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From the seat to the system: Re-designing a tram drivers' workstation combining technical and contextual aspects

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ABSTRACT

Through the detailed account of a design case-study, the paper aims to demonstrate how the activity-oriented approach promotes a systems perspective in ergonomics interventions. Specifically, by presenting an activity-oriented re-design of a tram drivers' workstation, it is shown: (i) how technical and contextual aspects were jointly considered, (ii) how their combination affects workers' activity in a non-trivial manner, and (iii) how this system level view helped generate feasible and sustainable design solutions. First, the activity-oriented theoretical lens is briefly presented, followed by the analysis of the tram driving activity, emphasizing on drivers' efforts to compensate for the original work-system design flaws. Next, key elements of the re-design process are presented, through a concept map, combining technical and contextual aspects, coupled with an account of stakeholder debates and resolution processes. The paper ends with a discussion on the lessons learned, concerning the adopted approach for design interventions in real work situations.

1. Introduction

The recent call for strengthening the systems perspective in the practice of Human Factors/Ergonomics (HF/E) (Dul et al., 2012; Wilson, 2014; Salmon et al., 2016), requires a debate on intervention approaches and associated methods. To this end, detailed accounts of HF/E case studies that claim to be authentically systemic are valuable, because (i) they provide feedback on the applicability of various methods in different domains, (ii) they foster debates on the pros and cons of alternative intervention approaches, and (iii) they offer concrete accounts of the process of intervening per-se, for dissemination and sharing among HF/E professionals and students.

Most HF/E case study accounts, however, focus primarily on the technical aspects, data and results, placing little emphasis or omitting altogether, the contextual aspects of the intervention process per-se, e.g. social, organizational and financial. Typically, in case study reports, parts devoted to the intervention process are simplified rationalizations of the methodology adopted. Often, the management structure of the project may be provided, e.g. the type of committees formed and the different decision milestones. However, the subtleties of the actual process, although an integral part of ergonomics practice and essential prerequisite for successful interventions, are only occasionally reported. For example, disciplined accounts on misunderstandings and/or conflicts of interest between different implicated parties –the ergonomists included– on how these are resolved, or on what grounds are trade-offs being made, are rarely presented. Notable exceptions are the few case studies following activity-oriented approaches and/or Action Research (e.g. Engeström, 2000; Daniellou and Rabardel, 2005; Neumann et al., 2012; Village et al., 2014). In fact, due to their situation-based theoretical lens and methodology (i.e. idiographic - interpretivist), activity-oriented and/or action research approaches make it easier to integrate various contextual aspects (e.g. social, organizational and financial) in case study reports.

An important reason why contextual aspects are often omitted in case study reports is that they are sensitive businesswise. Undeniably, reporting on misunderstandings, conflicting goals or on unclear agendas inside an organization is risky, subject to multiple interpretations, and marginally acceptable in many cultures. Contextual aspects are also often omitted from case study reports on the grounds that they are not prone to generalization or systematization and, therefore, of little methodological value. Moreover, putting emphasis on contextual issues is thought to compromise the "scientific" rigour of an intervention, and correspondingly of the discipline at large.

On the other hand, it is widely accepted that an ergonomic intervention cannot be defined without considering the particular socio-technical context (Wisner, 1995; Wilson, 2000; Guerin et al., 2007). As Wilson (2000, 2014) emphatically stresses, application of Ergonomics requires a good grasp of context, relevant contextual factors being

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financial, technological, legal, organizational, social, political and professional. Indeed, the above determinants pragmatically delimit the scope of an intervention. The consequence of the above is that HF/E interventions should not confine to a positivist epistemology (Marmaras and Nathanael, 2005; Nathanael and Marmaras, 2012).

The aim of the present paper is to demonstrate, through a detailed account of a successful HF/E design intervention, how the activity-oriented approach promotes a systems perspective in ergonomics interventions. Specifically, by presenting a tram drivers' workstation re-design, it is shown: (i) how technical and contextual aspects were jointly considered, (ii) how their combination affects workers' activity in a non-trivial manner, and (iii) how this system-level view helped generate feasible and sustainable design solutions. The specific case study involved the re-design of a tram drivers' workstation carried out in 2007, responding to a request for expert advice from the Athens Tram operator, after an alarming occurrence of musculoskeletal disorders (MSDs) among drivers (Nathanael and Marmaras, 2009). The intervention proposals were fully adopted by the Athens Tram and implemented with considerable success. In fact, after implementing the changes, drivers' MSDs gradually dropped, to a level comparable to that of the general population, up to this day.

The present retrospective account, ten years after the intervention, corresponds at least in part to “reflection-on-action” as introduced in Action Research (Schön, 1991; Neumann et al., 2012). Retrospective analyses, although distanced in time from actual events, present some important advantages: (i) being more detached in time, tend to ease the practitioner's inherent biases, acknowledging the limits of his objectivity and letting him contemplate on his/her stance and values, (ii) along with the immediate impact of the intervention, the long term effects can be evaluated as well, and (iii) the practitioner is less constrained in recounting sensitive issues that could possibly expose organizational entities, roles or offend particular people.

The structure of the remainder of the paper is as follows. First, the theoretical and methodological background of the case study is presented, putting particular emphasis on the notion of “activity”, and on how adopting an activity-oriented approach in ergonomic interventions promotes a system-centric view. The sociotechnical system's model used as framework, and the main phases of the intervention, are then presented. Next, the analysis of the driving activity is presented, stressing on the compensatory processes put-on by drivers, as they perform the driving task in the specific work system. Key elements of the re-design process are then presented, through a concept map, combining behavioural, technical and socio-organizational issues, along with an account of stakeholder debates and resolution processes. The paper ends with a discussion on the lessons learned from the case study, concerning HF/E design interventions in real work situations.

2. Theoretical and methodological background

The intervention presented in this paper followed an activity-oriented approach (Daniellou and Rabardel, 2005; Guerin et al., 2007). Activity, besides its common everyday meaning, is a psychological concept originating from the school of cultural-historical psychology in the former Soviet Union (Bedny and Meister, 1997). *Activity* differs from *task* in that it designates work-as-done, or real work, as opposed to work-as-imagined or theoretical work (Ombredanne and Faverge, 1955; Hollnagel, 2006). *Activity* should also be distinguished from *behaviour*, the latter only constituting its observable facet; activity, as a concept, includes both externally observable behaviour and its internal regulating mechanisms (Leplat, 2006).

The core theoretical principle of activity, which distinguishes it from task accomplishment, is that it considers work to be an original creation of the actor/s (Daniellou and Rabardel, 2005; Wisner, 1995). The above principle contends that a working person is energetic in choosing and regulating his conduct, subject to the external environment and his internal state, in order to obtain a balance of exogenous and endogenous demands (e.g. task accomplishment and well-being). Therefore, activity is the active integration by the working person/s of task requirements and perceived well-being, all moderated by contextual circumstances and by the working person's aspirations. In other words, activity is bounded physically, cognitively, socio-culturally and techno-economically, as well as ever-developing in time (Béguin, 2007).

Two important methodological premises stem from the above: (i) that an analysis of activity should consider, as far as possible, the full complexity of the situations where it naturally occurs, and (ii) that such an analysis needs as a prerequisite the sincere accord and active participation of the affected working population. The first methodological premise, reverberates well with the systems-centric trend in HF/E, which stresses the importance of studying socio-technical systems in their full complexity, consisting of people, however hierarchically and/or functionally organised, technological components, official rules, unofficial practices, up to financial issues and wider economic circumstances (Rasmussen, 2000; Moray, 2000; Carayon, 2006; Karsh et al., 2013; Wilson, 2014; Salmon et al., 2016; Karltun et al., 2017). As Moray (ibid) points out, all human behaviour and performance takes place in a setting or a context, and E/HF interventions must account for this context, which increasingly is that of complex socio-technical or even social systems.

The second methodological premise, i.e. the need for a the sincere accord and participation of the affected working population, reverberates well with the majority of participative methods to HF/E interventions (Eason, 1995; Wilson, 1995; Carayon, 2006; Vink et al., 2008; Neumann et al., 2012; Edwards and Jensen, 2014; Kasper and Per Langaa, 2014). As Eason (ibid) suggests, design processes should involve end-users themselves, so that they can influence the design to be compatible with their goals and beliefs. Indeed, HF/E solutions based on sincere accord and participation of the affected population tend to be stronger, more adaptable and more resilient against environmental variations (Imada, 1991).

3. The case study

3.1. The request for intervention and the socio-technical context

As already stated, the specific intervention began following a request from the Athens Tram operator, to consult on the purchase of a new driver's seat. This request was triggered by an alarming percentage of musculoskeletal disorders (MSDs) among the drivers. More specifically, twenty-one drivers (18% of the driver population) had been medically diagnosed with MSDs (tendonitis, epicondylitis, shoulder and neck strain etc.) in just three years of the Athens tram operation. Drivers' representatives were pressing for improvements, and had come to an initial agreement with management to change the driver's seat with a more ergonomic (*sic*) one.

At the time of the intervention, the Athens Tram was a rather young organization, having started its commercial operation in 2004, just before the opening of the Athens Olympic Games. From then on, it is serving three tram lines, operating around 35 tram vehicles. Of the total track length of 27 km approximately, half is on-street, sharing street real-estate with other urban vehicles, and half off-street, with dedicated unfenced track. The tram operates 20 h on weekdays, and 24 h on weekends.

Athens Tram at the time employed 117 drivers. Drivers' age ranged from 25 to 42 years with an average of 31.5 years (108 males and 8 females). Their anthropometric characteristics covered a wide range of values; for example, their stature ranged from 1.64 m (corresponding to the 61th percentile of females) to 1.93 m (corresponding to the 99th percentile of males), while their body mass ranged from 52 kg (corresponding to the 10th percentile of females) to 112 kg (corresponding to the 99th percentile of males). For the anthropometric percentiles the ANSUR data base (Gordon et al., 1988) was used.