Applied Ergonomics 45 (2014) 61–71

Contents lists available at SciVerse ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Developing human factors/ergonomics as a design discipline

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ARTICLE INFO

Article history:
Received 4 April 2013
Accepted 24 April 2013

Keywords:
Design thinking
Technology-in-use
Naturalistic approach
Core-task modelling

ABSTRACT

This paper deals with internal challenges that the human factors/ergonomics (HFE) research faces when wishing to strengthen its contribution to development of work systems. Three established characteristics of high-quality HFE, i.e., HFE takes a systems approach, HFE is design-driven, and HFE focuses on two closely related outcomes, performance and well-being, are taken as a starting point of a methodological discussion, in which conceptual innovations, e.g. adopting the technology-in-use perspective, are proposed to support development of HFE towards the high-quality aims. The feasibility of the proposed conceptual choices is demonstrated by introducing a naturalistic HFE analysis approach including four HFE functions. The gained experience of the use of this approach in a number of complex work domains allows the conclusion that becoming design-driven appears as that most difficult quality target for HFE to reach. Creating an own design discipline identity in a multi-voiced collaboration is the key internal challenge for human factors/ergonomics.

1. Introduction

This paper deals with methodological challenges that the human factors/ergonomics (HFE) research faces when it attempts to increase its contribution to design of complex work systems. I shall discuss the topic on the basis of own experience of HFE research at the Technical Research Centre of Finland, a multi-disciplinary national research institute that is positioned between the academia and the Finnish industry and interacts with both. The research at VTT is motivated by its input to development of technologies and work systems. Also HFE is considered potentially to contribute to technology development, in particularly in the meeting the safety objectives of organisations and in responding to the developing demands on personnel competencies. So far HFE has mainly been applied in improving the operations of the plants and organisations. A need to involve HFE in the design of tools and technologies, or in the planning of future operations, has been identified only relatively recently.

Beyond safety, further objectives, like usability of tools and services and experience concerning their use, have also been identified at VTT as significant motivators for exploitation of HFE. Reaching the usability-driven objectives is considered to have an influence on the performance of the systems. This potential is demonstrated by the interest that the concept of "User Experience" (UX) has raised among some leading companies of the Finnish and international metal industry, resulting in the launch of a large public–private-partnership type of research programme (UXUS, 2010). The emergence of the UX construct characterises the so-called third wave usability research, and it has, in particular, been connected to new business possibilities that the human-centred design could provide (Roto et al., 2011). Usability and UX research originate in the Human–Computer Interaction tradition that has the advantage of having an intimate connection to design activity (Savioja and Norros, 2012).

In spite of some positive signs of change towards acknowledging the role of HFE for the design and development of industrial organisations, we still face the situation both in the safety-critical and business-critical domains that HFE is interpreted as a secondary means in accomplishing the targets of the organisations. Hence, on the basis of my own experience, it is easy to agree with the conclusions of the recent article concerning the strategy of HFE (Dul et al., 2012) that the potential of HFE is underexploited. This applies in particular the stakeholders in the design and management of organisations who typically focus on performance outcome. Several reasons hinder the exploitation of the potential of HFE, such as insufficient awareness of the value of HFE, lack of high-quality HF or too limited scope of the input of HFE, the relatively small size of the discipline, and vagueness of its identity in cross-disciplinary connections.

The present paper continues this discussion, but, compared to the cited article, I will focus more on the HFE internal reasons for still incomplete exploitation of HFE in design. I believe (applying

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0003-6870/$ – see front matter © 2013 Elsevier Ltd and The Ergonomics Society. All rights reserved.
http://dx.doi.org/10.1016/j.apergo.2013.04.024

the idea of Bannon, 2002) that even though industry and engineering research probably share the human-oriented *values* with HFE, and even understand the potential benefits of applying HFE in design, this is not enough. There is a pressing need for *conceptual* innovations for tackling the HFE problems. Such innovations are needed to concretise the three characteristics of a *high-quality HFE* as defined by Dul et al. (2012), drawing on the definition of the International Ergonomics Association: HFE takes a systems approach, HFE is design-driven, and HFE focuses on two closely related outcomes, performance and well-being.

My intention is to propose concepts that would bring depth and concreteness to these three characteristics and, and via these improvements promote the goals of high-quality HFE. In particular I am interested in how to facilitate HFE as a design discipline. The examples from our own research aim to elaborate how we at VTT have attempted to move towards a more design-oriented HFE approach.

2. High-quality HFE – need for change of paradigm

The starting point of my discussion is that the three characteristics of a high-quality human factors/engineering mentioned above are presently taken too much as pre-given ahistorical characteristics of HFE, and the problem of HFE practice is seen as an incapability of realising these features fully, due to external reasons. As an example, the qualification of systemic approach reduces very often to an extended *listing of factors* that are considered in analyses, or as moving the focus of design *from* technology-driven *to* human-driven, of which tendencies even the Dul et al. (2012) paper tends to suffer. What would be needed is focussing on principles of *interaction* and *co-functioning* between elements of a *whole*. I assume that interpreting the three qualifications of HFE rather as goals towards which HFE is currently moving due to the pressures from the working life and modern society, would draw attention more on the needed changes in the basic definitions and content of HFE itself.

The quality attribute systems approach is most intimately related to the pressures of current working life and living environments that increase the complexity of these systems, induce dynamic changes and load the systems with unexpected phenomena. These changes are deeply rooted in the characteristics of the information and communication technology (ICT). While ICT has opened new sources of information, improved storing and transmitting information, and it has enabled new forms of communication, and new ways of organising activities in time and space, people's lives have become completely intertwined with and dependent on this technology. It has become a universally utilised medium in the modern society. Management of the changes in people's work and daily activities, and gaining control of the new medium is still on-going and the transition is mastered insufficiently. In this situation also HFE faces new challenges.

It has even been argued that due to the difficulties in tackling problems emerging from the above sketched broad transformations in work and daily life, HFE faces a pressure for change of paradigm (Hollnagel and Woods, 2005). The cited authors see that the traditional "natural" distinction between human and technology as two separate elements draws the interest to identifying the internal processes of human brain, and technical devices, and the computational connection with the elements in terms of their interaction. As a consequence, difficulties arise to see the wider connection in which the human and machine are situated, and the constraints the environment puts. The authors write further that because traditional ergonomics never questioned the validity of human-machine distinction, it has run to difficulties in reaching the systems view even though claims for such have been expressed widely.

Another example from a paradigm shift that especially HFE experts who work in safety-critical domains have identified regards the concept of safety. The prevailing basic assumption in systems engineering and also in the cognitive engineering is the assumption of a "perfect system" that ideally is reachable when appropriate principles of "defence in depth" are followed in design, and complied with during operations. Due to experience of a number of large accidents much self-reflection is currently going on in safety-related HFE to revise understanding of a safe system. The concept of "resilience" has been brought up as a key concept that would enable a more realistic understanding of safety of systems (Hollnagel et al., 2006, 2011). Central in the proposed new safety paradigm is acceptance of the variability and unexpected events in the system as inherent features of the system that cannot be fully eliminated. Finding concepts to characterise the variability and unexpected events have been proposed (Weick and Roberts, 1993; Weick and Sutcliffe, 2007; Furniss et al., 2011; Pidgeon, 2012) and appropriate means to respond to, and be prepared for them are currently sought intensively in the HFE community.

Pressure for paradigm change is characterised not only by overt difficulties in tackling existing problems, but also by the emergence of optional approaches that are capable of articulating new and more relevant problems. In the issue of identifying the overt problems that HFE faces in solving problems currently I rely on the analysis of Dul et al. (2012). As a complement to that, I shall focus on the optional concepts that are currently emerging within the HFE. Hence, in the forthcoming sections I shall discuss three methodical perspectives that I believe could support development of high-quality HFE. These perspectives are technology-in-use, extended conception of outcome of design, and adopting design thinking in HFE.

3. Technology-in-use

Common to new approaches in HFE is to conceive *human–technology–environment* a unity, and adopt this as the new object of analysis. These approaches offer articulated conceptions to what a systemic HFE could be.

Having first defined the object of design as the human–technology–environment united system, the critical point is to identify concepts and methods that are capable of tackling the functioning of this system in some details. One way is to consider technology from the point of view of its usage, *i.e. technology-in-use*. From this perspective the technological and human elements become automatically inseparable, and their mutual determination becomes evident (Orlikowski, 2000; Hollnagel and Woods, 2005). Several attempts to re-define the object of design of HFE from the technology-in-use perspective are currently under discussion in the international research community. A good example of this line of research is Wanda J. Orlikowski via her analyses of practices and the role technology in the formation of structural properties of social systems (2000). Orlikowski elaborates, e.g., the theories of Giddens (1979) or Bourdieu (1977), and provides a good insight of the ways how technology shapes the rules and resources of organisations.

My own approach to technology-in-use draws on philosophical and psychological theories concerning the human-environment relationship. This background provides several ways to approach technology-in-use. I shall name three which have emerged in our human factors research in different industrial domains. Arguments for these three views may also be found from the distinctions that John Ihde (1990), drawing on the philosopher Martin Heidegger, made regarding how human–technology–environment relationships may be experienced (embodied technology, hermeneutic technology, and technology as the other).