Adjusting the Design Target of Life-Cycle Aware HCI in Knowledge Work: Focus on Computing Practices

Heljä Franssila, Jussi Okkonen

Adjusting the design target of life-cycle aware HCI in knowledge work: focus on computing practices

Heljä Franssila, Jussi Okkonen

University of Tampere, School of Information Sciences
Kanslerinrinne 1, FIN 33014 University of Tampere, FINLAND
{helja.franssila, jussi.okkonen}@uta.fi

Abstract. The goal of this work-in-progress paper is to consider the utility of current theoretical and methodological HCI and work analysis approaches in understanding and supporting knowledge workers in their coping with contemporary computing ecosystems at work, and pinpoint the limitations of the design target formulation in current HCI approaches. The new approach discussed is to focus the design efforts, instead of technical artifacts, into the observation, understanding and development of *computing practices* as a resource for knowledge work. Alternative, emerging conceptualizations and methodological options to study and advice the development of everyday computing practices in knowledge work is proposed.

Keywords: knowledge work, work analysis, computing practices, design, use life-cycle, data collection methods

1 Introduction

When considering both popular and scholarly discussion related to the most prominent determinants of work wellbeing and performance of contemporary knowledge workers, certain themes recur with accelerating frequency. Information overload, interruptions, multitasking, work fragmentation, always-on availability and the growth of the computing ecosystem versatility are characteristics of everyday work potentially challenging the knowledge worker's sense of control in their work. All of the above mentioned challenging phenomena are more or less related to interaction between the human and the computing environment. Computing environment stretch the operational limits of human attention, concentration, memory and self-control, be it subjectively experienced or objectively measured. The change rate of the environment of knowledge work is high. New ways to do and organize work combined with constant evolution of computing environment shape the means of maintaining sense of control and coherence all the time. Understanding the relations between the characteristics of computing environment and work wellbeing are not yet very clear.

The goal of this conceptual work-in-progress paper is to consider the utility of current theoretical and methodological HCI and work analysis approaches in under-

adfa, p. 1, 2011.

standing and supporting knowledge workers in their coping with contemporary computing ecosystems at work. Special focus is to observe how the everyday *computing practices* of the knowledge workers is addressed in the HCI and work analysis literature. We examine how the target of design is conceptualized in HCI and in certain approaches of work analysis, and how the positioning of design target may limit the expected results of work practice design and development efforts. After that we propose an extension of the design target of HCI that we find relevant when analyzing and developing computing practices in knowledge work. To ground the feasibility of the proposed approach we discuss rather new data collection methods which serve the goals of the extended target of design in HCI. We also acknowledge certain concepts from contemporary HCI and work analysis as applicable in the newly framed HCI in work settings. The discussion is motivated by our research project related to the defining and developing information ergonomics in knowledge work settings.

2 Computing work practices in HCI and work analysis

The goal of HCI has been at least traditionally to understand, design, evaluate and implement interactive computing systems for human use. In work settings one of the more detailed goals has been enabling more productive work practices and processes [1]. HCI in work settings seeks to make work (and life) involving computing fit better with plethora of human characteristics. The time-scale of design and research approaches in HCI have lately been extended to cover also stages after the technical implementation and adoption of technologies. These stages are conceptualized as appropriation, configuring and design-in-use (see e.g. [2-4]).

The design goal of HCI - more successful interaction and use - however seems to be focused or framed in a certain way both in HCI research and practice. When considering design and development efforts, it seems that while the methods of practical HCI design aim to target *interaction*, most of the efforts of the design materialize as modified designs of the *technical applications and devices* - the computer side of the HCI concept dyad. Users and their activities, emotions and even biofeedback are shadowed, recorded, analyzed and modeled, but the implications and conclusions derived and the practical design recommendations and requirements given typically address only the computer or application side, not the human user side. This tendency can be observed for example in the literature reporting the application of participatory design in real world development projects. It is practically impossible to find a reported participatory design project related to the application of information technology, where the development effort would not have been motivated by an organizational, predetermined need to plan, develop, purchase or modify the information *technological* solution per se. Projects having as a core design goal to enhance and develop the utilization of *existing* technologies practically does not exist. Even the research interest to study the realization, details and lifecycle of IT use after system deployments in organizational contexts is very scarce (the rare exceptions are [5],[6],[7],[8],[9])

There's also strong tendency to try to model how the users will use the technical artifact in the future, and to equip the artifact with technical affordances that potentially could fulfill emerging user needs and preferences (e.g. infrastructuring proposed by [10]). When considering the quality of long-term HCI from the human side, this is somewhat desperate approach: majority of the development efforts stop when the application is released and not fundamentally changed any more (customization and tailoring functionalities are considered as features of mature application). The computer side of the relation is left practically untouched after the release of the application. After this, there's only the human side of the relation, which can be influenced.

One potential reason for the practical non-existence of approaches which seek to develop the user behavior in longer term and the human side of the HCI dyad is that underlying nearly all examinations of human-computer interaction pitfalls is the unexpressed assumption, that if the interaction fails, the weak or even evil party in the interaction process is the computer, not the user or his/her activities. Characteristics of the computing solution do not fit e.g. the work practices of individuals and groups. It is the technical solution, which needs to be fixed and which requires changes, not the human or the human computing practice. The evolving human computing practice is something that is often left to develop on its own. Often even unrealistic "abilities" are expected from the technical applications, like alertness to user's errors and capabilities to steer and advice user while he or she is computing whatever goals or tasks at hand.

Another characteristic of the conventional HCI is that it might be interested in studying interaction between human and computer in rich, "wild" computing ecologies, but typically design implications and recommendations derived from observations concern only a limited facet of the computing ecosystem the user operates, namely certain service, application or feature. The chains of real world computing activities, where the computing ecosystem is in versatile ways utilized by the user, are not considered as a development target per se. However, we believe that the human user can and will do a lot to influence the quality of HCI phenomenon after the deployment, during the life-cycle of interaction with the computing ecosystem, even though no iterations or considerable changes to the technical computing ecosystem (software and hardware) are deployed anymore.

3 Unknown practice of knowledge work

Contemporary knowledge work and knowledge workers are very often characterized as creative, boundary less and free. Knowledge work and workers are often pictured as contrary to the factory workers whose manual work is highly structured, repetitive, without freedom to choose the best method, place and time for the work execution. Knowledge work, individual knowledge worker and especially workers' concrete macro and micro working and computing methods and practices are most often left untouched and unexplored – both in practice and in research. Working methods, habits and practices of knowledge workers seem to be a great black box in the research literature. Even the knowledge workers themselves can be reluctant to scrutinize about their working methods [11]. Thomas Davenport [12],[13] is one of the rare scholars who have questioned this immunity of the knowledge work and knowledge workers' working methods and practices for research scrutiny.

However, several aspects of ICT intensive knowledge work settings have been actively studied. The new mobile and distributed nature of the work, which reduces the constraints related to the place and timing of the work execution, has been extensively explored in the research literature [14]. Especially the factors shaping the way the distributed work is executed in a team level are scrutinized. It is proposed that at least the nature of team task, team structure, team work processes, workplace (physical, virtual, social), and organization contexts mould the practical performance of the work [15].

If there is a goal to develop any practical activity, there needs to be some visions what the desired qualities of the more developed activity are, and how the development can be observed and confirmed. When considering development of knowledge work, there have been several attempts to collect and define key success factors of knowledge work in general. One way to classify the factors is divide them into input, process and output factors. Among the success factors related to the knowledge work process are management of individual work, organization of work, setting of goals, timeliness, quality of work related interaction, knowledge acquisition and sharing, team structure and continuous learning. New technologies are seen as input level factors of knowledge work process [16]. Studies exploring the impact of new technologies to the knowledge work often identify the change enabled in the organization of work, but do not elaborate the actual nature or principles of that organizing – organization of work is often undifferentiated dependent variable, e.g. [17]. Concrete practices of organizing individual knowledge work stay obscure.

The current popular and also academic concerns of the knowledge worker wellbeing and effectiveness relate to still controversial effects of work fragmentation, high amount of interruptions and multitasking [18],[19],[20]. Research conducted in real world work settings has so far been able to give evidence mainly about variable, subjective wellbeing and effectiveness responses to these new features of knowledge work. However, these new features relate to a central dimension of work practice, namely to the organization and management of individual workers' tasks. The information and communication intensive work environment where the knowledge workers are exposed to rich and frequent stimulus clearly has an impact on minute-to-minute organization of the tasks. Again, research exploring the actual organization and coordination of individual knowledge workers' task load both in macro and micro level is surprisingly scarce. Issues of organizing and coordinating tasks are detailed extensively when collaborative group work processes are studied in CSCW literature, e.g. [21], but the studies often concentrate to follow accomplishment of a certain task flow executed by a distributed group e.g. [22]. Less is known about the task organization, self-coordination and task management principles and conventions of an individual knowledge worker [23], where the individual worker organizes several personal subtasks, delegated and derived from group task flows.

It seems that continued, post-deployment *IT use* as one facet of knowledge work and its development per se in work contexts is not a prime interest of any HCI approach. The studies of appropriation, configuring and design-in-use address the rather long post-deployment period of use life-cycle, but the main interest is to understand and advice the design of deployed *technologies* or technical means to enable their technical adaptation. The detailed paths of computing activities of a user across different applications and the development potential during the life-cycle of everyday computing practices are considered rarely. We propose, that understanding computing micro-practices in detail is central when considering the work efficiency and control experiences of end-users, and when trying uncover the phenomena like the experience of information overload and interruption. HCI and work analysis seems to resist or at least hesitate to formulate human *computing practices* as a goal of design per se.

4 Promising conceptual and methodological approaches for more life-cycle aware HCI in knowledge work

In order to narrow the gap between the goal of enhancing knowledge work and the quality of HCI in real life computing environments there is a need for conceptual tools to effectively approach and characterize both knowledge work and computing. The nature of knowledge work and factors shaping its' execution can be conceptualized in several ways. When characterizing knowledge work practices, more empirical research concerning "*how"* the everyday work of *individual* knowledge workers in executed is needed.

Certainly, classical work analysis concepts from the fields of human factors and HCI are useful when characterizing knowledge work. The concepts of goal and task are needed when observing what is done in knowledge work. In knowledge work most often the task is to produce something intangible out of intangible, namely information and knowledge. That is why it is sometimes even for knowledge workers themselves a bit hard to describe, of what kind of tasks and subtasks their work contains [24]. They might take care e.g. about maintaining productive client accounts, make different kinds of designs, plans and decision, and create various kinds of information artifacts.

Basic, rather descriptive concepts of job design could be considered, when trying to detect the patterns of individual knowledge work organization, be they planned or unplanned. Observing the everyday conventions of task load planning and scheduling, sub-tasking of one's responsibilities, task ordering, task prioritizing and management of coworker interdependencies could reveal lots about the practical realities of work organization in knowledge work. These observations could be contrasted with the expressed principles and targets knowledge workers have considering the control of their everyday work organizing and further with the potential effects the nature of the information environment have on the actual conventions.

In several HCI design approaches targeted towards developing artifacts to support work and work processes, the key analytical concepts involved are the user, role, goals, tasks and some kind of flow of events. For example the five work models of contextual design – flow, sequence, artifact, cultural and physical – detect several distinctive characteristics shaping the execution of work [25]. However, these models are targeted for understanding only certain tasks processes, with the aim of aiding the design of an artifact supporting those particular task processes. Work modeling in contextual design does not try to detect the point of view of a particular worker executing the task, but rather the processes that can be executed by any worker in a domain under the study. It is typical for task analysis applied in HCI design methodologies that the focus of analysis is either a particular task, artifact use or task/work flow, but not the individual user or worker as the more or less goal oriented integrator of all the resources and constraints provided by the computing environment, e.g. [26]. When the target is to enhance the HCI and the computing practices applied across many, even concurrent tasks, new ways to conceptualize the work execution and its determinants is needed. What matters, is what happens to an individual in a given, complex environment. Thus there is need for concepts to characterize the information environment and events in there.

When considering the understanding and the systematic development of computing practices at work, the turn to the practice and the turn to the wild [27] in HCI provide promising conceptual tools. Detailed ethnographic descriptions of work practices may serve appropriate grounding for unfolding of actual computing conventions and methods knowledge workers apply. In the studies conducted in the tradition of workplace studies [28] and distributed cognition [29] have provided vivid accounts how users and communities in workplace enact to total work environment and its computational and representational resources. In the practice tradition there is emerging quest for not only analysis but also for systematic development and reforming of social practices when applying technology into work [30]. The cognitive work analysis is explicitly concerned about how HCI can enable designing for worker adaptation [31].

A sample of analytical concepts from the IS can also prove powerful when descriptions of work to enable systematic development of computing practices in work are pursued. The application of the concept of *computing habit* in IS research has devoted more attention to the human side of HCI dyad, even though so far the approaches have mainly been explorative and descriptive, not design or development oriented [32]. Computing habits are controversial when considering efficiency of human-computer interaction. Habits make any activity effortless and fluent, but at the same time they are very sticky and conservative, hindering possibilities to learn new, enhanced methods and practices [33].

Profiling basic, industry-independent knowledge work processes and knowledge work types has been provided scantily, but the account of Davenport makes an exception [11]. Davenport tries to formulate a set of basic working modes of knowledge workers, and presents a typology of knowledge workers. In addition, when trying to find a unit of work to serve as analytical basic element for characterizing knowledge work practice in meaningful granular level, the concept of *ensemble* is proposed. Ensembles are units of work which are concrete enough to be distinguished from thick account of work, and conceptually they lay between the unit of action and the unit of activity [34].

Promising conceptual tools for development oriented analysis of knowledge work, knowledge work practices and computing practices in work can be found from rather unexpected direction. In the context of lean management philosophy and development practice, treatment of information as a resource of work process and practices has emerged. Powerful categorization of different kinds of wastes in lean management approach is applied to the analysis of work practices which involve manipulation of information. In lean information management four categories of dysfunctional information waste events are conceptualized: information excess, lack of necessary information, laborious accessibility of information and errors in information [35]. Identification of information wastes is successfully applied when analyzing information processing in order-to-cash processes of manufacturing company [36] and engineering change management in product design [37]. Even the long abandoned tradition of taylorism and especially its most well-known development method, time-and-motion studies, could be successfully adapted to the study of work processes and practices which comprise of information flow manipulation. The profound developmental goal of time-motion studies was and is even nowadays to equip workers with better and more convenient working methods. While time-motion studies traditionally concentrated into physical ergonomics of the work task execution, the similar approach could be applied for studying information and communication intensive work tasks. Especially the basic concepts related to the detection of time spending in non-value generating activities like waiting, fixing errors and moving and collecting resources to be processed are equally applicable into knowledge work as for manual work.

Common to all above discussed concepts is their potential power to detect actual working patterns, conventions and habits of knowledge work. Diverse information technological resources are involved and applied in practically every step of executing knowledge work. The critical question is, how the computing practices and habits involved in the everyday task management and execution have been developed and evolved, how they serve the expressed goals of the knowledge workers and what is their fit with the human capabilities.

5 Development of empirical data collection for studying computing practices

Observing and analyzing the connections between computing practices and the success of knowledge work is not straightforward. Collecting reliable empirical data in real work settings for long periods without a presence of an observing, interviewing and intervening researcher has been so far difficult in practice. On the other hand, the mere presence and activities of the researcher may alter the situation and the behavior of the person observed. Detecting and scrutinizing the detailed patterns of task organization, computing activities and event flows in the work in nearly real time disturbs the activities of the person observed considerably.

The application of earlier mentioned analysis frameworks of work and computing practice are becoming feasible because of the emergence of new commercial tools of tracking the details of everyday computing practices in work. Portable lifelogging devices (e.g. Vicon Revue) and associated analysis software, screen navigation video recording, tracking software for capturing, logging and analyzing moment-to-moment screen activities related to different software use, and portable, mini-sized video cameras leaving both hands of the user free provide powerful but unobtrusive means to study naturally occurring micro-practices of computing in work. Tracking the computing activity with these tools does not disturb normal working of the person observed.

By integrating data collected by tracking and recording tools it is possible to observe computing micro-practices in a great detail. The data from different tracking sources (e.g. screen navigation video and screen activity tracking data detecting flow of user activity across different software tools, documents and files) can be merged into a single time-stamp based database. Even the filtering confidential content, which the person observed does not want to show for analysts, is possible programmatically without extensive manual browsing of many hours of recorded data. The activities on and by the screen can be detected as a continuous process, and viewed from different viewpoints. They provide rich and objective measure about what happens in the concrete level of computing operations, enabling both qualitative and quantitative analysis. Because the data can browsed in visually natural way (e.g. watching interesting events from screen navigation video), collaborative interpretation of the data with the persons observed is possible outside the tracking and recording moment. When this data capturing "computing behavior" in naturally occurring work situations and ecologically valid environment is applied as the source material for the analysis of actual computing methods, totally unrecognized possibilities can open up to recognize the details of computing habits and micro-practices, and to understand the determinants of efficacy of human-computer interaction in the service of knowledge work.

Researching computing practices in detail requires dedicated analytical units to be observed from the collected computing event and process data. Shifts between tools and documents, sequencing and patterning of the shifts, duration of events, recurring of events, and chains of operations to reach a certain goal are just examples of potential "raw" conceptually low observations, which need to be further correlated with conceptually more abstract observations detecting phenomena under interest. When considering particularly the impact of the quality of HCI on knowledge work, these more abstract dependent variables can be the success factors of knowledge work or the work wellbeing variables.

6 Conclusions

In this conceptual work-in-progress paper we have discussed kind of black spot of HCI and work analysis, namely the inability to systematically address the development on everyday computing practices of knowledge workers. In addition, we have discussed the state of the research evidence considering the nature of individual knowledge workers' working practices and principles of organizing their tasks in their information technologically intensive work environments. Much is still unknown about the character of knowledge work task management and practical computing methods. We still do not know how the computing practices and knowledge work success factors are related especially in the individual worker level.

When considering the life-cycle of use of any technology, the post-deployment period is the longest phase of the life-cycle of use. During the long post-deployment period, the everyday computing habits and practices evolve, and often very rapidly freeze – regardless of the affordances designed into the technical artifact potentially enabling a more sophisticated and efficient use. We have observed that development of computing practices and habits of individual users and user communities in work organizations are not central design targets of current HCI or work analysis efforts. This is an unfortunate limitation, considering the critical role the actual nature of use plays in the shaping of the overall impacts of computing for the qualities of work processes and experiences of the knowledge workers [38]. Therefore, we proposed that a central new design effort focus of HCI and work analysis should be the understanding and development of everyday computing practices of knowledge workers in their "as-is" computing environments. In addition, we proposed emerging and promising conceptual and methodological approaches to address the shortage.

7 References

1. Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S., Carey, T. (1994) Human-Computer Interaction. Addison-Wesley: Harlow.
2. Karapanos, E., Zimmerman, J., Forlizzi, J., Martens, J.-B. (2009) User Experience Over Time: An Initial Framework. Proceedings of the CHI 2009, April 4-9. 2009, Boston, Massachusetts, USA, pp. 729-738.
3. Stevens, G., Pipek, V., Wulf, V. (2009) Appropriation, Infrastructures: Supporting the Design of Usages. Proceedings of IS-UED 2009, LNCS 5435, pp. 50-69.
4. Balka, E., Wagner, I. (2006) Making Things Work: Dimensions of Configurability as Appropriation Work. Proceedings of the CSCW'06, November 4-8, 2006, Banff, Alberta, Canada, pp. 229-238.
5. Jasperson, J., Carter, P.E., Zmud, R.W. (2005) A Comprehensive Conceptualization of Post-Adoptive Behaviors Associated with Information Technology Enabled Work Systems. MIS Quarterly 29(3), pp. 525-557.
6. Devaraj, S., Kohli, R. (2003) Performance Impacts of Information Technology: Is Actual Usage the Missing Link? Management Science, 49(3), pp. 273-289.
7. Carter, M., Clements, J., Thatcher, J.B., George, J. (2011) Unraveling the "paradox of the active user": Determinants of individuals' innovation with IT-based work routines. Proceedings of the Seventeenth Americas Conference on Information Systems (AMCIS 2011) Proceedings - All Submissions. Paper 41. http://aisel.aisnet.org/amcis2011_submissions/41.
8. Saeed, K. A., Abdinnour, S. (2011), Understanding post-adoption IS usage stages: an empirical assessment of self-service information systems. Information Systems Journal. doi: 10.1111/j.1365-2575.2011.00389.x
9. Burton-Jones, A., Gallivan, M.J. (2007) Toward a Deeper Understanding of Systems Usage in Organizations: A Multilevel Perspective. MIS Quarterly, 31(4), pp. 657-679.
10. Pipek, V., Wulf, V. (2009) Infrastructuring: Toward an Integrated Perspective on the Design and Use of Information Technology. Journal of the Association for Information Systems, 10(5), pp. 447-473.
11. Davenport, T.H., Thomas, R.J., Cantrell, S. (2002) The Mysterious Art and Science of Knowledge-Worker Performance. MIT Sloan Management Review, Fall 2002, pp. 23-30.

12. Davenport, T. H. (2005) Thinking for a Living. How to Get Better Performance and Results from Knowledge Workers. Harvard Business School Press: Boston, MA.
13. Davenport, T.H. (2011) Rethinking Knowledge Work: A Strategic Approach. McKinsey Quarterly, February 2011.
14. Vartiainen, M., Hakonen, M., Koivisto, S., Mannonen, P., Manninen, M.P., Ruohomäki, V., Vartola, A. (2007) Distributed Mobile Work. Places, People, and Technology. Otatieto: Espoo.
15. Bosch-Sijtsema, P.M., Fruchter, R., Vartiainen, M., Ruohomäki, V. (2011) A Framework to Analyze Knowledge Work in Distributed Teams. Group & Organization Management, 36(3), 275-307.
16. Laihonen, H., Jääskeläinen A., Lönnqvist, A., Ruostela, J. (2012) Measuring the productivity impacts of new ways of working. Journal of Facilities Management, 10(2), pp. 102-113.
17. Beurer-Zuellig, B., Meckel, M. (2008) Smartphones Enabling Mobile Collaboration. Proceedings of the 41st Hawaii International Conference on Systems Sciences. IEEE.
18. Paridon, H.M., Kaufman, M. (2010) Multitasking in work-related situations and its relevance for occupational health and safety: Effects on performance, subjective strain and physiological parameters. Europe's Journal of Psychology, 6(4), pp. 110-124.
19. Mark, G., Gonzales, V., Harris, J. (2005) No Task Left Behing? Examining the Nature of Fragmented Work. In Proceedings oth the CHI 2005, April 2-7, Portland, Oregon, USA. ACM: New York, pp. 321-330.
20. Wajcman, J., Rose, E. (2011) Constant Connectivity: Rethinking Interruptions at Work. Organization Studies, 32(7), pp. 941-961.
21. Schmidt, K. (2011) Cooperative Work and Coordinative Practices. Contributions to the Conceptual Foundations of Computer-Supported Cooperative Work (CSCW). Springer: London.
22. Franssila, H., Okkonen, J., Savolainen, R., Talja, S. (2012) The formation of coordinative knowledge practices in distributed work: towards an explanatory model. Journal of Knowledge Management, 16 (4), pp.650 – 665.
23. Bellotti, V., Dalal, B., Good, N. Flynn, P., Bobrow, D.G. (2004) What a To-Do: Studies of Task Management Towards the Design of a Personal Task List Manager. In Proceedings of the CHI 2004, April 24-29, 2004, Vienna, Austria. ACM: New York, pp. 735-742.
24. Drucker, P.F. (1999) Knowledge-Worker Productivity: The Biggest Challenge. California Management Review, 41(2), pp. 78-94.
25. Beyer, H., Holtzblatt, K. (1998) Contextual Design. Defining Customer-Centered Systems. Morgan Kaufmann: San Francisco.
26. Courage, C., Jain, J., Redish, J., Wixon, D. (2012) Task Analysis. In Jacko, J.A. (ed.) The Human-Computer Interaction Handbook. Fundamentals, Evolving Technologies and Emerging Applications. CRC Press: Boca Raton.
27. Rogers, Y. (2012) HCI Theory: Classical, Modern, and Contemporary. Synthesis Lectures on Human-Centered Informatics, 14. Morgan & Claypool Publishers
28. Luff, P., Hindmarsh, J., Heath, C. (2000) Workplace Studies. Recovering Work Practice and Informing System Design. Cambridge University Press: Cambridge.
29. Hutchins, E. (1995) Cognition in the Wild. MIT Press: Cambridge, MA.
30. Jacucci, G. (2007) Social Practice Design (SPD), Pathos, Improvisation, Mood, and Bricolage: The Mediterranean Way to Make Place for IT? MCIS 2007 Proceedings, Paper 19.
31. Vicente, K.J. (2000) HCI in the Global Knowledge-Based Economy: Designing to Support Worker Adaptation. ACM Transactions on Computer-Human Interaction, 7(2), pp. 263-280.

32. Guinea, A.O., Markus, M.L. (2009) Why Break the Habit of a Lifetime? Rethinking the Roles of Intention, Habit, and Emotion in Continuing Information Technology Use. MIS Quarterly, 33(3), pp. 433-444.
33. Carroll, J.M., Rosson, M.B. (1987) Paradox of the Active User. In Carroll, J.M. (ed.) Interfacing Thought. Cognitive Aspects of Human-Computer Interaction. MIT Press: Cambridge, Massachusetts, pp. 80-111.
34. Gonzales, V.M., Nardi, B., Mark, G. (2009) Ensembles: understanding the instantiation of activities. Information Technology & People, 22(2), pp. 109-131.
35. Hicks, B.J. (2007) Lean information management: understanding and eliminating waste. International Journal of Information Management, 27, pp. 233-249.
36. Franssila, H. (2012) Information waste: Qualitative study in manufacturing enterprises. In Møller, C., Chaundry, S. (eds.) Advances inn Enterprise Information Systems II. CRC Press: London, pp. 105-110.
37. Hölttä, V., Mahlamäki, K, Eisto, T., Ström, M. (2010) Lean Information Management Model for Engineering Changes. In Proceedings of International Conference on Business, Economics and Management (ICBEM 2010), Paris, France, 28-30 June 2010.
38. Jain, V., Kanungo, S. (2005) Beyond Perceptions and Usage: Impact of Nature of Information Systems Use on Information System-Enabled Productivity. International Journal of Human-Computer Interaction, 19(1), pp. 113-136.

Acknowledgements

This article is based on a research project "Construction of evaluation and development approach for information ergonomics in knowledge work", which is funded by Finnish Work Environment Fund, grant number 112135.