the newly founded institutes is the following: Why did the very positively evaluated scientists need to learn so much and end up learning so slowly? This question refers to the contradiction between the results of the AoS institutes' evaluation and the difficulties faced by the new institutes' members in their learning process. Since the project on the development of the newly founded institutes has not yet been concluded, only a preliminary answer can be given. The evaluation of the AoS and the findings on different research cultures in the GDR and the FRG support the conclusion that excellent research results can be achieved in different ways. What the East German scientists and the new East German institutes have had to learn is to achieve excellent results in the West German way. On the level of individual scientists, this means no less than to undergo a completely different socialisation irrespective of their previous experience. On the level of the organisations, this means completely changing East German research cultures within just a few years. It is quite clear that these processes could not be successful in all cases.

5.2 Organisational learning in research institutes

As was to be expected, OL about the research topics and methods turned out to be an integrated part of doing research and only causes problems in exceptional circumstances. OL in research institutes refers mainly to strategic actions. All changes in these organisational actions were based upon a change in rules. This is caused by the loose coupling between an institute's strategic apex, on the one hand, and the organisational subsets and scientists, on the other hand. If a loose coupling exists, a change in behaviour can be achieved only by means of new or changed rules. This change in rules is, however, a change in the coupling itself. Therefore, we can assume that in loosely coupled organisations it is necessary to implement a tighter coupling in order to achieve new actions as a consequence of OL. This result firstly confirms Weick's postulate (1982: 387) that loosely coupled systems make it more difficult to achieve large-scale change. Secondly, it confirms our hypothesis that the institutes' institutional framework is an important means of mediation between OL and individual actions. Furthermore, the institutional framework changes as a result of OL and at the same time mediates between OL and individual actions. OL therefore changes its own conditions of action.

²⁶ The lack of time for learning seems to be a common feature of the East German transformation. Similar problems are discussed for the economic sector with regard to the policy of selling rather than redeveloping (Brücker 1995: 397-398).

With respect to the mediation between individual and organisational actions, differences were found between the functions of identities and institutional frameworks. Both can be understood as mechanisms which govern the actions of the institute's organisational subsets and scientists. *Within organisational subsets* (and thus also within institutes with one technical core), some of the governance functions are fulfilled by the identity. The more governance functions are fulfilled by the identity, the fewer rules are necessary and the narrower the basis for a formalisation is. *Outside organisational subsets*, i.e. on the organisational level of institutes with more than one technical core, the institute's identity can substitute rules in only few cases because it is reduced to the general aspects described above. In other words, since occupations typically build their basic self-image around their underlying technology, and technologically successful organisations tend to base their self-image around their technology (Schein 1985: 52-57), an institute's identity depends on the homogeneity of this technology. If the identity is built upon different technical cores, a process of abstraction is necessary which produces an identity containing only the common attributes of the technical cores. Within an organisational subset with its homogenous technical core, the subset's identity can mediate between collective (organisational or group) knowledge and individual actions. In all cases of loose coupling, the mediating functions are fulfilled by the institutional framework.

Furthermore, the organisational subsets' internal institutional rules and cultures turned out to be the most important restraints on OL. The influence of both the changed organisational knowledge and the new rules that were created as a consequence of OL was reduced by the internal conditions of the organisational subsets. To overcome these obstacles, high pressure from outside the subsets was necessary in one of the institutes with several technical cores. The lack of such a pressure was the main reason for the general lack of OL in the other institute with more than one technical core.

Summarising the empirical findings, we can state that a middle range theory of research institutes' OL must reject some of the abstract assumptions of the general OL theory. OL regarding an organisation's technology, an important issue in theories about the 'learning firm', is a constituent part of the technology in the case of a research institute and, thus, merits no specific attention.²⁷ OL takes place with regard to strategic actions and especially with regard to organisation-environment interactions. As a result of the empirical investigation, the hypothesis can be put forward that research institutes, as loosely coupled organisations, achieve changes in actions only by changing their institutional framework (i.e. the system of rules), or by changing the organisation's identity (which can sometimes serve as a functional equivalent for rules). The

²⁷ This is implicitly confirmed by the authors who regard a firm's R&D as a key source of OL (Cohen/ Levinthal 1990; Dodgson 1993: 386). If the organisation's technology *is* R&D, this aspect of learning is part of the technology.

question as to whether this hypothesis can be applied to loosely coupled systems in general, must be addressed by future empirical studies.

5.3 The research institute as a special type of organisation

The empirical results confirm that the special tasks/ the special technology of a research institute has consequences for all other aspects of the organisation. We are therefore justified in treating them as special types of organisations. The most important attribute of this type of organisation is the state of its technical core(s). The most fundamental distinction that can be made between research institutes is whether they have one or more than one technical core.

(a) If only one technical core exists, the institute's formal structure is less important. The institute is structured by the scientific community's informal rules, by informal rules emerging within the organisation and by the organisation's identity. The latter comprises both general aspects of the research (basic/ applied orientation, experimental/ theoretical orientation, quality, etc.) and the field-specific aspects (relevant research problems, main research methodologies, boundaries to other fields, etc.). Thus, the identity is suitable to guide the scientists' choice of research problems.²⁸ Because research projects are usually carried out by individuals or small groups, there is a loose coupling between an institute's scientists, or research groups. This coupling seems to be tighter in the choice of research problems and methods and looser with regard to the governing of a scientist's output.

(b) If several technical cores exist, these technical cores and the respective organisational subsets of different scientific communities are loosely coupled as well. The influence of the institute's strategic apex on research processes outside its 'own' technical core is reduced due to a lack of competence and of reputation in the other fields. Research strategies are developed within the organisational subsets, which have their own institutional rules and subcultures (of their scientific community). The functions of identities and rules within organisational subsets are similar to (a). For these reasons, the technical cores and organisational subsets always have a tendency towards segmentation. On the level of the institute, the interplay between the organisational subsets and the institute's strategic apex must be governed. This is done by institutional rules rather than by the institute's identity. Since organisational subsets are generally organised in formal structures, such as departments, the formal structure and institutional rules about decision processes perform an important function. The institute's identity is reduced to the general aspects of the research (see (a)). The evaluation of the institutes is based upon both performance (which is evaluated on the level of the different technical cores) and integration of the technical cores.

²⁸ Rules which govern that choice can exist as well, but are not necessary.

Generally, in the case of research institutes the degree of formalisation of the institutional framework seems to depend on the one technical core/ several technical cores distinction rather than on the degree of task uncertainty. Because of the applied character of Institute's 3 research, a comparatively low level of task uncertainty can be assumed. The degree of formalisation, however, was lower than in Institute 2. These findings show that the application of organisation studies' findings to research organisations has its shortcomings. However, it seems to be fruitful to integrate the analysis of research institutes into organisational sociology.

This study suggests two tasks for the further analysis of research institutes as special types of organisations: Firstly, a description of a research institutes' technology must be developed which allows a comparison with other types of organisations. The special aspects of an institute's technology referred to above were found to strongly influence all other organisational features. They thus merit further attention. In order to describe the technical core(s), it is necessary to adopt the classical variables complexity, task uncertainty and interdependence. Secondly, the 'loose coupling'-perspective on research institutes should be further developed by carrying out additional empirical studies. A synthesis of the technological paradigm and the loose coupling approach seems to be a promising direction for future research on organisations in science.

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