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Human factors for a sustainable future

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ABSTRACT

Current human activities are seriously eroding the ability of natural and social systems to cope. Clearly we cannot continue along our current path without seriously damaging our own ability to survive as a species. This problem is usually framed as one of sustainability. As concerned professionals, citizens, and humans there is a strong collective will to address what we see as a failure to protect the natural and social environments that supports us. While acknowledging that we cannot do this alone, human factors and ergonomics needs to apply its relevant skills and knowledge to assist where it can in addressing the commonly identified problem areas. These problems include pollution, climate change, renewable energy, land transformation, and social unrest amongst numerous other emerging global problems. The issue of sustainability raises two fundamental questions for human factors and ergonomics: which system requires sustaining and what length of time is considered sustainable? In this paper we apply Wilson (2014) parent-sibling-child model to understanding what is required of an HFE sustainability response. This model is used to frame the papers that appear in this Special Issue.

For most of human history (and pre-history), the worldwide population size was sufficiently small that humans either did not experience significant resource loss, they were able to re-locate, or resources were able to naturally regenerate. However, as the human population has expanded, the pressures on resources have become more prevalent. Sustainability is essentially an issue of resource scarcity or damage; either at present or at some projected time in the future (Johnston et al., 2007). Sustainability concerns manifest as resource depletion or absence, as resource degradation, as the deliberate or accidental damage of resources for short-term gain, or as a misunderstanding of the complex inter-relationships between resources and systems (Thatcher and Yeow, 2016; Wilson, 2014). Sustainable development, on the other hand, is often attributed to Brundlant's World Commission on Environment and Development (WCED, 1987) definition: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The WCED definition emphasises human social development that should be considered over an inter-generational time frame. According to Johnston et al. (2007), there are now hundreds of variants to the original WCED (1987) definition. In reviewing the most commonly used definitions of sustainable development, Thatcher (2014) recommended that the definition most appropriate for human factors and ergonomics (HFE) is the MONET definition (Altwegg et al., 2004, p. 14) which:

> "means ensuring dignified living conditions with regard to human rights by creating and maintaining the widest possible range of options for freely defining life plans. The principle of fairness among and between present and future generations should be taken into account in the use of environmental, economic and social resources. Putting these needs into practice entails comprehensive protection of bio-diversity in terms of ecosystem, species and genetic diversity, all of which are the vital foundations of life."

The MONET definition extends the WCED (1987) definition by putting greater emphasis on the balance between human and natural resources, while incorporating the triple bottom line perspective of social, economic, and natural capital. Over the last two decades several authors have outlined how they think HFE can contribute to issues of sustainability and sustainable development (Drury, 2014; Hanson, 2013; Moray, 1995; Nickerson, 1992; Steimle and Zink, 2006; Thatcher, 2013; Zink, 2014). These authors have concentrated on theoretically outlining the many places where

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human factors and ergonomics (HFE) can contribute to addressing sustainability issues. Despite a rather slow response, empirical work providing HFE solutions to sustainability problems is gradually gaining momentum. This Special Issue focusses specifically on applied efforts within the field of HFE that support a sustainable future. These efforts have taken place at various different levels; from micro-ergonomic interventions that have looked at how we design interfaces to use resources more efficiently to macro-ergonomic interventions that demonstrate how organisations can operate more efficiently. In this paper, we provide a framework that helps us understand how existing and future HFE interventions at different levels of impact might fit together to form a coherent whole.

1. A sustainable future?

For the greater part of two hundred thousand years the impact of human activity on the ecosphere that supports humankind was fairly negligible. Arguably, this changed around 200–250 years ago when the industrial revolution and the associated development of work technology, radically reorganised the way in which work was performed. From a human wellbeing perspective, the results were significant improvements in working conditions (i.e. less manually-intensive work and increased machine-based work) and living standards (i.e. widespread access to products, food, and services that were previously only accessible to the rich) for large parts of the world. Subsequent "revolutions" (i.e. the development of electricity as an indispensable commodity followed by significant advancements in medical care) saw further improvements in human wellbeing. The key question then is whether these developments can be sustained into the future (i.e. future generations are able to enjoy similar or better wellbeing, working conditions, and living standards than the current generation).

While the "revolutions" have undoubtedly increased the average standard of living, as well as the physical health and psychological wellbeing of the majority of humans (Hecht et al., 2012), the unintended consequence has been a significant growth in the human population and the resources required to provide sustenance to this burgeoning population (Vitousek et al., 1997). For example, Hecht et al. (2012) noted that the global population grew from 2.5 billion in 1950 to 7 billion by 2011 (almost a three-fold increase in six decades). Recently we have seen that this has resulted in extreme pressures on the carrying capacities of various ecosystems and their ability to maintain equilibrium. This has manifested as an imbalance in a number of human systems, including unequal access to food, shelter, basic sanitation, healthcare, jobs, energy, clean water, education, consumer goods, productive land, and communication infrastructure (Hecht et al., 2012). The resultant human consequences have inevitably been increased conflict over dominant ideologies and resources (e.g. land for farming, agriculture, and cultural uses, raw materials for energy production and consumer goods, and essential resources such as clean water), and the widespread distribution of communicable diseases, famine, unemployment (or unfair labour practices), and poverty (Munasinghe, 2011). The damage to the ecosystems that support our existence is particularly troubling amidst the growing concern over climate change, the loss of biodiversity, changes in worldwide biogeochemistry cycles, land transformation, and the potential decline in non-renewable energy resources on which we depend (Beddoe et al., 2009; Vitousek et al., 1997). These problems are complex and interconnected as demonstrated in Table 1.

The fact that these issues are primarily due to human (anthropogenic) activities has been scientifically established beyond any reasonable doubt (Oreskes, 2004; Vitousek, 1994) and evidence suggests that these issues are worsening (Cox et al., 2000; Intergovernmental Panel on Climate Change, 2013). All these anthropogenic environmental influences have also been linked to serious negative human health and well-being effects (Pimentel et al., 2007; Schmitz, 2007; Poon et al., 2016) including increases in respiratory problems, cancers, immune system defects, and birth defects. In addition, global warming effects have accelerated poverty and led to malnutrition and the spread of diseases that were previously unknown in certain geographical regions (Martens, 2013).

Can HFE provide support in addressing these sustainability issues? The problems are clearly human-created (see Fig. 1) and therefore it is also possible that they can be resolved through concerted human effort. In HFE, this means looking at ways we can assist in the design and implementation of sustainable systems that support appropriate behaviour and ensure sustainability. Corner et al. (2014) argue that this should be underpinned by appropriate human values towards the environment and humans' role in the environment. In fact, Lange-Morales et al. (2014) have already suggested a set of sustainability values for the HFE community: respect for the Earth, respect for human rights, respect for ethical decision-making, respect for transparency and openness, appreciation of complexity, and respect for diversity. These values also mean moving beyond approaches that seek to maintain a human dominance over natural systems, or at best providing solutions that leave things "as they are". Instead, work should be encouraged that seeks to redress past harm and to promote restorative and regenerative approaches (see the Living Building Challenge, the Living Product Challenge, biomimicry, and Cradle-to-Cradle design as examples). There is the concern, though, that the small local interventions typical in much of the HFE work would not transform into the necessary global impacts. However, Meadows (1999) identified "levers of change" within complex systems (e.g. breaking the power of positive feedback loops such as birth rates or interest rates, providing information feedback to the right people at the right time, and providing people and systems with the ability to self-organise), some of which will be familiar to the HFE community. With "levers of change", small changes can result in large changes in the outcomes of complex systems. Similarly, Wise et al. (2014), working in the global climate change adaptation space, have noted that a continuous cycle between incremental (small changes) and transformative actions is required to support sustainable adaptations.

2. Sustainable systems in HFE

In their paper on the future of HFE, Dul et al. (2012) noted that HFE primarily takes a systems approach. It is important for us to understand what is meant by a system in HFE. A system is an organised whole with interacting components contained within the boundaries of the whole (Wilson, 2014). In HFE, we are most concerned with the interactions between the components in the system rather than the components by themselves. To paraphrase Wilson (2014), from an HFE perspective a chair is not a system but a human interacting with that chair is a system. As Zink (2014) has demonstrated, it is therefore obvious that the design of sustainable work systems also requires a systems approach. A dictionary definition of a sustainable system is quite straightforward, suggesting that it is simply a system that can persist indefinitely (Costanza and Patten, 1995). However, this definition does not address the questions of (1) which sustainable system needs to be considered and (2) what time frame is considered sustainable (Costanza and Patten, 1995) in the HFE context. The following sections address these two questions.