



Correction to: Digitalization in knowledge work: the dream of enhanced performance

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According to decision by the rector of University of Tampere, a version of the paper was submitted and published due to negligence. This is erratum is to correct the error and to acknowledge the original work of authors of the studies based on the data also utilized in this paper. This requires changes in Sects. 3, 3.3, 4.3, and 6.

The following sections and paragraphs are changed or replaced to make sure the sources of data are acknowledged correctly. The analysis of one dataset is replaced and it also affects conclusions. Changed or added text is in italics. Deleted text is marked strikethrough in respective section.

Section 3: Datasets

References to studies that first utilized the data are added. Minor changes are made in order to make the text more comprehensible.

The data utilized in this paper was acquired in three different *fieldwork* settings. The first dataset is based on desktop tracking, subjective performance assessment and psychophysiological measurement during work days in a knowledge

work context (*cf. Okkonen et al. 2017*). The second dataset is based on thematic interviews of individuals from different professions conducting knowledge work.

(*cf. Helander et al. 2016*). The third dataset was gathered in the form of individual interviews and focus group interviews of knowledge workers in different organizations between 2012 and 2016 (*cf. Franssila et al. 2015; Bordi et al. 2018*). The datasets address the topic from different perspectives and provide more holistic view when put together. Moreover, use of different datasets executes *data triangulation* as dataset 1 provides evidence on work flow related productivity issues in knowledge work, data set 2 provides evidence on restraints and enablers in knowledge work, and data set 3 provides evidence of tackling *certain work flow related* shortcomings in knowledge work. Moreover, together the datasets address the digitalization in knowledge work more thoroughly than single analysis *would do*.

Section 3.3: Dataset 3

This section is corrected as the distinction between two different empiric studies should be made. Minor changes are made in order to make the text more comprehensible.

The third dataset is based on individual interviews and several focus group interviews on work practices of knowledge work. The data was gathered between June 2012 and May 2016 as a part of *two* larger, mixed-method action research *projects* focusing on the role of information ergonomics on workplace wellbeing. Preliminary interviews were conducted with 19 knowledge workers. The participants discussed aspects of their work in the context of the digital work environment and wellbeing at work and reflected on how to reduce information load and promote productivity in general. That data was applied to construct a research setting for further in-depth analysis *related to information ergonomics in knowledge work*. 35 employees representing three organizations (i.e. an industrial enterprise, an insurance company, and a financial administration

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services company) participated in the focus groups, and they are the same as in dataset 1. Data were gathered in development meetings in the organizations, where each held three workshops. The objective of the workshops was to develop methods for enhancing information ergonomics, yet the data acquired reveals a holistic view about the work in context. The focus groups were and arranged as workshop and the informants formed two or three smaller groups to discuss certain topics related to their work, such as work setting, work habits, work conventions or performance. The recordings of each group were transcribed for analysis. The summarizing discussion after each group session were also recorded.

Section 4.3: Dataset 3: Constant connectivity and communication volume causes task fragmentation

This section is completely replaced.

One key topic related to productivity is how work and work setting is adapted to individuals. In work science this often refers to ergonomics, so in the context of knowledge work, this is, logically, about information ergonomics (Franssila et al. 2015). Based on interviews with 19 knowledge workers, key items related to sufficient work execution, self-efficacy, and efficiency, i.e. subjectively assessed productivity and information ergonomics, were extracted. The informants described their work and those factors affecting it. The findings could be categorized according to performance issues in relation to technology, infrastructure, social aspects, or individual aspects that are subject to digital work environments. These components were brought about when informants discussed their digital work environments and socio-technical work settings.

Technology, per se, was affecting human technology interaction or user experience. Many informants also recognized their work habits having a strong relation to technology. In terms of productivity, technology is connected to self-efficacy since it deals with the ability to use and utilize technology. On the other hand, non-functioning or ill-functioning technology has a great impact over the control process and productivity. This is also connected to, in a sense, fragmentations since work does not have an even flow if technology has usability or dependability issues.

Infrastructure is connected to technology and the planned structure of an organization; it determines workflow by the means of production. In the knowledge work context, this is mostly about ICT and information infrastructure. Communication infrastructure is also important; it dictates the modes of working and therefore has an impact on the sense of control and workflow. If technological issues and shortcomings are reduced, infrastructure is about how the work setting in organized, how information is stored and utilized, and how

it manifests into the physical work setting. Infrastructure promotes efficiency thorough well functioning practices by providing sufficient tools for working. Infrastructure is also related to self-efficacy since people have certain expectations of how it could, and will, support their performance in relation to their peers and stakeholders.

According to the informants, the social component has significance because of organizational factors such as work convention. In almost all work settings, social or cooperative factors define individual and organizational performance. In digital or socio-technical work environments, this seems to be one of the most misunderstood themes. Technological determinism is often overruled by socially constructed conventions, thus those affecting the processes have more significance. However, if sophisticated technology is implemented, it is done so in vain if people are not motivated to adopt the application, service, or process. Moreover, people tend to have shared views on using technology, especially when problems are solved by asking peers, rather than checking a manual or tutorial. Socially constructed conventions have direct effects on productivity. They also affect efficiency through allocation of resources and, likewise, lead times. Acknowledging conventions supports a sense of self-efficacy and promotes a sense of control, thus reducing a negative stress factor that people cannot affect.

Individuals have several roles and these vary when a context or situations change. In digital work environments, individual habits have an effect on efficiency and overall performance. These habits are manifestations of conventions and reflect an individual style of working. These habits are often tacit, and in a sense people have only a vague idea of how their behavior affects the others in the organization. In digital work environments, many actions and processes are conducted efficiently as technology supports knowledge work, yet unexpected ways of using technology may have an opposite effect. Individual tasks are performed easily, but those requiring iteration or communication are often more complex and some leverage is diluted by the vast use of ICT.

The second set of interviews and workshop discussions were analyzed according to themes related to information ergonomics and to findings previously presented by the log data. The infrastructure and organization of the work was based on different digital tools for data and information management, and different synchronous and asynchronous communication applications or channels. Information related tasks and communication with peers or clientele were the key tasks performed by the interviewed knowledge workers. The array of different applications people use was extensive. In addition to typical desktop applications, people used special IT resources such as enterprise resource planning, customer databases, and service applications. They also used communication channels such as email, instant messaging, ticketing tools, conference calls, and telephone.

Technology was adopted to well and found sufficient for the intended use. In means of productivity, technology streamlined most processes, leveraged information related tasks, and boosted productivity. The flip side of the transition to digital work settings was a constant need for adapting to new applications and services, non-functioning infrastructure, slow connections, lack of face-to-face time with people, and excessive use of digital communication.

The most critical issues in this sense were learning new technologies and insufficient knowledge of use. Informants lacked time to introduce themselves to new technology yet, on the other hand, they experienced an increasing technology based workload. In many cases, the new implementations were introduced as performance enhancing, yet the complexity in learning to use required extra time. In many cases, people learned by trial and error, which leads to odd habits and slower implementation. Also, the allocation of time to learn to use new applications and services was too small, almost even non-existent. As there was no time for an introduction of how to use applications, learning was based on the worker's own willingness to learn the new technology.

Informants mentioned facing technical problems that could cause work to stop due to non-functioning tools. Most of the applications they used were web based and network problems sometimes caused restricted access to resources, information, or digital communication. Technical problems also caused accumulation of work because internal and external customers used several channels to be serviced. To some extent, informants had poor user experiences on certain applications and services, and often found that they must work with insufficient tools.

Based on tracking and discussions, email was the main channel of communication, and in most cases, the volume of use was significant. The average time spent engaged in email amounted to 7% of the workday. Taking the other communication channels into account, the percentage of digital communication related activities increased to 18%. Most other communication was through *teleconferencing*, *instant messaging*, *service platform*, or *ticketing tool*. When all forms of communication that are used during working hours were included, 23% of work time was spent on communication-related activities, such as emailing, messaging, discussing, or engaging in meetings. The average *interval* that an email inbox was opened was 15 min, yet taking all options into account, participants engaged in communication-related activities every 3 min, on average. In a sense, digital communication had a negative effect on sense of control over workload and self-efficacy.

The digitalization of knowledge work is pinned to the theme of digital communication. The informants were mostly satisfied with, or at least indifferent to, the technology and infrastructure provided to them. People were satisfied with the technical support they could get, and especially how the

work community had a key role in solving problems. What they mostly missed was setting their own pace of work and having enough time to perform such. Most of the informants found digital communication as the main cause of task fragmentation and stated that the volume of communication has a negative effect on workflow.

The effect of digital communication on workflow was reduced to two issues: the high amount of messages and time spent on communication. Also, the informants missed explicit rules for communication, since the quality of communication caused negative effects several times a day. Due to the ease of sending an email or placing a service ticket, people felt an excess load of use from peers and clientele. In addition, communication triggered other activities that requires effort and makes workflow uneven and fragmented. A large volume of communication also affected a sense of control and self-efficacy.

Informants also had issues with the diverse information infrastructures within several channels, inboxes, or shared tools. In particular, those working with customers felt pressure to keep up to pace with all communication channels. This also affected task performance since several possible channels of negotiating, iterating, or communicating caused lost messages and delays. Asynchronous communication especially was considered problematic, since it could be used for postponing, procrastination, or simply increasing the amount of messages and thus the amount of work. This is to some extent an issue of infrastructure, but mostly an issue of a need for better instructions and explicit conventions.

Looking at the social component, information practices and communication conventions play the most central role regarding productivity in knowledge work. The informants described interdependencies among their peers and clientele. Such *MO* requires coordinative actions by communication, yet it has a drastic effect on the ergonomic stages of the socio-technical system. Moreover, regarding individuals, the most evident findings related to how people maintain a balance between work and leisure during the day or week.

Individual working habits are derived from organizational virtues, i.e. people are socialized to act according to certain ways and this is shared within an organization. The extensive use of email was brought up in workshop discussions; it dictates the workflow. People use it to organize their tasks, and it is also shared working platform. There are certain explicit and implicit expectations of being available through communications channels. This seems to cause the overlapping use of email, instant messages, text messages, and so on. Excess communication causes task fragmentation, a sense of lack of control, and lack of self-efficacy. Moreover, people felt they were forced to response quickly to messages and had to be reachable even outside the office and office hours. This also led to an increasing amount of meta-work, i.e. planning, scheduling, discussions on how to work.

Even the informants felt pressure to be positive on how the socio-technical work environment supports flexibility in their life. A digital presence was sufficient, so they gained from asynchronous communication and working on digital platforms. People stated that knowledge work is better served by sufficient tools, and better if each individual can set their own pace and adapt to their work environment. Moreover, the socio-technical work environment created an excess of appreciation for freedom and flexibility; participants stated that the digital work environment made remote work possible, as resources were available almost anywhere from laptops or smartphones. The results from the log data indicate a broad digital landscape with many communication activities. A distinctive characteristic of the communication landscape was that most activities occurred in digital form, such as through email, IM, or via other digital means. The findings resonate with previous studies that underline the effect of increased communication, diversity of task affecting the volume of communication, and how sociotechnical work environments cause a need for constant connectivity (see, e.g. Mark et al. 2014; Okkonen et al. 2017).

Content analysis was applied to the interviews and workshop discussions. Content analysis was chosen for its flexibility in providing a data-driven approach for analyzing interviews and discussions and discovering key issues, not merely testing preset hypotheses and finding connections in unstructured data. Based on the notion of previously presented log data, the work environment of the participants was based on different digital tools, and several options for synchronous and asynchronous communication, both internally and externally, were provided. The participants conducted most internal communication (except face-to-face communication) via digital channels. External communication was more restrained, with the participants expected to use formal means of communication, such as ticketing systems or team emails. However, the demand for practicality tended to overrule the instructions, and the participants often arranged communication according to personal preferences and habits.

The participants used various communication channels in their day-to-day work. The typical channels used included email, Instant Messaging (IM), ticketing tools, telephone, and Internet conference calls. Based on tracking and discussions, email was the main means of communication, and in most cases, the volume was significant. The average time spent engaged in email amounted to 7% of the workday. When other communication channels were added, the percentage of digital communication-related activities increased to 18%. Most of the other communication was through IM or a ticketing tool. When all forms of communication that occur during working hours were included, 23% of working time was spent on communication-related activities, such as emailing, messaging, discussing, or engaging in meetings.

The average duration that an email inbox was open was 15 min, but taking all options into account, the participants engaged in communication-related activity every 3 min, on average.

The volume of digital communication and its effect on work flow was mostly addressed from two angles: the large quantity of messages and the variety of messages, which were also intertwined. The informants noted that the increase in digital communication channels had made communications easier and thus increased the amount of communication. They discussed how colleagues and clients were reluctant to seek information themselves, because sending a question was perceived to be an easier way to obtain an answer. This behavior increased the amount of digital communication and the recipient's workload, since communication also led to other work activities. The amount of digital communication was perceived to be extensive, especially the amount of email. The participants were often required to manage several inboxes, as they used team/group emails in addition to an individual work email. Multiple email addresses increased the risk of messages being sent to the wrong address. Sometimes email messages were lost in the process, and the sorting took extra time and caused delays, especially if the misplaced email was important for a certain task. Especially in interdependent tasks, asynchronous communication was also considered as a risk for poor performance due to lag in workflow.

The volume of email was perceived to be so high that for many it was impossible to read everything. The participants felt perplexed about how to prevent important email from getting buried under the constant flow of messages. The participants had tried various methods for managing the incoming email, such as labeling and flagging, but with large numbers of messages, they often found it too bothersome. The participants reported feelings of anxiety because of the constant flow of messages. They often experienced the fear of missing something important and/or falling behind on their tasks.

Email was considered a way of keeping up to date in one's work agenda, yet checking email caused work to spill over into leisure time. In addition to email, participants discussed the constant flow of instant messages. Some participants said they often had multiple discussions open in IM at the same time. This resulted in the overlapping use of communication channels and increased the communication load. This was considered to cause fragmentation on other work activities and to cause underperformance as well.

Discussions about the expectations of constant connectivity primarily fell within two categories of expectation, explicit and implicit. Explicit expectations had to do with, for example, set response times and digital communication being a medium for assigning tasks. Implicit expectations were expectations of connectivity or a quick response. This

also led to how work in general was supposed to be organized. Participants stated that there were expectations for constant connectivity in their work, which also led to expectations of shorter lead times. Moreover, such expectations led to an increased amount of metawork, i.e., scheduling and discussion on how work should be conducted. People also felt strong pressure to be available and respond immediately. For some, email was the main medium for task assignment, and therefore, they were obliged to check it all the time and, in many cases, to also take action. Constantly checking email frequently interrupted and fragmented tasks. The participants also noted that the interruptions made it difficult to concentrate. They could also disturb schedules and make it difficult to control one's work. However, the participants who worked in managerial or specialized expert positions had more control over when they were available. Some stated that they could block almost all communications if they were working with something that required their undivided attention and that people in their organization usually respected this decision. In contrast, the employees who worked in direct customer service had practically no control over when they were available. The interviewees described the constant connectivity in for example customer service as very stressful; the situation was worst for employees who were required to be available through various communication tools at the same time. The customer service employees pointed out about strictly set priorities and response times. For example, the insurance company employees were required to respond to customer chat messages within 15 s. During busy periods, participants found this exhausting, especially if only a few employees were working during the shift.

In addition to performing tasks that required constant connectivity, the participants felt an implicit pressure to react immediately. They perceived constant connectivity to be a part of that organizational culture. The pressure was often enforced by consecutive communication if the recipient did not reply immediately. In addition to implicit pressure, some participants wondered whether constantly checking messages was related to personal preferences. Some said they were intrigued to see what was in their inbox and wondered whether they had the self-discipline to refrain from constantly checking their email. Some also speculated that they were being too considerate and providing too good a service by replying right away, suggesting that they might be promoting the expectation of constant connectivity. However, the participants also noted that if they did not answer immediately, the lack of response generated even more communication, thereby increasing the employees' workload.

The participants brought about the frequent need to adapt to new digital tools. The discussions were mostly divided into two aspects: the often-inadequate resources for learning new technology and the increased workload caused by the addition of new tools. These new tools were

implemented to gain better performance and were usually quite complex, such as collaboration tools that provided features for communicating and sharing. Many felt pressure to keep up to date on new technologies but perceived the training to be lacking in their organizations. The participants often felt that they were left to their own devices when it came to learning new tools.

The participants revealed that although instructions and training might be available in their organizations, no time for learning these tools was allotted. This lack of scheduling was perceived to be problematic, as the participants felt that they could not find the time needed for training. Thus, they tried to balance the at times contradictory-seeming needs of taking the time to learn new technology and performing their basic tasks. The participants found that trying to schedule training in the middle of all their other tasks was difficult and burdensome, and for some, it even induced feelings of guilt, as taking time for training meant that they left other tasks unattended. The new communication tools were usually intended to replace email in certain cases, yet they seldom did.

Informants also described regularly encountering technical problems. The participants stressed the importance of functioning tools, as most of the work was conducted in a socio-technical work environment that was essential for executing the work. Application and network problems sometimes caused restricted access to resources, information or digital communication. The participants reported also experiencing delays in their work because of problems with communication tools. The delays caused by technical problems usually resulted in increased workloads after the tools started working again. At times, technical problems also prevented clients from getting in touch. In addition to causing delays, problems with networks and tools could result in excess communication with clients. In addition to the reliability problems with networks, informants stressed some tools' lack of user-friendliness. For example, the participants perceived some of the communication tools to be insufficient for their intended purpose. The tools could be difficult to use, or they lacked the functionalities the participants perceived as desirable. The participants thought these problems made work less efficient, and they caused frustration.

The main positive attribute of digital work environments described by the participants was the flexibility they provided in their work. Flexibility was mainly discussed in the context of time, place, and situation or task. In addition to describing the downsides of digital communication, participants stated their belief that asynchronous communication was a big improvement over more traditional communication channels, especially the telephone. Participants mentioned telephone calls as the worst form of interruption, and for the most part, participants perceived the decreased number

of phone calls positively. The participants noted that asynchronous communication was easier to manage. Even with the pressure to answer immediately, the participants felt that asynchronous communication, such as email and ticketing tools, provided them a better opportunity to decide when they were going to engage in communication activities.

The participants noted that the digital work environment had made remote work possible, as the employees could access their email accounts and company resources almost anywhere with their phones. Teleconferencing also made it possible to attend meetings from home. However, the participants stated that they usually tried to attend meetings in person, as they valued face-to-face interaction, and they preferred to do more solitary work when they worked remotely. Participants often found multitasking burdensome, and some stated that they liked to attend remote meetings and trainings because remote attendance made it possible to do other tasks simultaneously. This type of self-induced multitasking was not viewed negatively, while multitasking caused by an outside reason was considered to be negative.

The results from the log data indicate a broad digital landscape with many communication activities. A distinctive characteristic of the communication landscape was that most activities occurred in digital form, such as through email, IM, or other digital means. The findings are in line with those of previous studies, which have also shown that the amount of communication has increased, and that, for example, the diversity of tasks has increased communication (see, e.g. Mark et al. 2014; Okkonen et al. 2017). Understood in the context of previous studies, the present findings support the notion that employees work with multiple technologies at the same time and need to integrate and combine them effectively. Therefore, future studies should also investigate broad landscapes holistically, rather than focusing on the use of single technologies.

Participants also perceived that problems and negative user experiences with digital tools had negative effects on workflow. These problems included network problems hindering the use of the tools and the tools' lack of user-friendliness. Previous research has shown that ICT problems, such as malfunctions and incompatible tools, induce strain (Day et al. 2010; Tarafdar et al. 2011). This may indicate that the participants found that technology- and infrastructure-related factors were mostly sufficient and that the demanding aspects associated with digital environment were not due to the communication technology per se but to the social factors related to work in a socio-technical environment, such as the organizations' and work teams' conventions and practices.

The findings suggest that the demanding aspects of digital work environments noted by participants were more dominant, yet these findings might present some bias. This finding is in line with the large body of research suggesting that

users can experience ICT as demanding and stressful (e.g. Bordi et al. 2017; Salanova et al. 2013; Tarafdar et al. 2011). There are many possible explanations for this study's findings, as the current trend of digitalization may be translated into practice as a demand for the constant integration of new technology, which users typically experience as stressful (c.f. Tarafdar et al. 2011).

Section 6: Conclusions

The paragraphs 4 and 5 are replaced.

As stated in the interviews knowledge workers are affected by the expectations of constant connectivity (cf. Wajcman and Rose 2011). As discussed in Bordi et al. (2018) communication channels serve several purposes in work and cannot be just neglected. As pointed out, people in different professions face the same pressure of being available and responding immediately. As the digital work environment is based on implicit expectations of short lead times also in communication activities, it causes a vicious circle of excess communication and task fragmentation. Moreover, several previous studies have discussed the issue from the perspective of how knowledge work is about digital communication to significant extent. The peers have their expectations about it, as well as the clientele and other stakeholders. Especially email seem to cause redundant work and stress (e.g. Barber and Santuzzi 2015; Bordi et al. 2018). Diverse communication landscape leverages the even flow, yet it can cause constipation too if the time is spend with (somewhat trivial) communication through digital channels.

Those people working with high interdependent setting need explicit norms to build sustainable work habits. Sustainability here refer at least to how people are affected by interruptions, when they are addressed, how they are expected to react, and how work is spilled to leisure (cf. Mark et al. 2016). This is also issue of how individual habits should resonate with organizational conventions. Intraorganisational setting allows to set norms of productive working habits e.g. for communication behavior that people are not expected to reply, or even check messages constantly. The setting is very also different when taking into account extended organization with large clientele. How they are supposed to be served? Especially on professional setting when service is attached to a person she or he is easily addressed and having pressure caused by digital work environment.

The knowledge workers studied in this research perceived expectations of constant connectivity as demanding. Constant connectivity included communication channels functioning as tools for task distribution, thus requiring constant monitoring and inducing a pressure to reply immediately. Previous research does not explicitly describe

digital communication as a tool for task assignment, which the participants mentioned repeatedly. However, it has been noted that digital communication is an integral component of knowledge work, and the flow of digital communication cannot be separated from the workflow in general (Wajcman and Rose 2011). In addition, the expectation of availability and the implicit pressure to reply immediately mentioned in this study have also been recognized in previous studies as taxing (Barber and Santuzzi 2015; Barley et al. 2011; Brown et al. 2014; Wajcman and Rose 2011).

This study, along with previous studies, shows that the expectation of constant connectivity has multifold effects on the workflow and wellbeing of employees and that the demanding aspects of digital communication are interconnected and cannot be understood separately. For example, self-inflicted interruptions and a non-moderated digital work environment seem to cause stress (cf. Mark et al. 2014; Mark, Iqbal, Czerwinski, Johns and Sano 2016), as was also the case in this study, and some of the previous studies identified the pressure to reply quickly as the reason for work–non-work conflict (e.g., Barber and Santuzzi 2015), but in dataset 3, the participants mainly discussed the spillover in the context of the large number of messages. However, this does not rule out the implicit expectations that may also lead these informants, for example, to check messages during non-work hours.

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