

## HTO - a complementary ergonomics perspective

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**Abstract.** While the broad field of ergonomics and human factors provides a strong potential in systems analysis, design and improvement, the focus risks being perceived unclear for different stakeholders. This paper addresses how focusing the interactions between Humans, Technology and Organization by using the HTO concept contributes to the understanding, communication and use of systems thinking inherent in the discipline of Ergonomics and Human Factors. The authors' experiences illustrate how the use of the HTO concept in various industries and in academic teaching gives advantages regarding interactions, communicativeness, attractiveness, activity and pedagogical benefits.

**Keywords.** Systems perspective, Interaction, Human Factors, Activity.

### 1. Introduction

The multidisciplinary basis in the Human Factors and Ergonomics (HFE) discipline provides a strong potential in analysing, designing, and improving systems performance in operations of various kinds. On the other hand, just because the discipline spans over such broad fields, there is a risk that the focus and the content are perceived unclear. As a result it is difficult to communicate its potential value to different stakeholders and promoting education of Ergonomics and Human Factors specialists as pointed out by Dul et al. (2012). These dilemmas are now under scrutiny within the HFE scientific domain. The need for clarifying the focus and content of the discipline is discussed in the special issue Systems Ergonomics/Human Factors in Applied Ergonomics in which Wilson (2014) argues that the focus should stress the interaction between systems' constituents rather than the activities or entities themselves. Hollnagel (2014) claims in line with this that there should be an emphasis on what the system does rather than what it is. This conveys the idea of a dynamic system with on-going activities that concurrently continue to transform the system itself, which adds to further complexity. The authors of this article agree that these properties are highly important in identifying and communicating the HFE discipline. In order to clarify the systems perspective of HFE and focus on the interaction between the constituents to avoid limiting interpretations, the Human-Technology-Organisation (HTO) concept has been used and elaborated by the authors as well as by other researchers.

The aim of this paper is to address how the HTO concept can contribute to the understanding, communication and use of systems thinking inherent in the HFE discipline.

### 2. Ergonomics and Human Factors development

Historically Ergonomics and Human Factors have multidisciplinary roots and became a recognized scientific discipline in the late 1940s. In the UK the development of the

discipline led to the formation of the two subgroupings anatomy/physiology and experimental psychology. In parallel, there was a growing Human Factors discipline in the United States strongly influenced by the discipline of psychology and engineering. In Scandinavia, Germany and the Netherlands the basis for ergonomics evolved from work in medicine and functional anatomy while it in Eastern Europe largely grew out from the industrial engineering profession (Wilson, 2000; Singleton, 1982). Among people in general, the term ergonomics has often been associated with physical aspects and individual factors (Wilson, 2000). In the US, the terms Human Factors or Human Factors Engineering have been used. The terms ergonomics and human factors are now used more or less synonymously although they can be derived from partially different research traditions. The HFE acronym is by now used frequently and it is used for the remainder of this paper to denote the discipline.

In several disciplines, the need for a holistic view as a complement to the reductionist research approach became apparent with the development of systems theory about 70 years ago. The whole system is more than its parts, and in order to understand the whole system, understanding of both the parts and their interactions is needed (von Bertalanffy, 1972). This has largely influenced research in such different areas as biology, engineering and organisational development. This development also occurred within HFE with influence from different disciplines involving systems thinking (Wilson, 2014). In order to strengthen the awareness of the systems view and a holistic perspective in the organisational development focus of ergonomics (ODAM), different models have been proposed and used, illustrating the different constituents and their interactions, for example Porras & Robertson (1992), Eklund (2003), Rollenhagen (1997), and Carayon et al. (2006). The different models proposed have different methodological approaches regarding how to structure and analyse the system, which to some extent reflect that they are developed for different purposes.

### **3. Development and specifics of the HTO concept**

The conceptual idea of HTO is that most activities can be sufficiently described, analysed and understood at a systemic level by describing the interactions between the main subsystems humans (H), technology (T) and organization (O). "H" can be defined as the description of the human at four levels being 1) a biological energy processing system; 2) an information processing system; 3) a psychic subject with a unique history and 4) a member of social groups and cultures (Daniellou, 2001). "T" can be defined as means for the transforming of input to output using artefacts, procedures, and methods including know-how (Porras & Robertson, 1992). Finally "O" can be defined as a consciously coordinated social entity, with a relatively identifiable border, which is relatively continually working for reaching common goals (Robbins, 1990).

The HTO concept is today a well-established unifying concept within the Swedish nuclear industry (Strålsäkerhetsmyndigheten, 2014). The concept initially had a strong connection to nuclear power plant safety but has over time acquired a wider application. Today it includes different aspects of interaction between the subsystems human, technology and organization in various operations and settings related to systems performance, safety and health issues. By focusing the interaction between the three major interdependent subsystems H, T and O the concept is easy to grasp. The interaction further indicates on-going activities in a dynamic system and conveys systems performance as a whole (compare Wilson, 2014 and Hollnagel, 2014). The systems performance is directly dependent on how well the interactions work between the three subsystems, making them all important to take into account (Ahlin, 1999; Berglund & J. Karlun 2007; Eklund, 2003;

A. Karlton, 2011).

The HTO concept is akin to socio-technical systems theory but with an important difference. It includes humans as a separate main subsystem at the same level as technology and organization, thereby emphasising that the interactions with humans are at the core of the systems performance. This makes it possible to view the humans from different perspectives. For example, humans can be viewed both as actors in the system, exposed to the system, cooperating in the system or learning in a technical organizational context (Westlander in Ahlin, 1999). Such views in turn affect both analysis and results and open up to understand conditions which otherwise would not be apparent (A. Karlton, 2007). The authors have experienced that the HTO concept has potential benefits in a number of aspects discussed below.

### *3.1 Interactions*

The HTO concept is intuitively associated with the three subsystems Humans, Technology and Organization. By describing the subsystems it makes it easier to approach also constituents that are not within one's special domain and acknowledge the need to bring knowledge of the other constituents into a thorough analysis. The concept highlights the interactions that take place. It therefore makes users more aware of the different interactions that exist as a key to understanding the overall system. Since the interaction is highlighted in the concept in an apparent and systematic way, stakeholders seem to perceive it more tangible and to better understand that human interaction with products and work systems is far more than "common sense" and may be handled in a structured way with a systems perspective.

### *3.2 Communicativeness*

The problem mentioned above regarding the difficulties of communicating the potential value of HFE to different stakeholders due to its complexity has turned out to be facilitated by using the HTO concept – be it potential students, organizations, or clients – regarding aims, applications and benefits. The authors argue that one reason for this is the neutral connotation of the HTO concept, which has advantages in communicating to a wider group of stakeholders. Communicating a visual HTO concept further facilitates the understanding of the concept, the subsystems and the interactions. In this way, it is also easier to position one's own focus in relation to the subsystems, communicating to project members, students or stakeholders that e.g. a project focuses on certain aspects of the concept and how that aspect is situated in relation to the overall system.

### *3.3 Attractiveness*

Stakeholder groups such as managers and technicians are easier to attract because the HTO concept conveys functionality and systems performance and thus relates to their responsibilities and duties to a greater extent than health and wellbeing benefits, which HFE imply. Especially the term ergonomics evokes thoughts on reactive and costly measures to adapt the work environment rather than inferring investment and increased systems performance. This seems to be a deeply culturally rooted connotation and attitude of ergonomics that is difficult to change. By attracting managers, access is also created to organizational layers with more powerful mandates to make decisions regarding HTO measures. When comparing the use of the terms ergonomics and HTO among engineering students, it has become obvious that the engineering students consider that it will not be their responsibility to work with ergonomics in their future working life. However, they consider that their task might be broader than responsibility for the technology, i.e. responsible for systems performance. The HTO concept is thus more attractive. Still HTO

is attractive for HFE professionals as systems performance affects health and wellbeing and vice versa.

### *3.4 Activity*

Human activity is at the core in all organizations, and coordinating these in a well functioning way is the main task of all organizations. The activities form (more or less dynamic) processes and on an aggregated level constitute the organization's operating system. Positioning individual work activities within an HTO concept has proven to facilitate individuals' understanding of their own contribution within the overall work system. In most cases, the added value of a system cannot be reached without an activity performed by or for a human being; this is what the system does.

### *3.5 Pedagogical benefits*

Since the HTO concept is easy to visualize, it offers a pedagogical tool for conveying a way of structuring organisations and work systems, a way of analysing the systems as well as a basis for improving the systems. This applies for both education and R&D. Furthermore, the HTO concept has been brought forward in academic courses in Product Ergonomics and Customer Focused Product & Service Development in order to enhance and expand the systems perspective in the user-environment relationship.

## **4. Experiences of working with the HTO concept**

The authors have experiences from working with the HTO concept in a number of contexts, in different constellations and with various stakeholders, as well as with varying objectives, as described below.

### *4.1 HTO – teaching students*

A master's program in ergonomics was started in Sweden in 1996 through collaboration between two national universities and the national Working Life Institute (closed down in 2007). The content of the program matched the HFE systems perspective. It turned out, however, that the program attracted a surplus of physiotherapists and occupational therapists, probably because the term ergonomics was associated to the physical and individual conception of the discipline.

In order to attract students from other disciplines, the program title was changed to "Master in Ergonomics / Humans, Technology and Organisation in 2007. A separate course in HTO was added to the program and the HTO concept now constitutes a common thread through the program courses focusing to a higher degree on the systems perspective and the dynamics in the interaction between the subsystems. This shift has proven to be more attractive for students from other disciplines such as engineering, social science, behaviour science, cognitive science, organizational science, etc. The exchange between students with different academic background has furthermore contributed to convey a richer systems approach through different disciplinary perspectives.

### *4.2 HTO – research and development*

The focus on improving systems performance has likewise proven easy to communicate with managers and decision makers via the HTO concept. Below, some examples of HTO-focused projects within different domains are presented.

In an interactive research-supported work for change within the Swedish mail distribution division, the HTO concept was used as a systems perspective during investigation, analysis, design and implementation of measures as well as training managers at different levels in the organization. The HTO concept was also used as a pedagogical tool to educate managers in understanding how actions promoting good interaction between subsystems contribute to smoother flows and activities and thereby increase overall systems performance. For example, the postmen increased their capacity of mail sorting by introducing a number of HTO improvement measures including organisational and technical improvements as well as enhanced cognitive and physical working conditions (A. Karlton, 2008; A. Karlton & Eklund, 2008). By concentrating on the three main subsystems, H, T and O, it was comparatively easy to keep focus on the interaction between them, which in turn supported managers and employees to understand and accept what measures needed to be developed and implemented to address the problems at hand.

#### *Fork lift truck drivers*

In a study of working conditions for fork lift truck drivers, the HTO analysis of driver activities revealed activities that caused risk situations for the drivers' health. These activities also caused time losses due to the difficulties they imposed on the drivers. Ergonomic improvements were tested and found to decrease the risks for the drivers at the same time as the activities could be performed more rapidly. An economic calculation indicated that the ergonomic improvements were profitable. The relationships between the costs for manpower, for the fork lift truck and for other types of costs clearly illustrated the benefits of using the HTO concept in analysing the consequences of the ergonomic improvements (Nolimo Solman, 2002).

#### *Meat cutters*

In an effort to improve the working conditions for meat cutters in the whole Swedish meat industry the HTO concept served as being one of the main structures for organizing this work in different industry development groups. The HTO concept was also used to analyse, communicate and comprehend results from different development efforts into a more holistic understanding of the industry. Moreover, it served as a tool for focusing research and finding key factors where additional knowledge were likely to contribute to the improvement of meat cutters' work (J. Karlton et al., 2014).

#### *Production planning and scheduling*

In a study to gain deeper understanding of how production planning and scheduling is carried out in practice, the HTO perspective served as an analytical tool to describe the complexity of everyday planning and scheduling work (Berglund & J. Karlton, 2007). It demonstrated that this work is strongly influenced by human aspects (the planners' skills and capabilities) but also on organizational structures and technical systems. The HTO-perspective in this study facilitated the development of a systematic description and analysis of the planners' multifaceted work.

## **5. Conclusions**

This paper shows the convenience of the HTO concept in facilitating the understanding, communication and use of systems thinking potentiated in the HFE discipline by emphasizing 1) interactions, 2) communicativeness, 3) attractiveness, 4) activity, and 5) pedagogical benefits. The authors' experiences in the empirical examples

illustrate how the HTO concept has been used in various industries and in academic teaching in order to enhance communication and comprehension during interventions. It has been applied in investigation, analysis, design, and implementation as well as being used as a pedagogical tool to increase the understanding of systems performance and the benefits of applying a HFE systems perspective in operations.

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