Activity theory as a framework for analyzing and redesigning work

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Cultural–historical activity theory is a new framework aimed at transcending the dichotomies of micro- and macro-, mental and material, observation and intervention in analysis and redesign of work. The approach distinguishes between short-lived goal-directed actions and durable, object-oriented activity systems. A historically evolving collective activity system, seen in its network relations to other activity systems, is taken as the prime unit of analysis against which scripted strings of goal-directed actions and automatic operations are interpreted. Activity systems are driven by communal motives that are often difficult to articulate for individual participants. Activity systems are in constant movement and internally contradictory. Their systemic contradictions, manifested in disturbances and mundane innovations, offer possibilities for expansive developmental transformations. Such transformations proceed through stepwise cycles of expansive learning which begin with actions of questioning the existing standard practice, then proceed to actions of analyzing its contradictions and modelling a vision for its zone of proximal development, then to actions of examining and implementing the new model in practice. New forms of work organization increasingly require negotiated 'knotworking' across boundaries. Correspondingly, expansive learning increasingly involves horizontal widening of collective expertise by means of debating, negotiating and hybridizing different perspectives and conceptualizations. Findings from a longitudinal intervention study of children's medical care illuminate the theoretical arguments.

1. Introduction

Many boundaries are collapsing in the world of work and, correspondingly, in the conceptual frameworks of research on work. The persistent dichotomy between micro-level processes and macro-structures is a case in point. We are witnessing rapid and powerful waves of emergence and adoption of such concepts as 'learning organization', 'knowledge management' and 'social capital'. These are hybrids that cut across disciplines, from economics and sociology to cognitive science and ergonomics. They draw on psychological notions of mental processes, yet they take institutions and communities rather than individuals as their units of analysis.

While hybrid concepts such as those mentioned above are fruitful, they are not theories in themselves. They are more like stimulating but eclectic meeting points

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between different theoretical approaches and methodologies. Coherent new theoretical frameworks that attempt to overcome the aged dichotomies between micro- and macro-, mental and material, quantitative and qualitative, observation and intervention, are few and far between (Engeström and Middleton 1996).

Cultural–historical activity theory will be introduced here as such a framework. Initiated in the 1920s and 1930s by the Russian psychologists Vygotsky (1978) and Leont'ev (1978), activity theory is today a global multidisciplinary research approach (Engeström et al. 1998, Chaiklin et al. 1999), which is increasingly oriented toward the study of work and technologies (Nardi 1996).

Activity theory will be discussed with the help of concrete examples and findings from a longitudinal study of work redesign in the multi-organizational field of children's medical care in the Helsinki area of Finland (Engeström 1999, Engeström et al. 1999, 2000).

2. Actions, scripts and activity systems

A junior hospital physician is taken as the starting point. He works on the urgent care unit of the outpatient clinic of the Children's Hospital. At the moment he is reading a patient's lab test results on a computer screen. This action of reading displays the classical set-up of human–machine interaction studies: a human operator working on a machine.

However, even a slight temporal and spatial extension of this observation reveals that the physician is not only working on the computer. He is simultaneously reading the patient's medical records on paper charts. So the human–machine interaction is actually interaction between the human and multiple mediating artefacts in complementary representational modalities.
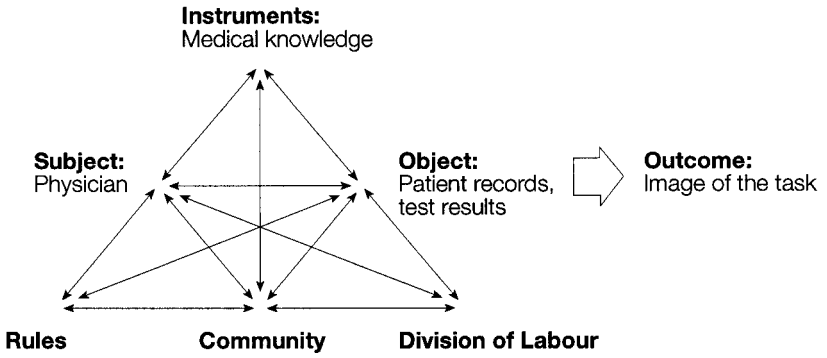
As the observation is extended, the physician, assisted by a nurse, goes to an examination room to see the patient. The patient, a 1-year-old boy born prematurely and now with a chronic lung condition, has acute breathing difficulties. The physician's attention is now focused on the patient, and on the patient's father.

The physician makes a phone call and invites a lung specialist into the examination room. As she arrives, the physician lets her take the lead in the decision-making actions concerning the next steps of the patient's care.
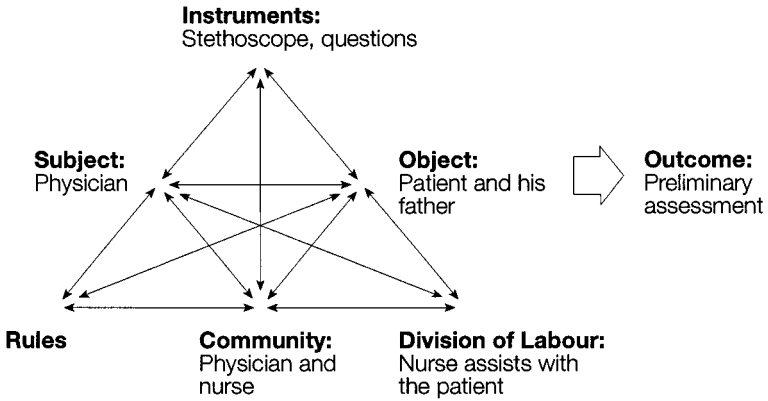
Within some 10 minutes a string of four rather distinctive actions was observed: (1) reading medical records and test results, (2) examining and diagnosing a patient, (3) making a phone call to invite a specialist into the scene, and (4) deliberating and making a decision concerning the next steps of care of the patient.

How can one make sense of these actions in terms of their impact on the participants and their developmental potential? The first step is to uncover the anatomy of these actions as successive, momentary instantiations of a wider and more stable system of collective activity. For this, a model of the human activity system is used (Engeström 1987: 78) (figures 1 and 2).

In figure 1, the junior physician's first action of reading medical records and test results is represented without underlining the importance of the computer. It is not the computer the physician is focused on, it is the test results on the screen. The computer would only become the focus of his attention if he had problems operating it. In activity–theoretical terms, the computer as a technical instrument remains at the level of automatic operations, it is not a central element of the goal-directed conscious action in this case. The bottom part of the first action (rules, community, division of labour) is left empty because these elements, while they undoubtedly

Instruments:
Medical knowledge

Subject:
Physician

Object:
Patient records,
test results

Outcome:
Image of the task

Rules **Community** **Division of Labour**

ACTION 1: READING PATIENT RECORDS AND TEST RESULTS

Instruments:
Stethoscope, questions

Subject:
Physician

Object:
Patient and his
father

Outcome:
Preliminary
assessment

Rules **Community:**
Physician and
nurse

Division of Labour:
Nurse assists with
the patient

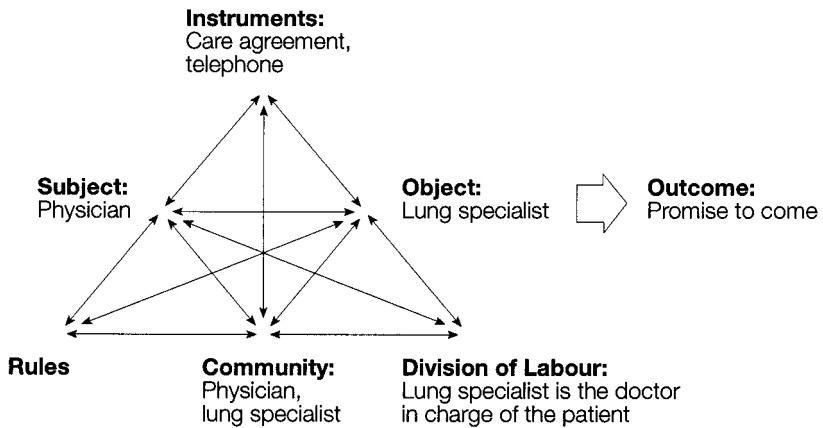**ACTION 2: EXAMINING AND DIAGNOSING THE PATIENT**

Figure 1. First two work actions.

frame the action, are not made visible and articulated by the participants in this particular action (this issue will be discussed below). The outcome of the first action is a preliminary image of the task, accomplished by drawing on the physician's explicit and experiential medical knowledge. This is articulated by the physician as he is interviewed on the spot or immediately after the string of actions, typically viewing the action on videotape as a stimulated-recall prompt.
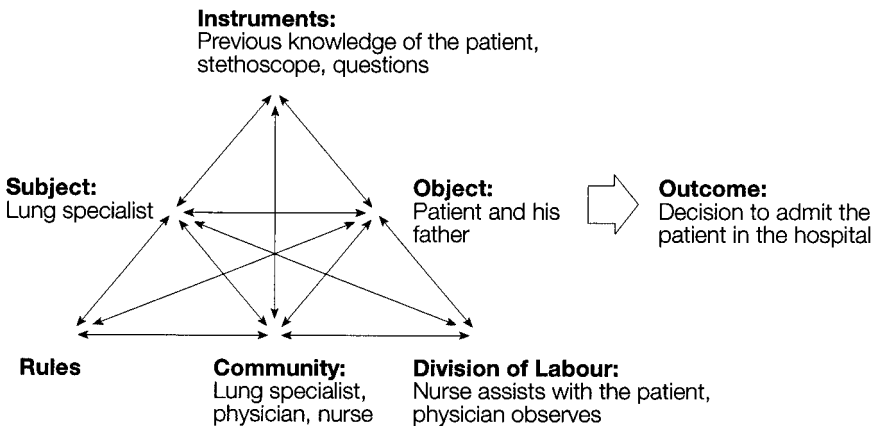
In the second action of examining and diagnosing, the object of attention shifts from documents to the patient and his father. The outcome is a preliminary assessment of the patient's condition: the physician explicates the possibility that the child may have pneumonia. This outcome is reached my means of examination operations in which the use of stethoscope and questions to the father about the child's symptoms play prominent roles. Another important mediating factor in the action is the division of labour between the physician and the nurse; the latter assists the physician in the examination. Together, the two are the visibly present representatives of the community of the outpatient clinic.

In the third action (figure 2), the focus shifts again to the lung specialist of the clinic. From observing and recording a large number of patient visits to the outpatient clinic, this action is known to deviate from the standard script. Instead of calling the senior physician on duty, the junior physician called a specific lung specialist. From interviewing the junior physician immediately after this string of actions, it is known that he did this because he had seen a box in the patient's medical chart, titled 'Care agreement'. In this box, the lung specialist was named as the physician in charge of the continuous care of this patient within the Children's Hospital. This information, together with the telephone, mediated the junior physician's action.

Finally, in the fourth action the subject position was taken over by the lung specialist and the junior physician moved to the background. The action itself

Instruments:
Care agreement, telephone

Subject:
Physician

Object:
Lung specialist

Outcome:
Promise to come

Rules

Community:
Physician, lung specialist

Division of Labour:
Lung specialist is the doctor in charge of the patient

ACTION 3: CALLING THE LUNG SPECIALIST

Instruments:
Previous knowledge of the patient, stethoscope, questions

Subject:
Lung specialist

Object:
Patient and his father

Outcome:
Decision to admit the patient in the hospital

Rules

Community:
Lung specialist, physician, nurse

Division of Labour:
Nurse assists with the patient, physician observes

ACTION 4: DELIBERATING AND MAKING A DECISION

Figure 2. Third and fourth work actions.

resembles action 2, only it was mediated by deeper and longer-term knowledge of the patient and his medical condition.

The shift in the subject position in action 4 demonstrates that the actor's identity is not a sufficiently robust basis for understanding the continuity and coherence of actions. Different participants may take the lead in different steps within a string of actions.

At an intermediate level, the continuity of actions is accounted for by the existence of standardized or habitual scripts that dictate the expected normal order of actions. But the notion of script itself requires an explanation: how do the scripts emerge and gain coherence? Scripts alone leave unanswered the crucial question of motivation. If the essence of work boils down to collections of scripted action strings, what drives the practitioners in their actions? Is it rational willpower and force of habit only?

In activity theory, the distinction between short-lived goal-directed action and durable, object-oriented activity is of central importance. A historically evolving collective activity system, seen in its network relations to other activity systems, is taken as the prime unit of analysis. Goal-directed actions, as well as automatic operations, are relatively independent but subordinate units of analysis, eventually understandable only when interpreted against the background of entire activity systems. Activity systems realise and reproduce themselves by generating actions and operations.

If medical practitioners are asked why they do what they do, the eventual answer almost invariably is because of the patients. This is not merely an idealist statement naively reproducing or advocating selfless devotion to a higher calling among healthcare employees. What observably more than anything arouses involvement, effort, emotion, excitement, frustration, and stress among frontline primary care and hospital staff is daily encounters with real, live patients, no matter how cynical or instrumentally oriented the individual employee may be. The object of medical work is the patient, with his or her health problem or illness. This is what in the end gives rise to continuity and coherence to both the actions and the scripts. Without patients the activity would cease.

A collective activity system is driven by a deeply communal motive. The motive is embedded in the object of the activity. The patient as object of medical work is a generalized patient that carries the cultural motive of fighting illness and promoting health. At the same time, each specific patient brings the object to life and embodies the motive in a unique way. The four actions discussed above were all driven by the same object and motive—the patient and the challenge of illness/health. The object and motive give actions their ultimate continuity, coherence and meaning, even when the ostensible object of many actions (such as actions 1 and 3) does not coincide with the object of the overall activity.

3.   Disturbances and contradictions

In activity–theoretical studies of work, deviations from standard scripts are called disturbances (e.g. Engeström 1996b, Norros 1996). They typically indicate developmentally significant systemic contradictions and change potentials within the activity. In other words, while the object and motive give actions coherence and continuity, by virtue of being internally contradictory, they also keep the activity system in constant instability.

In studies of children's medical care in Helsinki, large numbers of repeated disturbances were encountered which resulted in costly gaps, overlaps and discoordinations of care. The disturbances were uncovered as patients were followed through the system, their encounters with care providers videotaped and the practitioners and parents interviewed. These disturbances were most prevalent among chronic patients who had multiple diagnoses or problems and who frequently moved between the primary care health centre and hospitals. Typical cases were children with severe allergies, asthma, and repeated respiratory and other infections. These patients would often have more than 20 visits to different care providers during 1 year.

In figure 3, systemic contradictions giving rise to disturbances are depicted with the help of two-headed lightning-shaped arrows. The first contradictions are between the object and the instruments. In the Children's Hospital, so-called critical paths or critical pathways were the officially accepted instruments for dealing with complex cases. They are normative guidelines that explicate step-by-step how a case representing a given diagnosis is to be moved through the different levels of the healthcare system. The problem with critical pathways is that they are based on the assumption that a patient has a single diagnosis. When a child has, for instance, both asthma and severe food allergies, he or she falls into two separate critical pathways. In these cases, critical pathways are clearly insufficient instruments, possibly even sources of additional trouble.

There are two additional contradictions in figure 3. Multiproblem patients who move between different care providers require collaboration across institutional boundaries. However, the traditional rules of the hospital organization emphasize that each physician is alone responsible for the care of his or her patients. Similarly, the division of labour in the hospital has traditionally emphasized solo performance where a physician may refer a patient forward to another specialist but does not engage in collaborative negotiations about the course of care.

Figure 3 is a working hypothesis. The first version of the contradictions represented in it was derived with the help of analyzing the history of the activity system of the Children's Hospital. Subsequently, the model was tested and refined through in-depth analyses of specific patients' trajectories through the healthcare system. These analyses were in large part carried out in Boundary Crossing
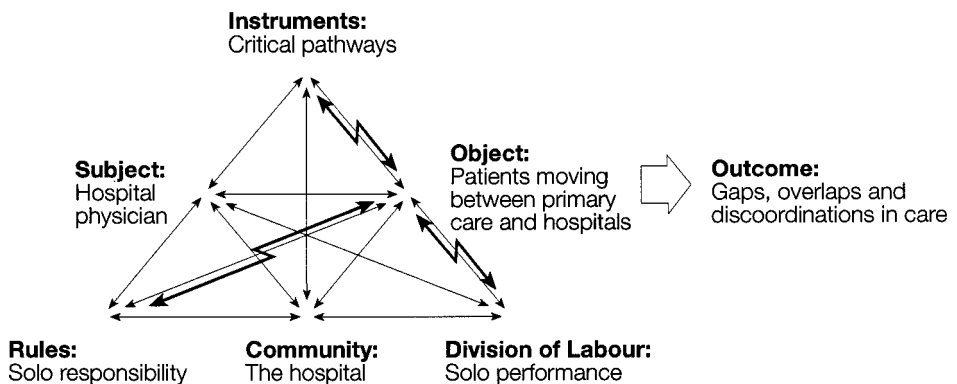

Figure 3. Contradictions in the activity system of the Children's Hospital.

Laboratory sessions. About 60 invited representatives of physicians, nurses, other staff and management from the different institutions responsible for children's healthcare in the Helsinki area met in 10 3-hour sessions, the last one of which was held in mid-February 1998. In several of these sessions, mothers of patients also participated.

The participants viewed and discussed a series of patient cases videotaped by the researchers. The cases demonstrated in various ways troubles caused by lack of coordination and communication between the different care providers in the area. The troubles took the form of excessive numbers of visits, unclear loci of responsibility, and failure to inform other involved care providers (including the patient's family) of the practitioner's diagnoses, actions and plans.

4. Innovations and visions

The identification of contradictions in an activity system helps practitioners and administrators to focus their efforts on the root causes of problems. Such collaborative analysis and modelling is a crucial precondition for the creation of a shared vision for the expansive solution of the contradictions.

Let us return to the third action in figure 2. The junior physician performed an innovative action. Instead of following the standard script and notifying only the senior physician on duty, he invited to the examination room the lung specialist responsible for this particular patient's long-term care.

This innovation was made possible by the fact that the hospital had recently begun to implement a new instrument, the care agreement. As such, this action tells about developmental possibilities of the activity. In his interview, the junior physician explained. 'I've seen in practice how this care agreement works. I noticed in the patient's papers that there was a designated physician responsible for his care in the hospital, so I called to consult with her. And it happened so well that she could come to the spot herself. Now it's important that the personal physician gets informed about the patient's phases here, now that she is also involved in the care.'

Through painstaking debates and design efforts, the participants of the Boundary Crossing Laboratory had constructed an expansive solution to the contradictions identified. The solution, centred around the idea of *care agreement*, distinguishes between two layers of responsibility: each practitioner's traditional responsibility for his or her patient's specific care, and the shared responsibility for the formation, coordination and monitoring of the patient's overall network and trajectory of care. Figure 4 depicts a simplified model of the care agreement, designed by participants of the Boundary Crossing Laboratory.

Four interconnected solutions were created. First, the patient's personal physician—a general practitioner in the local health centre—was designated as the *coordinator* in charge of the patient's network and trajectory of care across institutional boundaries. Second, whenever a child becomes a patient of the children's hospital for more than a single visit, the hospital physician and nurse in charge of the child draft a *care agreement* which includes a plan for the patient's care and the division of labour between the different care providers contributing to the care of the child. The draft agreement is given to the child's family and sent to the child's personal health centre physician (and when appropriate, to the physicians in charge of the child in other hospitals) for their scrutiny. Third, if one or more of the parties find it necessary, they will have a *care negotiation* (by e-mail, by telephone or
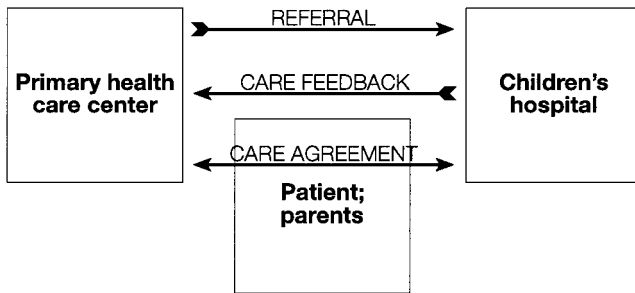
Figure 4.   Practitioners' model for the envisioned care agreement practice.

face to face) to formulate a mutually acceptable care agreement. Fourth, *care feedback*, in the form of a copy of the patient's medical record, is automatically and without delay given or sent to the other parties of the care agreement after the patient's unplanned visit or changes in diagnoses or care plans.

The projected care agreement practice aims at resolving the contradictions depicted in figure 3 by creating a new instrumentality. This instrumentality, when shared by practitioners across institutional boundaries, is supposed to expand the object of their work by opening up horizontal, socio-spatial interactions in the patient's evolving network of care, making the parties conceptually aware of and practically responsible for the coordination of multiple parallel medical needs and services in many patients' lives.

The model in figure 4 implies a radical expansion of the object of activity for all parties: from singular illness episodes or care visits to a long-term trajectory (temporal expansion), and from relationships between the patient and a singular practitioner to the joint monitoring of the entire network of care involved with the patient (socio-spatial expansion). In other words, the model is a spearhead of the zone of proximal development of the activity systems involved, a vehicle for traversing 'the distance between the present everyday actions of the individuals and the historically new form of the societal activity that can be collectively generated as a solution to the double bind potentially embedded in the everyday actions' (Engeström 1987: 174).

To achieve such an expansion both conceptually and in practice, a new kind of learning process was needed.

5.   Cycles of expansive learning

Theories of organizational learning are typically weak in spelling out the specific processes or actions that make up the learning process. One of the more interesting attempts to open up this issue is Nonaka and Takeuchi's (1995) framework of cyclic knowledge creation, based on conversions between tacit and explicit knowledge. Their model posits four basic moves in knowledge creation: socialization, externalization, combination and internalization.

A central problem with Nonaka and Takeuchi's model, and with many other models of organizational learning, is the assumption that the assignment for knowledge creation is relatively unproblematically given from above. In other words,

what is to be created and learned is depicted as a management decision that is outside the bounds of the local process (Engeström 1998). This assumption leads to a model in which the first step consists of smooth, conflict-free socializing, the creation of 'sympathized knowledge' as Nonaka and Takeuchi (1995) call it.

In contrast, a crucial triggering action in the expansive learning process discussed in here, as in other analogous processes analyzed, is the conflictual *questioning* of the existing standard practice. In the Boundary Crossing Laboratory, this questioning was invoked by the troublesome patient cases, to be defensively rejected time and again. The practitioners did also begin to produce questioning actions in their own voices. This led to deepening *analyses* of the cases, and eventually to sharper and more articulated questioning. The analysis of contradictions culminated later as the conflict between critical pathways (available tool) and patients with multiple illnesses (new object) was articulated.

Actions of questioning and analysis are aimed at finding and defining problems and contradictions behind them. If the management tries to give a fixed learning assignment from above in this type of process, it is typically rejected (Engeström 1999b). Out of these debates, a new direction begins to emerge.

The third strategic action in expansive learning is *modelling*. Modelling is already involved in the formulation of the framework and results of the analysis of contradictions, and it reaches its fruition in the modelling of the new solution, the new instrumentality, the new pattern of activity. In the Boundary Crossing Laboratory, the first proposal toward a new model was rejected (excerpt 1).

Excerpt 1 (Boundary Crossing Laboratory, session 4)

Hospital head nurse: Well, this is the title—proposal for a trial period for the month of January, and a trial must always be evaluated, whether it succeeds or not, and what needs to be improved. And I say already at this point that this trial requires additional work, it brings more work. For the outpatient clinic, we propose a procedure in which the outpatient clinic during the entire month sends written feedback on every patient visit regardless of the continuation. To whom, to the home, to the personal primary care physician, to the physician who wrote the referral .

The proposal met with a range of objections, largely centring on the excessive amount of work the feedback system was expected to cause. The head physician of Children's Hospital joined in the chorus of objections, employing the available concept of critical pathways as a warrant in his argument.

Excerpt 2 (Boundary Crossing Laboratory, session 4)

Hospital head physician: We have these task force groups for the critical pathways in place, and they have also discussed this matter, and without exception they have the opinion that definitely not for every visit—I, too, would be afraid that if there is feedback for every visit, there will be so many pieces of paper that the essential information gets easily lost, so surely it would be better that the sender, that is those who are in charge of the care of the patient, should themselves assess when feedback needs to be sent.

The critical discussion and rejection of this proposal (excerpt 2) is an example of the action of *examining the new model*.

In the fifth session of the Boundary Crossing Laboratory, the head nurse came back with a new proposal. In the discussion, the new proposal was mainly referred to as 'care responsibility negotiation'. The term 'care agreement' was also mentioned. The proposal emphasized communication and negotiation between the parents and the different practitioners involved in a child's care. This proposal had a favourable response. It was elaborated further in the sixth session. In this session, the 'care agreement' emerged as the central new concept. The older concept of critical pathways was still used side by side with the new idea of care agreement (excerpt 3).

> Excerpt 3 (Boundary Crossing Laboratory, session 6)
>
> Hospital head nurse: Then an important thing in this is the division of care responsibility which we have discussed, which is difficult to chew on. Now this also takes a stand with regard to the division of care responsibility, and at the end there is the important point that parents have accepted the plan and the concept of feedback refers simply to a copy of the medical record text which contains necessary contact information. And in our opinion this would mean additional work but this would be simple enough, flexible and possible to realise if we embark on this, and the goal is to develop dialogue ...
>
> Data security specialist: Well, if I may comment on this. This would in my opinion be exactly building the critical pathway model, finding ways to improve the critical pathway and the work within it.
>
> Hospital physician 1: An agreement is made only if the hospital care exceeds two visits or goes beyond a standard protocol, so in fact we imagine that the majority of visits will fall into those not exceeding two visits or the protocol.
>
> Hospital physician 2: ... what may be new in this is that in the second visit, or the visit when the outpatient clinic physician makes the care agreement proposal, which is a kind of a vision for continuation of care, so he or she kind of presents this vision also to the parents sitting there, who become committed this way to this continuation of care and to the distribution of care responsibility, however the distribution is defined, something that probably has not been talked about so clearly to the parents. That's what makes this excellent.

The care agreement model has been implemented in practice since May 1998. A good example of *implementation* actions is the third action of the junior physician depicted above in figure 2. The actions of an expansive learning cycle are schematically depicted in figure 5.

In children's medical care in Helsinki, the cycle of expansion is not completed yet. Our research group continues to follow and document the implementation and to feed back intermediate findings to the practitioners.
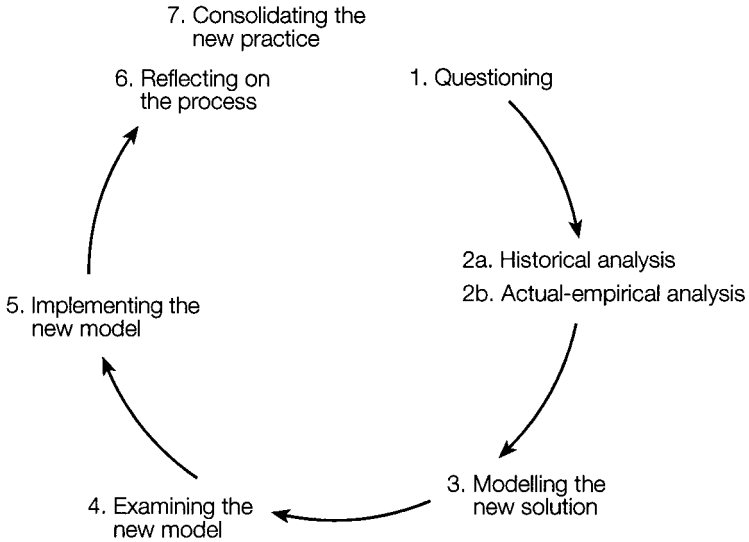
7. Consolidating the
new practice

6. Reflecting on   1. Questioning
the process

2a. Historical analysis
2b. Actual-empirical analysis

5. Implementing the
new model

4. Examining the   3. Modelling the
new model   new solution

Figure 5.   Expansive cycle of learning actions.

6.   The horizontal dimension

One habitually tends to depict learning and development as vertical processes, aimed at elevating the human upward, to higher levels of competence. Recent activity– theoretical research (e.g. Engeström 1996a) suggests that a complementary perspective is constructed, namely that of horizontal or sideways learning and development. The case discussed here provides rich indications of such a complementary dimension.

In particular, the construction of the concept of care agreement (with the related concepts of care responsibility negotiation and knotworking) by the participants of the Boundary Crossing Laboratory is a useful example of developmentally significant sideways learning. In his classic work on concept formation, Vygotsky (1987) basically presented the process as a creative meeting between everyday concepts growing upward and scientific concepts growing downward. While this view opened up a tremendously fertile field of inquiry into the interplay between different types of concepts in learning, it did retain and reproduce the basic singular directionality of vertical movement.

Concept formation in the laboratory sessions started out with the 'scientific concept' proposed by the management: *critical pathways*. Instead of identifiable everyday concepts, it was met and confronted by our videotaped cases and live parents, reporting on children with *multiple illnesses and fragmented care*. The meeting was uneasy, if not outright conflictual.

What followed was a sideways move. Instead of trying to merge the possibly incompatible worlds of the 'scientific concept' of critical pathways and the everyday experience of the patients, a group of practitioners presented a series of alternative conceptualizations. This sideways move started with the poorly articulated idea of *automatic feedback* on every patient visit from the hospital to the primary care health centre. This attempt at formulating a new deliberate concept was rejected 'from

below', using the experiential threat of *excessive paperwork* as the main conceptual argument.

The proponents of the new idea did not give up. They initiated another sideways move and proposed a new concept: *care responsibility negotiation.* This was met more favourably. The practitioners used their experiences of the need for *parent involvement* to elaborate, refine and concretize the concept. This led to yet another sideways move: the formulation of the concept of care agreement. Since Spring 1998, through their actions of implementing this concept in practice, practitioners and parents have accumulated experiences to challenge and transform this concept again in new sideways moves.

This stepwise construction of the new concept and model of care agreement is quantitatively depicted in figure 6. The height of the bars represents the frequency of mention of the given concept. Figure 6 tells us that at the beginning of the sessions, the officially adopted concept of critical pathways dominated. In the second and third sessions, the patient cases effectively eliminated the use of such official terminology. As pointed out above, in session 4 a proposal was presented to test a new feedback procedure. This proposal did not have a conceptual shape and name. It was seen as an attempt to mechanically increase paperwork, and it was rejected. In session 5, a new communication- and collaboration-oriented proposal was presented, first referred to as care responsibility negotiation. In session 6, the new proposal was worked out in more detail, now firmly under the title of care agreement.

Still, the new model was discussed in parallel with the older concept of critical pathways. In session 7, these two concepts actually clashed. In sessions 8 and 9, the new concept gained currency, until it was fully accepted in session 10. Still, even in that last session, the notion of critical pathways was taken up again as a contender to the idea of care agreement. The tension-laden coexistence and struggle between the two is far from over.
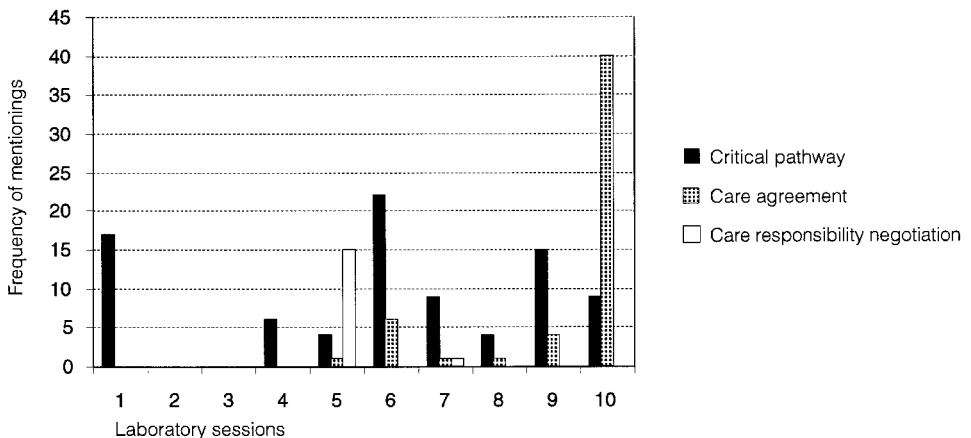

Figure 6.   Frequency of mentionings of three key concepts in the sessions of the Boundary Crossing Laboratory.

   This account leads us a to a new, two-dimensional view of concept formation and learning (figure 7).

   These findings have direct relevance for the more general issue of emerging new types of work organization.

7.   Knotworking as an historical challenge

The care agreement model worked out by healthcare practitioners in Helsinki is a good example of steps toward an emerging type of work organization called here *knotworking*. The notion of knot refers to rapidly pulsating, distributed and partially improvized orchestration of collaborative performance between otherwise loosely connected actors and activity systems. A movement of tying, untying and retying together seemingly separate threads of activity characterizes knotworking. The tying and dissolution of a knot of collaborative work is not reducible to any specific individual or fixed organizational entity as the centre of control. The centre does not hold. The locus of initiative changes from moment to moment within a knotworking sequence. Thus, knotworking cannot be adequately analyzed from the point of view of an assumed centre of coordination and control, or as an additive sum of the separate perspectives of individuals or institutions contributing to it. The unstable knot itself needs to be made the focus of analysis.

   The rise and proliferation of knotworking is associated with ongoing historical changes in work and organizations. Victor and Boynton's (1998) concept of co-configuration is particularly interesting from the point of view of knotworking.

> When a firm does co-configuration work, it creates a product that can learn and adapt, but it also builds an ongoing relationship between each customer – product pair and the company. Doing mass customisation requires designing the product at least once for each customer. This design process requires the company to sense and respond to the individual customer's needs. But co-configuration work takes this relationship up one level—it brings the value of an intelligent and 'adapting' product. The company then continues to work with this customer – product pair to make the product more responsive to each user. In this way, the customisation work becomes continuous. Unlike previous work, co-configuration never results in a 'finished' product. Instead, a living, growing network develops between customer, product, and company. (Victor and Boynton 1998: 195)
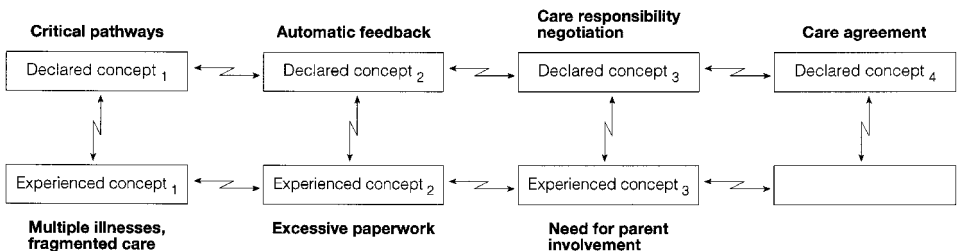

Figure 7.   Vertical and horizontal movement in concept formation and learning: the case of 'care agreement'.

A hallmark of co-configuration is 'customer intelligence'. To achieve it, a company will have continuously to configure its products and services in interaction with the customer. Victor and Boynton (1998: 197) name medical devices and computer software systems as two leading industries where co-configuration is being implemented. They emphasize that co-configuration is more than just smart, adaptive products. 'The application of configuration intelligence to the product creates a system of customer, product or service, and company. The complex of interactions among all three, as a product or service adapts and responds to the changing needs of the customer, is the underlying, dynamic source of value. ... With the organization of work under co-configuration, the customer becomes, in a sense, a real partner with the producer' (Victor and Boynton 1998: 198–199).

Victor and Boynton give a model of three interdependent components: customer, product/service and company. What is missing in this picture is interdependency between multiple producers forming a strategic alliance, supplier network, or other such pattern of partnership which collaboratively puts together a complex product or service. This extension adds to the complexity of interactions in co-configuration work. Against this background, knotworking may be seen as the emerging interactional core of co-configuration.

To sum up, there are six criteria of co-configuration: (1) adaptive product or service; (2) continuous relationship between customer, product/service and company; (3) ongoing configuration or customization; (4) active customer involvement; (5) multiple collaborating producers; and (6) mutual learning from interactions between the parties involved. Currently researchers at the Center for Activity Theory and Developmental Work Research at the University of Helsinki are analyzing emerging forms of knotworking in regional healthcare networks, in alliances between small- and medium-size manufacturing companies, in producer-customer relations in the development and implementation of new medical technologies, and in complex criminal investigations requiring collaboration between different authorities. In all these settings, various layers of team formation may co-exist with emerging forms of knotworking.

Knotworking is related to the rise of temporary groups (Meyerson *et al.* 1996). However, temporary groups are understood as one-time formations created for the purpose of completing a task with a clear deadline. Knotworking, on the contrary, is a longitudinal process in which knots are formed, dissolved, and re-formed as the object is co-configured time and time again, typically with no clear deadline or fixed end point. In temporary groups, the centre still firmly rests in a definable, bounded group. In knotworking, the centre does not hold.

Knotworking poses qualitatively new challenges to work communities and researchers. The relatively stable standard procedures of cooperative continuous improvement are not sufficient in conditions of knotworking. Rapid negotiation and improvization with constantly changing configurations of partners gain central importance. On the other hand, these quick, pulsating negotiations have to be embedded in a radically extended time perspective—the entire life trajectory of the product or service. As demonstrated by programmers of the open source software movement, this type of work opens up new possibilities for initiative and innovation from below (Raymond 1999). At the same time, the disappearance of stable timetables and centralized structures may become a threat to the identities of entire generations (Sennett 2000).

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