An Activity-Theoretical Method for Studying User Participation in IS Design

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Summary

Objectives: This paper aims to present an activity-theoretical method for studying the effects of user participation in IS development.

Methods: This method is developed through a case study of the process of designing a diabetes database.

Results and Conclusions: The method consists of a historical analysis of the design process, an ethnographical study of the use of the database, and researcher-driven interventions into the on-going user-producer interaction. In the historical analysis, we study particularly which user groups of the database have influenced the design work and which perspectives need to be incorporated into the design in the near future. An analytical model consisting of perspectives on local design, particular technology, and societal domain is introduced as a conceptual tool for this analysis. We also introduce the possibility of employing the historical analysis in guiding an ethnographical study of the user sites and researcher-driven interventions, which provide the participants with tools for improving their design process.

Keywords

Diabetes databases, activity theory, historical analysis, ethnography, interventions

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1. Introduction

One of the key challenges for information-systems development is to anticipate who the future users will be and what requirements the users and contexts of use will enforce upon the new IS. In this paper, we introduce a method for identifying future key users and those aspects of user needs that need to be taken into account in IS development. We base our suggestions on the principles of the theoretical framework of activity theory and on a case analysis of a development project of a diabetes database completed by a software company and clinical experts.

An important insight of participatory design has been the engagement of end users directly into the design process [1, 2]. User participation has proven particularly advantageous in those projects where technology has been customized for a particular organization. As experts of their own work, users are able to contribute to the design processes [3]. The importance of studying the users' work context has also been recognized in user-centered design methods, especially in ethnographically based methods such as contextual design [4].

However, modern information technologies pose challenges for the participation of all the relevant parties. An IS often has multiple user groups in various vocations and institutions. Even finding the representatives of all the central user groups may prove difficult. Formality, superficiality or bias are aspects of user collaboration that may constitute major barriers to the success of an IS.

In business literature, such methods as relying on advanced users, the so-called "lead users", have been introduced as viable alternatives to finding relevant collaboration partners [5]. These methods overlook users who do not stand at the cutting edge of technical development. Modern knowledge systems may have many groups of users that are not in any lead position in relation to new technology, but are nevertheless strongly affected by the new technology, and crucially involved in its future operation.

These "crucial" users may also pose a problem for participatory design efforts, as they may not be in a position to indicate any wish to participate in product development, and other groups of users may regard their contribution as insignificant. This is a real and practical problem for commercially oriented product development. Overlooking the needs of these invisible users may significantly restrict and even disable applications, such as groupware.

In the following, we shall introduce a method for technology analysis based on activity theory. This method may help in

1) delineating and giving a voice to the relevant participants and revealing the missing but crucial voices of the design process;
2) gaining a better understanding of the organizational and practice-based constraints that a particular technology will encounter in key user activities;
3) providing suggestions for critical improvements in IS on the basis of analyses and user feedback; and
4) organizing collaboration with critical user groups and product developers.

Our presentation is based on the research carried out on the Prowellness Diabetes Management System (PDMS) developed in Finland between 1996 and 2001. The PDMS is an Internet- and Intranet-based database that stores health information, such as the level of blood glucose of a diabetic. The health-care personnel of health

centers and hospitals use this information in various ways in the treatment of diabetes. We have studied the designing and user-collaboration of the PDMS since the beginning of 1999, and the PDMS has now been introduced into several health-care organizations in Finland. Simultaneously, the question of who will use the database has risen, as we shall show in the following. The data used in this analysis consist of historical documents, program versions, and interviews related to the PDMS, as well as of ethnographic data on the use of the PDMS and experiences of our researcher-driven interventions.

2. Activity Theoretical Perspective for Studying Design Processes

Activity theory is a meta-theory derived from the dialectical philosophical tradition and the theory of psychology [6, 7]. During the 1990s, applications of activity theory appeared in science and technology studies and human-computer interaction (HCI) [e.g. 8] [9-11].

Activity theory understands human activity as mediated practice. Historically and culturally formed means and artifacts, such as language and instruments, mediate an individual's actions [6]. For example, the actions of a physician in a diabetic clinic are, on the one hand, mediated by material artifacts, such as medical instruments and architectural design, and, on the other hand, by language and symbols, such as the care instructions and classification of diseases. According to activity theory, means and artifacts exercise a fundamental influence on an individual's work, thinking and learning. Furthermore, an individual's actions are socially mediated [7]. A diabetes physician's actions take place in the working community of a diabetic clinic that has rules and divisions of labor between workers from different occupational groups. The actions of one worker are meaningful only in the context of the activity of the whole diabetic clinic. The object of this activity is substantially different from the individual goals of workers. For instance, a goal of a physician is to diagnose and treat the patients who came to the clinic, whereas the object of the activity of a diabetic clinic is the treatment and prevention of diabetes in a large population. The activity of the diabetic clinic is, thus, defined as an artifact-mediated, collective and object-oriented activity system [12, 13].

When new significant technologies are implemented in an activity system, they generally require modifications themselves and, simultaneously, they may entail fundamental changes in the users' activity. This multi-faceted implementation process generally takes place only if the new technology is seen to enhance the current way of working or if it enables users to resolve inherent problems or contradictions within the activity. For example, in a diabetic clinic, the growing number of patients may not be manageable with the existing paper-based reception tools, which causes disturbances during work routines and calls for new tools in the form of electronic patient record systems. From an activity theoretical viewpoint, the implementation of significant technologies, such as a new IS, into working practices is hardly ever a smooth operation, and the process is vulnerable to many disturbances, use avoidance or misuse of the technology [11].

An on-going challenge for activity theory is to understand and analyze constellations in which several activity systems are involved in an organizational network. This is usually the case in the development and implementation of a new IS. The developer and user activities of a new IS are networked with other activities and have different historical layers of tools and social organization [12]. Activity theoretical research has developed a research approach of innovation networks that is able to analyze heterogeneous networks of activities [14, 15]. This approach combines the activity theoretical framework with the ideas of constructivist sociology of science and technology [16-18]. A technological project is analyzed as a collaborative network where the resources and know-how of the participating activities are complementary in regard to the product that is being jointly developed. The product is called, in activity theoretical terms, a shared object of an innovation network. The emphasis lies on the analysis of the contributions of the participants in different phases. The history of each institutional participant is analyzed in order to illuminate its interest in and resources for contributing to the design work. In activity-theoretical terms, the artifact under development is understood as the object of the developer's activity and a potential tool or means in the activity of its users.

Developmental work research is an application of activity theory to study change and work in organizations [e.g. 19]. In short, it is based on collaboration between the employees and researchers in modeling historical conditions, current problems and possible future directions, and launching developmental projects based on appropriate analyses. Methodologically, developmental work research moves in cycles of research and development. In the first phase, a historical analysis is conducted to find the developmental contradictions that set conditions for the current and future development of the activity under study. In the second phase, current problems are mapped, usually by ethnographic observation. In the third phase, observations are related to historical understandings and future expectations in order to create a model for new organizational solutions. After this, the new model is gradually improved and implemented. The original analyses may be revised on the basis of the experiences, and, if needed, new development actions may be taken [19, p. 970].

We suggest an activity theoretical research framework that grows out of the above-mentioned research approaches of innovation networks and developmental work research. First, we analyze the collaborative network of developer and user activities of the PDMS diabetes database in order to illuminate the interests and capabilities of participant actors. Second, we propose developmental research that proceeds through the interrelated phases of historical analysis, ethnographical research and researcher-driven interventions. Third, and most importantly, our research perspective is instrument-oriented rather that activity-oriented. We are not interested in activities, per se, but how new IS and similar

instruments are developed and used within these and ancillary activities. This instrument-orientation allows us to associate the local product development project of the PDMS with other design projects and user sites of similar instruments. It also enables us to demarcate the scope of different data collecting methods and combine research results achieved by them. Our scheme is the following:

1) Historical analysis of the activities relevant to the current and future IS use seeks to determine:
   a) what resources and interests have been incorporated into the IS project concerned (in activity theoretical terms, the analysis of the process of constructing the shared object);
   b) what is the history of developing the tools that the current IS replaces in user activities (in activity theoretical terms, the analysis of the dynamics of developing tools for user activities); and
   c) what are the major developmental trends in targeted user activities in the recent past and near future (developmental conditions for user communities)?
2) Focused ethnography is being conducted on how the technology fits into key work practices identified by the historical analysis. Attention is paid especially to features of work that would cause bottlenecks, disturbances and contradictions if the IS were in use.
3) Research-driven interventions in the form of seminars are organized where both key users and developers are present. Research results are used as tools to promote discussion and further development of the IS.

3. Historical Analysis of the Design Work of the PDMS

3.1 The Local Design Process of the PDMS

As we wished to study user collaboration in a design process, we traced the user participants and their contributions to the design process of the PDMS historically. The database project was initiated by medical researchers who desired to achieve a statistical tool for retinopathy at the University of Oulu, Finland, in the early 1990's. By the year 1996, a local diabetic clinic and a software company, Prowellness Inc., had joined in the design collaboration. The collaboration was based on complementary resources: The medical personnel provided the expertise in their work practice and information contents of the database, while, reciprocally, the software company brought in their programming skills and experience with www-applications. Co-design was accomplished in discussions, e-mail exchanges, iterating paper drawings and prototype program tests. During the years 1998-2001, the participants enrolled a number of hospital clinics into the collaboration network in order to incorporate the requirements and the perspective of specialized diabetes care into the program. What caught our attention at this stage of our research was that all the medical participants were diabetes experts and enthusiasts. Some of them told us about their previous attempts to develop similar databases. We became interested in finding out what it would mean if the requirements of one of the major groups of users, non-specialized GPs and nurses, were provided by the experts. Moreover, if there had been previous design projects, what happened to them and could perhaps a similar dynamic be prevailing in those projects?

3.2 The Analysis of the Technological Lineage: a Graveyard of Abandoned Technology

To gain a better grasp of the dynamics at play in the development of the diabetes databases, we decided to undertake a comprehensive mapping of all the diabetes database projects in Finland. To our surprise, our interview round revealed that in 11 out of 20 hospital districts in Finland, all together 21 programs had been created since the mid 1980's (excluding PDMS). Only four of those programs were still in active use. In none of the cases had the use proliferated beyond the care unit where the program was developed. Alas, these projects devoted to developing and maintaining databases were not random or without effort: in 13 cases the program was used more than three years, yet only one or two of the programs had "lived" long enough to yield genuine benefits for patient reception or research. We also learned that the projects had been mostly unaware of the other similar efforts. The two strongest findings, however, had to do with the way the programs were developed and withdrawn. Even though almost all the design projects had been collaborative and included doctors, nurses and often also computer scientists, the projects were dominated by an enthusiastic expert, whose research and management interests became strongly incorporated into the program. Second, we found that the most common reason why these programs had ended up in "the graveyard of abandoned diabetes databases" could be best termed "poor usability". By this we mean that the program was too complex for daily practice; the operation of the program, or the filing and updating of patient data was too slow and tedious for the pace of reception work. It seemed that the information content, which the experts had desired, turned out to be in a strong contradiction with the requirements of daily use by the other personnel.

3.3 The Societal Domain of Diabetes Care

To clarify whether the above-identified patterns of use and design might match the PDMS project, we deemed it necessary to trace the changes that had taken place in diabetes care since the mid 1980's to the present. In activity-theoretical terms, we looked at the major developmental trends in relevant user activities in the recent past and near future. During the 1980s and 1990s, public diabetes care had been allocated to three sectors in Finland: first, to a special ward, available in central hospitals for complicated cases such as acute juvenile-onset diabetes; second, to municipal

diabetic clinics conducting the advice and treatment of acute adult-onset diabetes; and third, health centers engaged in the treatment of non-complicated patients. Citizens sought treatment from the treatment facility specialized in their specific type of diabetes. By the turn of the millennium, this public health-care structure had started to change. The GPs working in health centers were given "population responsibility", which meant that they had to manage all the illnesses of a certain population in their district. As a consequence, many routine tasks formerly conducted in diabetic clinics were now conducted in health centers. This indicated that in the treatment of diabetes, and especially in recording the treatment data, the role of non-specialized physicians and nurses in health centers was decisively increasing.

4. From Historical Analysis Towards Future Action

In developmental work research, a historical analysis provides orientation for future action [14, 20]. The results of a historical analysis can be further elaborated into a developmental hypothesis to be presented to key participants to facilitate the expression of different points of view. Typically, this takes place in researcher-driven intervention meetings that allow for different points of view to be expressed and for the rejection, adjustment or confirmation of the hypothesis [14] [cf. 21].

Our historical analysis suggested that diabetes researchers and specialists in primary or secondary care would probably use the PDMS and be satisfied with it in their work. Their requirements had been carefully incorporated into the PDMS, and their desire for this kind of application had been indicated by the large number of the previous database projects. At the same time, neither the staff in normal health care centers, nor diabetics themselves, were involved in the PDMS project or in any of the previous database projects. However, our analysis of the societal domain of diabetes care clearly indicated that the structural changes in the health care system were rendering their work radically more crucial for any database in the future. There are common denominators in the reasons why previous projects failed: the enthusiastic experts and their interests dominated the design process; the requirements of the specialized care and research determined the program, and, yet, intended major user groups of normal GP's and nurses were excluded from the design. The missing voice of health center personnel is a potential threat to the success of the PDMS, which may well suffer the fate of its predecessors. In its condensed form, our developmental hypothesis was the following: "The requirements of the user activity of the GPs and other personnel of health centers must be recognized and incorporated in the design of the PDMS."

This developmental hypothesis had two implications for our research. First, it provided a backbone for our interventions and further discussions with our research subjects (see Section 6). Second, the condensed hypothesis helped us to focus our ethnographical field study on gaining a more extensive understanding of the differences between the specialized and non-specialized diabetes care.

5. Launching the Ethnography of the Use of the PDMS

In November 2000 and March 2001, we conducted an ethnographic field-study in two primary care settings: the diabetic clinic of the city of Oulu and the health care center of Paltamo. In 2001, the Paltamo health care center was the first non-specialized unit to begin to use the PDMS. The use of the PDMS could be compared with that at our Oulu site, a diabetes treatment unit that had been an active development partner and user of the program for over three years. All together, we observed and videotaped some thirty patient receptions in which the PDMS was available or used by physicians, nurses, and assisting nurses.

The most important findings regarding the work routines can be summarized as follows. First, the PDMS was used together with a wide range of mediating artifacts, such as laboratory and appointment databases, electronic health records, paper documents, diabetes sheets, as well as patients' own notebooks. Each staff member used this repertoire in a different manner and order. While some physicians filled in the PDMS first, and then various other papers, others filled in the papers first and entered the data in the computer only after the reception. Nonetheless, all the people we observed struggled to get the mass of reading and recording done during the reception. They had developed clever routines for handling the data during intervals allowed by, for instance, blood-pressure measurements, but it was still common that data had to be filled in at the end of the reception or even at the end of the day. Contrary to our expectation, the PDMS software did not ease the interaction between humans and artifacts, but made it more difficult. Not only was the use of highly sophisticated paper "diabetes sheets" faster than the SW, per se, but, in addition, in the current transition to computerized tools, most of the data also had to be booked twice, either to the PDMS and the other papers, or to the PDMS and some other electronic health record. We also learned that because individual patients are treated at a number of locations, this double booking will persist at least until all the units within a hospital district had moved their existing records into the SW. This will take years, and even at that point the documents would be replaced by various kinds of medical software.

Our second surprise was the extent to which the patients participated in the entering and interpreting of medical data about themselves. The PDMS significantly facilitated this, as patients were able to discuss the graphical illustrations of their treatment balance and manipulate the data variables on the screen. The patients were, on some occasions, the only ones who had the complete record of their treatment, as there were numerous breakdowns in the information flow between the care-units in hospital and primary care.

The key differences between the two sites did not consist so much in the way the

reception of a diabetic patient was carried out, but rather in the relative importance that the diabetes reception had to the overall work. While the PDMS created extra work in both settings, only the staff in Oulu expected, that future benefits would justify the use of the program. In contrast, the Paltamo staff clearly expressed the opinion, that the promise of the future benefits would not compensate for the inconveniences of its current use, as only a fragment of their patients were diabetic. Moreover, the amount of devotion that had to go into the learning and maintaining the skill of the use of the program was significantly better in Oulu, where the program was used in all their receptions. In Paltamo, a diabetic might not appear even once a week.

While these results confirmed and added details to the findings of our historical analysis, they also provided some clear suggestions for further design improvements. In the health-center practice, the database should be simpler and more closely incorporated into existing databases, whereas in a diabetic clinic, the database can be more complex, comprehensive and autonomous. Since the double registration seems to last a relatively long period of time, the PDMS should diminish this hindrance by offering compact and comprehensive printing options (replacing paper documents), and enhancing connections to existing databases, such as laboratory databases (diminishing typing). In general, any measures to ease the work in the filing and reading of the PDMS data in health-centers are crucial, including the extensive use of defaults etc. As long as the system remains untailored for the use of health center personnel, its expansion into those user environments will prove difficult. This problem may even conceal the potential of the program to function as an information channel between the primary and specialized health care.

6. The Challenge of Researcher-Driven Interventions: Organizing a User Seminar of the PDMS

Both our historical analysis and ethnographical research produced opportunities for researcher-driven interventions. We saw our developmental hypothesis as crucial for the concurrent design process, and, in September 2000, we organized a user seminar jointly with Prowellness Inc. All the PDMS user sites and some potential new users were present. We gave a presentation of the preliminary findings of our historical analysis and presented our developmental hypothesis for discussion. We emphasized the risk that the GPs and nurses of health centers were perhaps not interested in becoming users of the current program and stressed the importance of especially considering their needs in design. We asked the participants to comment and make suggestions on the actions that should be taken.

The discussion was dominated by the users who had been active in the design process. Their comments tended to focus on how to convince, educate or enroll the GPs in using the system. The comments took, on one hand, a normative stance: the GPs should use the database, owing to the obvious advantages to the patients, and "no more simplifications can be made, as all these things should be checked, anyway" (diabetes clinician 1). The participants were hopeful about the attitude of the GPs: "I think they will see the benefits"; "…now that the computers are coming into a more general use in the city of Oulu, I believe that the health centers will start using the system" (diabetes clinician 2). On the other hand, the participants commented on the constraints of the system, which hindered the GP's use of such programs: "Only 5-10% of their patients are diabetics, and the GPs already have other medical records to keep. So it is critical that they don't need to maintain two different databases" (diabetes clinician 3). These issues were discussed only on a general level.

Overall, the seminar participants avoided the question of what would happen if the health centers did not use the system as the specialized and centralized diabetes care hoped for. The only direct reaction came from the two users who expressed their support for our suggestion to enroll the GPs and nurses of health centers in development work. The company wanted to see our concerns as already incorporated. They claimed that the simplification of the program had been going on ever since the early prototypes, and that the company was currently building links between the existing electronic patient records and the PDMS.

For us, the user seminar confirmed some of our previous findings. The company and major users did not possess sufficient first-hand know-how about the needs and daily practices of health centers. Suggestions for possible incentives to health center personnel, such as shared care and screening of risk patients, arose primarily from the interests of the specialists. In wider terms, the discussion during the user seminar may reflect tensions in the transition currently taking place in the development of the PDMS. The program has recently been made available for a number of health care centers, but its use has not been established yet. Previously, the company has relied on the strategy of giving the program to user sites and then enrolling the new users into giving feedback and suggestions for further development. This way of working may, however, prove insufficient when the PDMS is used in regular health care centers. They do not have as great an interest in the program as diabetes specialists, and if the current version does not fit their work routines well enough, they may never end up using it.

The results of the user seminar motivated our ethnographical research of the PDMS in health center practices. In the spring 2001, the results of our ethnographical research were discussed in two small meetings with the representatives from our user site, the diabetic clinic of the city of Oulu, and from Prowellness Inc. With the personnel of the diabetic clinic we discussed the practical findings of the ethnography. We also discussed the upcoming use of the PDMS in other health centers of the city. Proper training in the use of the pro-

gram was seen as crucial in the expansion of its implementation in the city district. In the meeting with Prowellness Inc., its representative drew the same conclusion. The health center practice was not thought to be demanding any major changes in the program content or involvement of the health center practitioners in the design. These conclusions contradicted our developmental hypothesis and the results of our ethnographical research.

Why did our interventions have such limited success? By far, the major reason lies in the network dynamics of the PDMS project. We entered the process relatively late, and our interventions coincided with a phase where the company regarded the product to be more or less ready and had radically reduced its collaboration with user-partners. This short-circuited our attempts to broaden the collaboration network. Yet, we hope to have lowered the threshold for such action, if the program fails to proliferate into health care centers in the future and the development partners come to see this as an urgent problem.

7. Conclusions

We have described an activity-theoretical method for studying the effects of user-participation in IS development. The method was developed through a case study of a design process of a diabetes database. It consisted of a historical analysis of the design process, an ethnographical study of the use of the database, and researcher-driven interventions in the on-going user-producer interaction.

Three foci for the historical analysis were suggested: the local design (construction of the specific object), the technological lineage (the development and use of similar tools) and the societal domain (the developmental conditions of user communities). In the PDMS case, the clarity of the patterns revealed by our historical analysis surprised us: the collaboration dynamics in local design, the graveyard of previous attempts, as well as the clarity of societal change. It particularly showed the disadvantages of entering into collaboration only with one type of user group, even if the collaboration proved otherwise productive.

The results of the historical analysis sharpened our focus and gave us guidelines for our ethnographical study of user sites. In the PDMS case, the ethnographic study provided us with a detailed understanding about the structure of the work and associated artifact use. This was important in confirming the findings and suspicions arising from our historical analysis. Some immediate design suggestions arose from this study. Nevertheless, we think that the major benefits would have lain in orienting future design actions if the fieldwork had been conducted by actual designers, or if we had actively participated in the future development.

Finally, the historical study provided a basis for our researcher-driven interventions. Intervention seminars were organized and our research results were discussed with the user and producer parties. In the PDMS case, our late entry and the collaboration dynamics of the network hampered our attempts to broaden the collaboration. Nevertheless, the interventions remained a fruitful way of gaining understanding about these dynamics.

How generalizeable are these findings? The development of diabetes databases in health-care practice is a specific research object and has unique features in comparison with other IS environments. We suggest, however, that a historical analysis of local design work is important in every IS research project, as it helps to identify which participants have been incorporated into the design work in its different phases, and what kind of resources, know-how, and perspectives they have brought into it. This explains the interests of participants and choices they make in the design process. The absent but still crucial users of the IS may be detected by studying other efforts of developing tools for similar purposes and developmental trends taking place in the societal domain. It may be unreasonable to expect to obtain such clear historical patterns in all cases. Nonetheless, the key in our thinking is that the historical analysis orients ethnographic study and interventions. If a historical analysis does not "make a difference that makes the difference", more emphasis will be placed on the latter steps in the methodology, which in the PDMS case served mainly to complement our historical findings. Rather than being a "data-machine" for every case, our method provides an empirically and theoretically grounded set of guidelines that should be modified and developed further for other cases.

References

1. Greenbaum J, Kyng M, editors. Design at work, cooperative design of computer systems. Hillsdale (NJ): Lawrence Erlbaum Associates; 1991.
2. Schuler D, Namioka A, editors. Participatory design, principles and practices Hillsdale (NJ): Lawrence Erlbaum Associates; 1993.
3. Ehn P. Scandinavian design: on participation and skill. In: Adler PS, Winograd T, editors. Usability, turning technologies into tools. New York: Oxford University Press, 1992, pp. 96-132.
4. Beyer H, Holzblatt K. Contextual design, defining customer centered systems. San Francisco: Morgan Kaufmann Publishers; 1998.
5. Hearstatt C, von Hippel E. From experience: developing new product concepts via the lead user method. A case study in a "low tech" field. Journal of Product Innovation Management 1992; 9: 213-21.
6. Vygotsky LS. Mind in society, the development of higher psychological processes. Cambridge (MA): Harvard University Press; 1978.
7. Leontjev AN. Activity, consciousness, and personality. Moscow: Progress Publishers; 1978.
8. Engeström Y, Escalante V. Mundane tool or object of affection? The rise and fall of postal buddy. In: Nardi B, editor. Activity theory and human-computer interaction. Cambridge (MA): MIT Press; 1995, pp. 325-73.
9. Nardi BA. Context and consciousness, activity theory and human-computer interaction. Cambridge (MA): MIT Press; 1996.
10. Miettinen R. Object Construction and networks in research work, the case of research on cellulose degrading enzymes. Social Studies of Science 1998; 28: 423-63.
11. Hasu M. Constructing clinical use, an activity-theorectical perspective on implementing new technology. Technology Analysis & Strategic Management 2000; 12: 369-82.
12. Engeström Y. From individual action to collective activity and back, developmental work research as an interventionist methodology. In: Luff P, Hindmarsh J et al, editors. Workplace studies: recovering work practice and informing system design. Cambridge: Cambridge University Press; 2000.
13. Engeström Y. Collaborative expertise, expansive learning in medical work. Cambridge: Cambridge University Press; in press.
14. Miettinen R. The riddle of things, activity theory and Actor network theory as approaches of studying innovations. Mind, Culture, and Activity 1999; 6: 170-95.

15. Lehenkari J. Studying innovation trajectories and networks, the case of Benecol margarine. Science Studies 2000; 13: 50-67.
16. Latour B. Science in action, how to follow scientists and engineers through society. Cambridge (MA): Harvard University Press; 1987.
17. Bijker WE, Law J, editors. Shaping technology/vuilding Society, studies in sociotechnical Change. Cambridge (MA): MIT Press; 1992.
18. Bijker WE, Hughes TP, Pinch TJ, The social construction of technological systems, new directions in the sociology and history of technology. Cambridge (MA): MIT Press; 1987.
19. Engeström Y. Activity theory as a framework for analyzing and redesigning work. Ergonomics 2000; 43: 960-74.
20. Engeström Y. Learning, working, imagining, twelve studies in activity theory. Helsinki: Orienta Consulting; 1990.
21. Dewey J. Logic: the theory of inquiry. In: Boyndston JA, editor. The later works of John Dewey, volume 12. Carbondale: Southern Illinois University Press; 1986, pp. 108-20.

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