Tietoa välittävät artefaktit työssäoppimisen ja kehittämisen välineinä

Miettinen R, Virkkunen J: Learning in and for Work, and the Joint Construction of Mediational Artifacts: an Activity Theoretical View

Pertti Huhtanen

Abstract

Three dilemmas have haunted the discussion concerning workplace learning: How to explain the retention of learning outcomes, how to understand the relationship between individual and collective learning, and what is the relationship between learning and the development of work practices. In this chapter, we suggest that the appropriation, use and development of artifacts that mediate the joint activity is a key for understanding workplace learning and the development of work practices. We maintain, that this activity-theory based explanation has several merits compared to the prevailing views that ascribe the retention of learning outcomes to changes in individuals' minds or body schemes or to shared practices and routines in work communities. We will elaborate this idea by presenting a case example, in which the development new instruments not only led to an expansive transformation of the work activity but also to a new, more effective form of individual and collective learning.

KIINKO

Työssäoppimisesta

- Organizational Learning (Argyris & Schön, 1978)
- Knowledge Management (Nonaka & Takeuchi 1995)
- Participation in "communities of practice" (Lave & Wenger, 1991)
- Oppiminen on yhteisöllinen tapahtuma
- Kulttuurista tietoa säilytetään, jaetaan ja siirretään tulokkaille paikallisesti
- Selitysmalleina   1) mielen mallit
                   2) kehollistuneet taidot
                   3) esineellistäminen artefakteiksi

Introduction

During the past two decades, learning in and for work has been conceptualized in terms of "organizational learning" (Argyris & Schön, 1978), "knowledge management" (Nonaka & Takeuchi, 1995) and participation in "communities of practice" (Lave & Wenger, 1991). All of these conceptions suggest that learning is a collective phenomenon, implying that cultural knowledge is somehow locally preserved, shared and transmitted to newcomers. Different explanations have been proposed for how learning results are actually preserved and further transmitted. We will discuss three of the main theoretical explanations: **the deposit of mental schemes in the mind, embodied skills, and the objectification of knowledge into artifacts**. We argue that the idea of joint creation and use of mediating artifacts has several merits when compared with the two other explanations within the analysis of learning in and for work. We will elaborate on this position by analysing the creation and implementation of a new set of tools that have been used in the work of labour-protection inspectors in Finland (Virkkunen, 1995). This case example will help us demonstrate the ways in which the construction of a new set of jointly used instruments has radically changed the way the labour protection district carries out its work, and how these new instrumentalities both demanded and enhanced inspectors' collective and individual learning.

Yksilöllisten kokemusten yleistäminen "jos-niin" mallilla

- Argyris 1993, Kolb 1984, Schön 1983
- Tietoteoreetikot: kokemus on theory-laden (Kuhn 1970, Wartofsky 1979)
- Tietoisuutta ei ole ilman ulkoisia välineitä (Dennett 2000, Clark 2002)
- Miten selittyy jaettu asiantuntijuus, sen kehittyminen ja siirtäminen?

Kuva: Akseli Huhtanen

www.kiinko.fi   © Pertti Huhtanen 2008
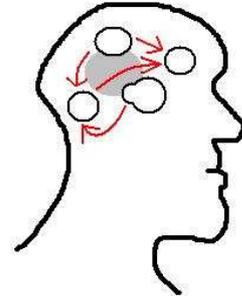
How the results of learning are preserved, accumulated, and transmitted

Probably the most widely held theory regards learning at work as a process of developing a deposit of individual experiences of situations and inductive generalizations in the form of "if-then" propositions in the actor's mind (Argyris, 1993; Kolb, 1984; Schön, 1983). This view has been extensively discussed. At the present time, epistemologists (s. tietoteoreetikot) agree that perception is theory-laden, that is, it is penetrated by culturally-developed models and presuppositions (Kuhn, 1970; Wartofsky, 1979). Two eminent philosophers of the mind have recently even suggested that consciousness cannot exist without external tools (Dennet, 2000; Clark, 2002). The metaphor of individual deposits of experience thus includes a serious philosophical problem. Furthermore, it lacks an explanation for the way in which expertise is shared, developed, and transmitted.

Habitus, habit, routine

- Habitus: Bordieau 1977, habit: Joas 1996, routine: Nelson&Winter 1982
- Keho "muistaa" ja välittää tietoa, taitoa ja jäsentelyjä: prereflective, tacit
- ~etnometodologia (Bohman 1999), pragmatistit (Aboufalia 1999, Joas 1996)

The second alternative for explaining the transmission of results of learning is based on the concepts habitus (Bordieu, 1977), habit (Joas, 1996) and routine (Nelson & Winter, 1982). Bourdieu's theory of habitus is based on the phenomenological ontology developed by Heidegger (1962) and Maurice Merleau-Ponty (1958). These philosophers reject the rationalistic idea of individual's internal representations or plans as the basis of their actions. Instead, they maintain that understanding exists in forms of embodied knowledge, skills and dispositions that are 'remembered' and transmitted within the form of bodily schemes. This type of knowledge is, by nature, prereflective and tacit. Bourdieu's concept of habitus and practical reason bears a strong resemblance to ethnomethodology (Bohman, 1999, 130) and also has much in common with the pragmatist concept of habit (Aboufalia, 1999; Joas, 1996).

Fenomenologisen kritiikki 1

- Vygotsky 1986, Tomasello 1999, Wartofsky 1979: artefaktit ovat kulttuuriselle oppimiselle välttämättömiä
  - Keholliset skeemat ilman artefakteja keinotekoisia
- Aivoihin, hermostoon, kehoon koodautunut tieto on työkalujen käytön sosiaalisia tapoja
- Ihmisen sosiaalisuus ilmenee työkaluissa

There are two ways in which the phenomenological concept of habit and skill can be critisized. First, many psychologists and philosophers regard artifacts as a seminal condition for cultural learning (Vygotsky, 1986; Tomasello, 1999; Wartofsky, 1979). From this point of view, the idea of a body scheme as memory or deposit of cultural learning detached from artefacts is artificial. The things that are coded in the brain, as well as in the nervous system and the body, are social forms of using tools and instruments for human purposes. The human form of sociality is objectified within the tools themselves.

Fenomenologisen kritiikki 2

- Missä dynamiikka, joka luo ja muuttaa vanhoja tapoja (Crossley 2001)
- Fenomenologiset käytännön teoriat unohtavat reflektion ja representaation
- Evoluutioekonomistit ja jotkut OTt: tieto säilyy organisaation rutiinien muutoksien avulla (Nelson&Winter 1982)
- Toiminta perustuu aikaa myöten muotoutu-neisiin rutiineihin, jotka asteittain parantuvat ja siirtyvät tulokkaille sosialisaation avulla (Levitt&March 1988)

Second, many philosophers and sociologists agree on the central limitation regarding the concept of embodied knowledge as also exemplified with the concept of habitus. This concept does not satisfactorily deal with transformative agency, that is, it does not deal with the ways in which subjects are able to articulate and elaborate alternatives to prevailing habits (Bohman, 1999; Burkitt, 1999; Butler, 1999; Emimbayer & Miche, 1998). Nick Crossley nicely summarizes these concerns (2001, 116): "There is something more to agency than the concept of habit can fully capture; a creative and generative dynamic which makes and modifies habits." The phenomenology-based theories of practice – in empathetically rejecting the idea of individual's internal representations – tend to ignore the problem of reflection and representation altogether. Evolutionary economists (Nelson & Winter, 1982) and a number of organization theorists have suggested that the outcomes of learning are preserved by transforming organizational routines. Levitt and March (1988), for instance, maintain that, contrary to rationalistic theories, action is based on historically formed routines that are incrementally developed. These routines are transmitted to new individuals through the process of socialization.

Fenomenologisen kritiikki 3

- Tulokkaat sisäistävät yhteisön nykykäytännöt (Lave&Wenger 1991, Wenger 1998)
- Artefaktit osana tietämisen ja oppimisen välineistöä, mutta…
- …ei riittävää huomiota tietoiseen pyrkimykseen muuttaa käytäntöjä

Lave and Wenger (1991) and Wenger (1998) also view learning as a process in which newcomers internalize the existing practices of a community of practice. While these explanations have the merit of making culture and artifacts a part of knowing and learning, they also do not pay proper attention to conscious attempts to change and transform the prevailing practices.

KIINKO

Yhdessä luodut artefaktit oppimisessa ja tiedon siirtämisessä

- Toiminnan teoria ja historiallinen epistemologia: toiminnan aineellistaminen artefakteihin on pääasiallinen oppimisen ja tiedon siirtämisen keino (Ilyenkov 1977)
- Hegel: henki kehittyy aineellisen ilmiasun avulla
- Marx (1964): ihmisolemus on hänen oman työnsä tulos

Joint creation of artifacts as a key to collective learning at work

According to activity theory and historical epistemology, the embodiment of forms of human activity within artifacts is the primary means of learning and transmitting human achievement. "All forms of activity (active faculties) are passed on only in the form of objects created by man for man" (Ilyenkov 1977, 277). This insight goes back to Hegel, who suggested that the "spirit" develops through its objectifications into material forms, such as artefacts. Marx expressed his admiration of Hegel's Phenomenology, because it grasps the nature of man "as result of his own labour" (1964, 177). The transformation of nature, the creation and use of cultural artefacts, and the development of man and his powers belong to one-and-the-same process. Marx suggested that the "history of industry and the established objective existence of industry are the open book of man's essential powers" (1964, 142). This idea seems all the more sensible in the present-day context of computers, electron microscopes, mobile phones and the Internet.

Yhdessä luodut artefaktit

- Burkitt 1999: "proteettiset" artefaktit kulttuurisen kehityksen perusyksikkö (vs. Dawkinsin "meemit")
- Donaldin (2001) näkemyksen mukaan ihmisen tietoisuus ei voi olla biologisen evoluution tulosta, vaan perustuu "ulkoiseen muistiin", ihmiskunnan historian luomaan aineelliseen kulttuuriin, joka esineellistyy työkaluihin, rakennuksiin, lakeihin ja merkkijärjestelmiin

Numerous cultural psychologists, social scientists and philosophers have analyzed the significance of artefacts. Ian Burkitt calls cultural artefacts a "prosthetic extension of the body" and regards them as the basic units of cultural development–instead of the "memes" suggested by Richard Dawkins (Burkitt, 1999). Mervin Donald, in his theory regarding the emergence of human consciousness, demonstrates that human consciousness cannot be the result of biological evolution. Instead, the key to human consciousness is the external memory, which is composed of the world of material culture that has been created by human history and objectified in tools, buildings, laws and sign systems (Donald, 2001).

Kuva: Akseli Huhtanen

Yhdessä luodut artefaktit

- Latour 1994: tekn. artefaktilla on käsikirjoitus, kyky tuottaa hyötyä, funktio ja tavoitteet
- Hajautettu toimijuus ja tietoisuus (Hutchins 1995, Goodwin 1994)
1. asteen artefakti = työkalu
   - abstrahointi, yleistäminen, yhteinen tarkastelu ja reflektio
2. asteen a: toimintaa kuvaavat ohjeet, kuvat ja mallit
   - tehostaa oppimista, kokeilua, suunnittelua (nuotit)
3. asteen a. mahdollistaa kuvitteellisten, tulevien maailmojen ja käytäntöjen luomisen ja ilmentämisen arkikäytännön ulkopuolella (Wartofsky 1978)

www.kiinko.fi

© Pertti Huhtanen 2008
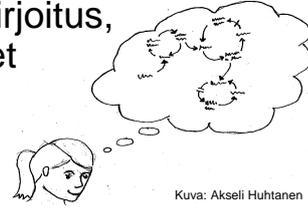
One premier philosopher of technology and science, Bruno Latour, has analyzed the ways in which man (humanity) "delegates" tasks and norms to artifacts (Latour, 1992). As a result, technical artifacts have a script, an affordance, a function or program of action and goals (Latour,1994). Human agency is here distributed between men and artefacts. This has been demonstrated in empirical research conducted by Edwin Hutchins (1995) and other students of distributed cognition (Goodwin 1994). Philosophers John Dewey and V. Lektorsky both analyze the intentional and subjective nature of artifacts: "A tool is also a mode of language. For it says something, to those who understand it, about the operations of use and their consequences," Dewey states, adding: "In the present cultural setting, these objects are so intimately bound up with intentions, occupations and purposes that they have an eloquent voice." (Dewey 1991, 52) "The instrumental man-made objects function as objective forms of expression of cognitive norms, standards and object-hypotheses existing outside the individual" (Lektorsky 1980, 137)

The philosopher Marx Wartofsky suggests (1978, 201): "The critical character of the human artifact is that its production, its use, and the attainment of the skill of these, can be transmitted, and thus preserved within the social group, and through time, from one generation to the next." Wartofsky also analyzes the functions of artefacts in activity, and concludes that tools are primary artifacts. According to Wartofsky representational artifacts, such as pictures or models of forms of action, are secondary artefacts "…created for the purpose of preserving and transmitting skills, in the production and use of primary artefacts" (ibid). A third type of artefact, the tertiary artefact, makes it possible outside of the daily practice to create and depict imaginary worlds and practices that do not yet exist.

The creation of representational artefacts includes the use of abstraction and generalization. Important features of specific practices are made objects of shared attention and reflection. Part of the generalizations gained in human practice become preserved in the form of the actual tools and in the ways and methods of using them in productive work, as the theories based on embodied knowledge propose. The objectification of generalizations into secondary artefacts such as instructions, drawings and models is a historically more recent from of learning and knowledge creation, which makes learning much more effective, and opens up new possibilities for experimentation and design. One can both compose and play music without using notes, but understanding the skill of notation enormously enriches the possibilities for transferring, composing and learning music.

Remediation, *retooling*

- Työssäoppimisen ehdotetaan olevan tietoa välittävien artefaktien kehittämistä ja käyttämistä ongelmien ja haasteiden ratkaisemiseksi (Vygotsky 1986)
- Kehittyvät aiempia kulttuurisia artefakteja asteittain parantamalla, yhdistelemällä ja muuntamalla
- Toiminnan työkalut syntyvät systemaattisesti kehittämällä tai löytyvät oman yhteisön ulkopuolisista kulttuuripiireistä

The theoretical literature we have briefly reviewed above suggests to us a view of learning at work as the development and use of mediating artefacts to solve vital problems and challenges of the work activity. This view, inspired by L. S. Vygotsky (1986), depicts learning as a process of remediation or retooling. Cultural artefacts and the generalizations embodied in them cannot be derived from an individual, or by sheer organizational experience. They rather evolve as a long series of incremental improvements, combinations and transformations of pre-existing cultural artefacts. Often, the relevant tools for an activity are systematically developed, or can be found in the domains of culture that exist outside a singular organization or community.

In the following sections we will analyze the use of artifacts in the transformation of the activity of the aforementioned labor-protection inspectors, and the creation of a new collective tool-kit that makes a new type of labor-safety inspection possible. We will analyze how the new set of instruments influenced the conception of the overall object and purpose of the inspection activity, as well as the social forms of collaboration. Then, we will analyze the creation and use of the new tool-kit, and how it changed the nature of learning in the labor protection district.

The developmental contradictions of the labor–protection inspector's work: in the 1980's In Finland, there exists state legislation and norms concerning working conditions and the safety of employees at work. The enforcement of this labor-protection legislation is the responsibility of eleven district authorities. The Ministry of Health and Social Welfare (formerly the National Board of Labor Protection) supervises this safety enforcement work. It also issues instructions and guidelines concerning working conditions, machinery and equipment. The main form of activity within the labor-protection districts has traditionally been the inspection of working premises, which is carried out by labor-protection inspectors. The purpose of their work is to ensure that labor-protection regulations are being observed, and to give advise about the improvement of working conditions and work place safety. These inspectors typically have college- or university-level technical training, and/or a background as labor-protection managers or labor-protection delegates within the industry. During the 1970's, the scope of workplaces to be inspected was radically broadened by new legislation. In order to manage this increased workload with a staff that did not increase proportionally, the newly-established National Board of Labor Protection issued detailed instructions for the inspectors, and tried to standardize their inspection procedures. The Board also developed a system of strategic planning to determine priorities, and launched campaigns and projects to make sure the inspectors' work focused on important areas. In the 1980s, the optimism of the reform work that took place during the 1970s was, however, lost. There was a growing awareness and discussion that suggested that by making traditional kind of surveys in work premises inspectors could not get an accurate diagnostic picture of the safety situation, nor could they have an impact on the root causes of safety defects and hazards. The inspectors were frustrated by the lack of progress being made in safety at work, and they complained that the same defects appeared repeatedly, despite the instructions they had previously given. In 1989, The National Board of Labor Protection initiated a project to develop the inspection practices. The second author of this paper acted as a researcher-consultant in this process (Virkkunen 1995). The following description of the change process has been based on the data collected and created during this project. At the beginning of the project a task force of inspectors was established. It was their goal to analyze the historical development of the labor inspectors' work, in order to recognize the historical roots of the present-day practices and to identify contradictions within the inspectors' current activity. The ensuing analysis showed that despite the increased, number of workplaces to be inspected and the rapid technological development that had taken place in production, the method and organization of the inspectors' on-the-job activity had remained largely the same. Each inspector was in charge of set of workplaces representing certain industry or being located in a specific geographical area. This set might comprise hundreds of workplaces. In addition, inspectors encountered novel technologies and new types of hazards at the workplaces. Nevertheless, the inspectors felt that they should inspect their "own" workplaces once each year, as in the earlier days, although this was really no longer possible because of the increased amount of workplaces to be inspected.
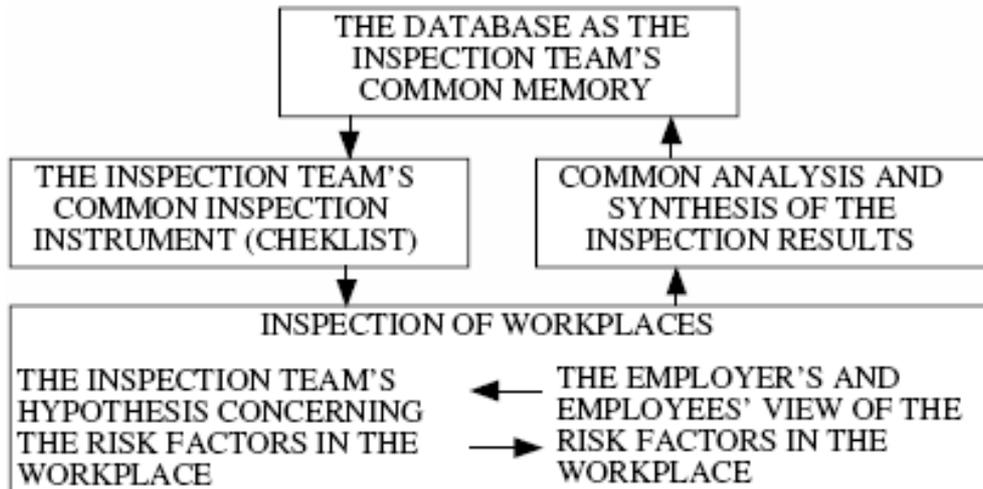
In its analysis, the task force identified two main problems calling for developmental measures. First, an inspector working alone had an over-extensive and increasingly heterogeneous set of workplaces to inspect. In addition, the inspectors' tools for analyzing the situation in the workplaces were partly inadequate in view of the rapidly changing safety problems. Secondly, because of the prevailing fixed division of labor among the inspectors, it was difficult to concentrate the inspections to important problem areas. The analysis and possibilities as regards the developing the inspectors' activities were discussed in the common seminar of both management and representatives of the inspectors. A recurrent theme in the seminar was the necessity of concentrating the district's work efforts on the most severe problems. In this seminar, a model for a new form of inspection work was outlined. It comprised new instruments that would enable the labor-protection districts and the inspectors to identify important general safety problems, analyze their causes, and plan interventions to change the situation.

Creating a new instrument for inspection work within the Uusimaa Labor Protection District: In 1990, a project was established in the Labor Protection District of Uusimaa to develop the new instrument for the planning of inspection activities outlined in the seminar to solve the central problems the task force had identified in its analysis. A new set of tools called the "System for Depicting the Field of Activity (SDFA)" was developed and tested. This system was based on a hierarchic three-tiered depiction of indices of safety problems within the district's jurisdiction area, allowing people to "zoom in" on important areas of interest and intervention. First, the project generated a general statistical description of the labor hazards, accidents, and occupational diseases as they existed in different branches of industry and different trades in the district's area. This first level of analysis made it possible to identify and delineate a set of important problem areas for a more detailed study. The second level of description focused on analyzing the occurrence, type and causes of the labor-safety hazards in these areas. The idea of the project group was that the third level of the SDFA would consist of a plan of intervention to remove the identified labor-safety problems. According to the first level analysis, labor safety was weakest in construction industry. In 1991, the labour district initiated a project team to develop a way to analyze the factors affecting labor-safety in construction industry. The task of the team was characterized in its report (19.9.1992) as follows: "First, maps describing the construction activity in Uusimaa are formed. Then the risk indices describing the working conditions are inserted in them in a suitable way. Once the possible aggregations of the indices have been found, the reasons for the problems will be clarified." The team developed a database for recording data about labor safety in different forms of construction and in different trades within construction industry to be used as a second-level tool of the System of Depicting the Field of Activity (the SDFA).

Työkalut, toiminnat, yhteistyö

THE DATABASE AS THE INSPECTION TEAM'S COMMON MEMORY

THE INSPECTION TEAM'S COMMON INSPECTION INSTRUMENT (CHEKLIST)

COMMON ANALYSIS AND SYNTHESIS OF THE INSPECTION RESULTS

INSPECTION OF WORKPLACES

THE INSPECTION TEAM'S HYPOTHESIS CONCERNING THE RISK FACTORS IN THE WORKPLACE

THE EMPLOYER'S AND EMPLOYEES' VIEW OF THE RISK FACTORS IN THE WORKPLACE

1. The database as common memory and organizer of inquiries. After finalizing the conceptual map of the construction industry, the team began to collect data of construction firms and -trades in the district's area. It analyzed also all of the available research results on labor safety in construction and recorded their findings in the database. The developing database aroused interest in the industry and a new type of network of cooperation began to develop between the district and the Confederation of Finnish Construction Industries as well as some large construction firms. These contacts also gave the group access to information that was not readily available in public statistics. At first, the team collected their information manually, but it soon became evident that the amount of data was too over-whelming to be processed in that way. Consequently, one of the team members developed an electronic database using the database features of the M.S.Excel spreadsheet program. All of the collected information was then accessible to the members, and it became easy to update the database. When the first gathering of information had been accomplished, the team thoroughly analyzed the results along with the help of other inspectors working within the construction branch. Then, they set new inspection tasks, as well as tasks for further analysis.

2. The extended hypothesis-driven checklist for inspections as a means of intellectualization of inspection work. Next, the team prepared a new instrument – a type of checklist for the inspections, within which the most important safety risks found in the data analysis were included. The use of the list became a means to verify and further develop the results of the data analysis. The deputy director of the Uusimaa Labor Protection District explained in an interview that the common preparation of a shared inspection instru-ment was very important. According to him each inspector had to interpret what the data collected in the common database meant in terms of the inspection work, and then relate it to his or her own experiences and conceptions concerning the causes of the hazards. The inspectors also began to systematically compare their observations. The collaborative analysis of the causes of hazards and the testing of hypotheses led the inspectors to assess and sharpen their views of the hazards' causes. Individual inspections got a new meaning as they were now connected to the use and development of the common database.

3. An altered script for inspection discussions as a means of stimulating a multi-voiced dialogue. The inspectors also changed the way they conducted their discussions during an inspection. Instead of only focusing on areas they individually regarded as important, they negotiated with the stakeholders of the workplace, concerning the specific important problems that needed to be atten-ded to. One-third of the discussion items were to be derived from the collected data, one-third from the inspector's experience, and one-third to be established at the workplace during the inspection. The inspectors who participated in the development of the new way of working reported that this new form of discussion gave them information about matters they did not even know existed. The inspectors' new approach turned the entire discussion into a dialogue, and led the inspectors also to recognize differences of opinion between the different actors in a given workplace.

4. The project report as means of synthesizing and drawing conclusions. After having inspected the selected workplaces and collected data, the inspectors summarized and analyzed their findings and discussed them with their colleagues. In the discussions, inspectors made further generalizations regarding their findings, and decided upon further targets by their inspection work. For example, it was found that occupational risks were often connected with the poor quality of construction machines used. These machines were often rented from equipment rental companies, who did not make sure that the machines they delivered were flawless. The district took action to encourage these firms to improve their quality control systems. It was also discovered that the commonly-used subcontracting contracts were outdated and did not take into account new labor practices. This led the inspection team to take the initiative to change legislation and the control practices within the subcontracting trade. These examples demonstrate how the object of the inspectors' work had changed. Instead of working only with individual workplaces site-specific safety defects, they now addressed the causes of safety defects and hazards on an industry-wide level in cooperation with other actors. When using the database, the inspectors noticed that the number of accidents was not a good indicator of labor safety because of its random variation. To overcome this problem, the labor-protection district let a research organization construct an assessment instrument that would provide a quantitative estimate of the state of the risk factors in work conditions that they had deemed important. The inspectors next began to collect standardized assessment data about working conditions within construction sites using this instrument. Through analyzing this data, they could now demonstrate to the top managers the relative position of their firm as regards the quality of its working conditions. This knowledge proved to be an effective incentive for the managers to correct the situation within their firm.

Case työpaikkatarkastus, SDFA

- yhteistyö laajeni sekä yrityksiin
  - *dialogisemmaksi, analyyttisemmaksi*
- että työtovereihin päin
  - *havainnot kirjataan tietokantaan -> yhteistoiminnallinen oppiminen*
- työnjako muuttui ja yhteistyömuodot kehittyivät

During this project, the second level of the SDFA was gradually constructed as a set of new instruments and social forms of collaboration. The new system was composed of four artefacts: 1) A conceptual map of the structure of an industrial field, with a corresponding database, 2) the hypothesis-driven checklist for the inspection of individual workplaces in the industry, 3) a new "script" for inspection discussions, 4) the project report about the results of the studied field of industry. The way in which these artefacts were interconnected was essential for the new form of inspection activity. Statistical data and knowledge from research on occupational diseases, accidents and wellbeing of workers in the industry were combined to the observations concerning defects in working conditions the inspectors had made in their inspections were recorded in the same database. This, therefore, served as a means of combining knowledge from different sources, and also served as a collective memory to which all of the inspectors had access.

The development and use of these new tools concretized and elaborated upon the vague idea of the new form of activity that was produced in the seminar. As the tools were taken in use, the inspectors' relationship to and interaction with the work places in the district's area became remediated and the object and motive of their work changed qualitatively. Instead of inspecting individual workplaces, they now analyzed the causes of lack of safety at work in different industries and created measures to improve labor safety. In this sense, the new set of tools formed an instrumentality, a complementary set of jointly-used instruments that combine to produce a new object and motive for the work, as well as a new mentality within the inspectors' community (see also Engeström & al. 1999). By defining a common object of attention and providing collectively used tools, the SDFA made the team a collective subject of both learning and productive work. The interdependencies between the new tools and actions are presented in Figure 1. In the following, an account is presented of how each of the artefacts were constructed and used during the experimental project focusing on the construction industry.

…

The instrumentality described above in effect changed the form of learning in and for work within the district radically. First, the SDFA provided an effective means for speaking about the inspections and planning the inspection activity. It made possible for the management and the inspectors in the Uusimaa District of Labor Protection to identify and describe objects of work for the inspection teams. After the first pilot team, similar inspection teams were established to analyze other areas and to plan and execute labor-safety interventions on them. Second, then new instruments informed both the design and use of the checklists and later the standardized assessment method used in the inspections. Third, it extensively broadened the scope of variation in workplace conditions, as well as safety solutions the inspectors used in identifying and defining important factors affecting labor safety and good solutions to the recurrent safety problems. Fourth, the database and the use of the computer sped the processing of data dramatically, and made new types of comparisons possible. This contributed to the further analysis of causes of safety problems and identifying effective safety measures in the specific branch of industry. Fifth, the sharing of new assessment tool and the data radically extended the community of actors involved in the same collective learning process by providing comparable data and a way to compare and exchange experiences between construction firms.

Case työpaikkatarkastus, SDFA

- Uusi instrumentaalisuus toi uuden tavoitteen ja tarkoituksen toimintaan: työpaikkatarkastuksesta rakentamistoimialan suurimpien työturvallisuusriskien analysointiin
- Paikallisista korjaavista toimenpiteistä laajennuttiin koko alan ennakolta ehkäisevään ohjelmaan
- Mochin kolmannen asteen muutos ja Argyriksen kaksikehäinen oppiminen: muutos pääasiassa arvojen ja ideoiden tasolla.

Conclusions

We suggested that learning in and for work can fruitfully be analyzed as the processes of joint creation of mediating artefacts or "collaborative retooling". This view is also instrumental in analyzing the relationships between the transformation of the system of joint activity and the learning of individual practitioners who take part in it. The analysis of the construction of a new set of tools within the labour protection district is a good illustration of this. The creation and implementation of the SDFA instrumentality changed the activity of all stakeholders profoundly supplying a powerful new system of inquiry and learning for the safety inspectors.

According to activity theory human activities have a systemic nature. When a new set of instruments is introduced, the community of collaborating actors, the division of labour and the forms of collaboration also change. What is even more significant is that, the new instrumentality also creates a new object and purpose for the activity. In the Uusimaa labor protection district, the object of work evolved from inspecting the specific working conditions and labor-safety problems of individual workplaces into analyzing the reasons for major hazards in particular industrial sector. Accordingly, the measures that were taken from the correction the recommendations to correct separate local safety defects in individual workplaces grew into industry-wide preventive measures. Both the creation of the quality management system for the machine-rental firms, and the initiative to reform the form of subcontracting contracts revealed collaboration both with other public authorities and firms, and ended up influencing the entire construction industry.

The transformation process we have described above can be characterized in terms of J. Bartunek's and Moch's (1987) conception of third-order change as well as in terms of C. Argyris' theory of double-loop learning (1993). Both theories envision higher-order learning and change as taking place primarily within the sphere of values and ideas. In the "third-order change" or "double-loop learning" that took place within the Uusimaa labor-protection district, the subsequent changes in values were an integral part of the general qualitative transformation of the inspectors' work, in which the creation of new practical tools played a decisive role.

The new instrumentality and knowledge produced also began to change the relationship of the inspectors and the representatives of the workplaces into one that was more dialogical and analytical. Instead of focusing only on safety norms and recommendations, the inspectors now also used the collectively developed hypothesis of important safety factors in their inspections. The inspectors were supposed to supply the information from their inspections to the data base for further analysis. The new script for the inspection discussion designated the inspectors to systematically encourage dialogue between the different parties of the workplace concerning the primary health hazards and risks. Both the construction of the database and the measures taken to eliminate the sources of the hazards broadened the collaboration between the inspectors and the other actors in the field. The new tool and the knowledge produced with it changed also the district's way of interacting with the management of firms. The use of shared tools also increased the possibilities of individual inspectors to learn. The collective formulation of hypotheses made it possible for the inspectors to learn more from their inspections of separate workplaces, and to systematically compare their findings with those of others. This analysis of a field enabled a new level of understanding: the analysis of the major hazards in the field, and the causes of such hazards. This new level was the beginning of a cumulative account, if not theory, about the development of labour safety in Finnish working life.

Learning by collective investigation

- ICT:n informatiivinen ja episteeminen (tietoteoreettinen) potentiaali korostuu: eri lähteistä ja oloista kerätyn tiedon vertailu ja havaintojen yleistäminen tuli mahdolliseksi - *learning by collective investigation*
- Analyysit esineellistyivät tietokannan
  - *työkaluihin*
  - *rakenteisiin ja tarkastusohjeisiin*
  - *raporttimalleihin*
- Artefakteista tuli *oppimisen kantajia* ja *uuden tarkastuskulttuurin levittäjiä*

This case emphasizes the "informative" and epistemic potential of computer-based tools. The database made it possible to collect, compare and generalize observations that were gleaned from different sources of information, and from scores of separate working places. As a whole, the process of depicting and analyzing an area resembles the kind ol learning typical to research work, although the inspections that brought the information to the analysis were ordinary inspections in the legal sense and led to corrections in individual work places: data was collected, a hypothesis was made, more data was gathered … and, finally, an analysis led to a report with conclusions and suggestions for measures to be taken. This can be characterized as learning by collective investigation. However, there was no ready-made vision or plan at the beginning of the project as to what an analysis of the field should include. The idea was developed through the design and testing of the artifacts, and the actions that were related to them. The achievements of projects and analyses of fields were objectified in the tools, structure and content of the database used, as well as in the checklist for inspections and the content of reports. The artifacts, therefore, became "carriers" of learning and transmitters of the new, rapidly evolving culture of labour protection inspection.