A systems ergonomics approach to engineering design projects

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Abstract: How can a systems ergonomics approach be applied in practice? This is a challenge many ergonomists faces. In an industrial case, we illustrate how ergonomists can learn and adopt the system features: system focus, context, interactions, holism, emergence, and embedding. We conclude that using a visual work system model is a good starting point for developing systems ergonomics skills.

Keywords: Systems ergonomics, engineering design, practitioner training.

1. Introduction and research focus

In recent years, many researchers within ergonomics and human factors (E/HF) have pointed to the discipline as a systems discipline. In his seminal paper, Wilson (2014) states: *"There should be few researchers or practitioners in ergonomics/human factors (E/HF) who do not think of it being a systems discipline, and of themselves as taking a systems-oriented perspective".* In Wilson's definition *"systems ergonomics examines, accounts for an enhances the design of a system, and people's interactions with it, rather than concentrating on an individual part of it."* He proposes an E/HF systems framework including six defining features: system focus, context, interactions, holism, emergence, and embedding. This is a general framework that needs to be operationalised in order for ergonomics practitioners to take advantage of it.

The aim of this paper is to revisit and re-analyse a previous research program on workspace design (Seim & Broberg 2010, Broberg 2010, Seim & Broberg 2014) in order to discuss and illustrate how practitioners can work with the six features in practice. We focus on an interactive research project (Eklund et al. 2008) with a dual aim: 1) organising industrial workers' participation in an engineering design project, and 2) training ergonomics practitioners (OHS consultants) in a new design and systems oriented practice when consulting companies.

2. Methodology

The overall methodology was to reanalyse a previous case study, in which researchers intervened in an engineering design project in a company in order to set up a participatory design process. In the original study we collected data by means of semi-structured interviews and participant observation. Further, we facilitated the workshops that were an important instrument to foster workers' participation in an engineering project. We re-interpreted the process and the tools applied in terms of Wilson's framework to see how each feature played out. We then summarised the learning in terms of how a systems ergonomics perspective can be made useful for practitioners.

The case was about the design of a new mixing facility in an industrial plant. A team of researchers and OHS consultants were invited by the company to organise an intervention in the design

process aimed at involving the future workers of the new facility. The intervention included applying tools and methods for understanding the current work practice, setting up workshops with design engineers and workers, and applying tools such as walk-through in existing facility, picture work book, layout design game, scenario-based simulations, and facility OHS requirements. (Seim & Broberg 2010)

3. Findings

The intervention process and tools could clearly be interpreted as a systems ergonomics approach. To help understand the *system focus* we introduced a work system model (Figure 1). The SOFT model, which regards the work practice as embedded in four interdependent elements (Horgen et al. 1999): space (S), organisation (O), finance (F), and technology (T). The model was useful in scoping and focussing the intervention. Further, it facilitated a work system perspective on the technical engineering design project. In setting up the intervention the team investigated and negotiated the frames and networks surrounding the engineering design project. Having the SOFT model in mind, the intervention team enquired into the status of the design project by asking what in the four corners was open to alternative options and what seemed to be closed. The SOFT model also pointed to relevant actors to be considered as participants in the intervention activities, and could thus be used as a tool for stakeholder analysis

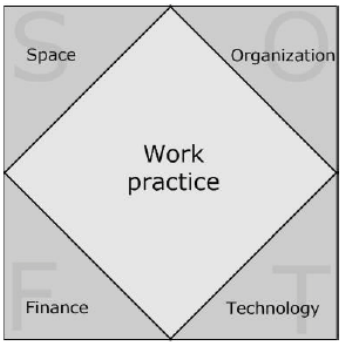

Figure 1: The SOFT model (Horgen et al. 1999)

In order to understand the *context* of the intervention, we applied a number of tools to map the current work practices: Interviews with management, a walk-through in the current facility by the intervention team, including contextual interviews (Beyer & Holtzblatt 1998). By sticking to the SOFT system model the participatory workshops developed a new design of the facility that transformed the engineering focus on piping design (T) into design of human-machine *interactions* (O, S and T).

Our approach additionally demonstrated *holism* in cutting across the E/HF sub-disciplines of physical, cognitive, and organisational ergonomics. Facilitating input from workers and OHS consultants in both mapping current work practices and in the design project resulted in all three sub-disciplines being addressed simultaneously. Holism was also demonstrated by help of the SOFT model, which emphasizes the need to consider all four systems elements and their interdependence. The *emergent* properties of the system were illustrated in two ways: in the mapping of the current work practices, it was revealed how workers had to do many unintended tasks to keep the current technology running. This realisation was included in the design project as a useful input to the new facility design. Further, an overseen requirement from the fire authorities suddenly made it apparent that one of design proposal made by the design engineers did not comply with legislation. It was the employees that pointed to this overseen requirement.

Overall, the emergent feature of the system illustrated to the OHS consultants how the engineering design project could be reframed by mobilising new system actors, the workers and the fire authorities.
We as researchers got access to the company organisation and we completed a participatory process not known to the company and the OHS consultancy before. However, we were outsiders but trying to learn the company how to *embed* E/HF in design projects and other change projects by help of a participatory, systems ergonomics approach.

4. Conclusion

We conclude that applying a systems ergonomics approach in practice requires skills development, models, and tools. Visualizing a systems model, like the SOFT model, is a good starting point. At the surface, it is easy to understand, and it "forces" you to look for all elements in the specific context of taking part in a design or change process or in improving an existing part of a workplace.
Further, the learning by doing training approach seemed to be an important 'mechanism' for the ergonomics practitioners to develop systems skills. Working actively with the SOFT system model in a real-world case proved to be an eye-opener towards practising systems ergonomics. Finally, the ergonomics practitioners learned how a participatory approach to systems ergonomics was enabled by using tangible artefacts for representing the system in the design phase of the project.

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