Design for humans

What is human factors/ergonomics and why is it relevant? **STEVEN SHORROCK** explains with a stove analogy, and challenges H&S practitioners to engage with the subject.

Have you ever turned on the wrong burner on your stove? I am almost certain that you have. I do, often. If the consequences were more severe I would check the little diagram often, too. But I would still make mistakes, mostly because the layout of the stoves is incompatible with the layout of the dials, which look identical and are co-located. The dials are on a vertical panel at hip height. If the consequences were more severe, cooker designers might be forced to design the controls with users in mind.

And yet, this sort of problem remains in some safety-critical industries. In January, there was large scale distress in Hawaii when a missile threat test warning was inadvertently broadcast to residents. The false alarm was blamed on 'human error', but when we look just beyond this predictable throwaway 'cause', we find among a bizarre jumble of menu options 'PACOM (CDW) – STATE ONLY' (which was selected) and 'DRILL – PACOM (CDW) – STATE ONLY' (which should have been selected).

This has similarities with a series of accidents during the Second World War, when B-17 Flying Fortresses bomber pilots retracted the landing gear instead of the flaps. Psychologist Alphonse Chapanis identified the problem of controls that were co-located and looked and felt alike. He fixed it by designing an intervention that met user needs: he made the controls for the flaps and wheels look and feel like a miniature flap and wheel. The discipline of human factors and ergonomics (HF/E) was born.

USEFUL DEFINITIONS

So what is HF/E? The formal definition by the International Ergonomics Association (the umbrella association for national HF/E societies) is:

"Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance."

Another simpler definition was provided by the late John Wilson, who later defined 'systems ergonomics and human factors' as: "*Understanding the interactions between people and all other elements within a system, and design in light of this understanding*". Simpler still, HF/E is sometimes referred to as 'Design for human use'.

Since the 1950s, HF/E researchers and practitioners have come from various academic backgrounds and increasingly a wide variety of professional backgrounds and industries. We work with all sorts of people at all levels: consumers and service users, front-line and support staff, supervisors and senior management, regulators, policy makers, even judiciary, in almost all industrial sectors.

INTERACTIONS ARE THE KEY

The focus on *interactions* differentiates HF/E from other design and engineering disciplines. At a *micro* level, we have basic interactions such as pulling a lever, pressing a button, selecting a menu item, or hearing an alarm. At a *meso* level, elements

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and interactions combine to bring more complexity, such as communication and coordination between a pilot, co-pilot, and cockpit. At a *macro* level, this increases further, perhaps expanding to interactions between air traffic controllers, air navigation equipment, ground staff, airport, airspace, management, regulation, etc. For industrial applications, HF/E seeks to optimise the *design of work*, but with a focus on work-as-done, and not simply work-as-imagined.

Our approaches try to reveal system interactions and influences. We use methods for data collection, analysis and synthesis, to understand and map system interaction at every stage of the life cycle of a system or product. HF/E can therefore help in the design of interactions in the context of:

- artefacts (eg equipment, signs, procedures)
- designed environments (eg airport layout, airspace design, hospital design, lighting)
- planned organisational activity (eg supervision, training, regulation, handover, communication, scheduling)
- work and job design (eg pacing, timing, sequencing, variety, rostering, critical tasks)
- emergent aspects of organisations and groups (eg culture, workload, trust, teamwork, relationships).

TYPES OF THINKING

I like to think of human factors and ergonomics as rooted in four kinds of thinking:

- *systems thinking*, including an understanding of system goals, system structure, system boundaries, system dynamics and system outcomes;
- *design thinking*, including the principles and processes of designing for human use;
- *humanistic thinking*, emphasising human agency, awareness, wholeness, intention, meaning, values, choice, and responsibility; and
- *scientific thinking*, purposeful thinking that aims to enhance scientific understanding by problem specification, hypothesising, predicting, observing, measuring, and testing.

The ultimate goals of this thinking and design activity are to *optimise human well-being and overall system performance*.

While a science by definition, in practice, HF/E – like health and safety – is a blend of craft, engineering and applied science. Especially as the lens widens – from micro through meso to macro – so does the number of goals, needs and system or design requirements that need to be considered. So HF/E practitioners help to optimise or balance several goals concerning the effectiveness of purposeful activity (such as efficiency, productivity, maintainability) and particular human values (such as safety, security, comfort, acceptance, job satisfaction, and joy). Some goals are usually of higher priority than others for particular applications, but they often conflict and compete, requiring practical trade-offs, in management, design and operation.

BASIC PROBLEMS REMAIN

Despite the knowledge and skills available to design for human use, it is remarkable that so many basic design problems remain in many industries, 70 years since the beginnings of HF/E. In healthcare, for instance, different medicines look alike and sound alike. There are thousands of machines with design problems so basic as different number formats; in a single hospital, one can find pumps with keypads that are like a telephone, like a calculator, and like neither.

The symptoms of these design problems are usually termed 'human error', which neatly sidesteps the underlying problems and the responsibility for fixing them. This shows how far ahead of its time was the work of the pioneers of the 1940s, who put this 'throwaway cause' in inverted commas, 70 years ago. Interestingly, it was Chapanis who designed the standard telephone numerical keypad configuration that is in use today on every telephone and smartphone around the world. He tested six configurations of buttons, two vertical, two horizontal rows, and different three-by-three arrangements. All of these variations can still be found in safety-critical equipment. And most of the problems in using flight deck controls cited in a landmark report by Paul Fitts and Richard Jones in 1947 can still be found in safety-critical equipment used for mining, oil and gas extraction, agriculture, forestry, fishing, manufacturing, construction, recycling, digital products, telecommunication, transport, and healthcare. So why hasn't HF/E managed to crack the design problem?

NO CLEAR ELEVATOR PITCH

One reason may be a failure of branding and marketing. HF/E specialists have not come from marketing backgrounds are not typically good at it. For a start, HF/E is a discipline and profession with two names: human factors and ergonomics. The terms are seen as equivalent in the discipline, but different in industry and the media (with 'human factors' associated with accidents, and ergonomics associated with 'design').

The focus on 'system interactions' appears to be lost to most outside of the profession. We don't have a clear elevator pitch, and HF/E is not instantly

Courtesy the author

Examples of non-standard keypads on two pumps used in hospitals.

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recognised and understood by the public in the way that we would like it to be (with 'ergonomics' being associated with office furniture, and 'human factors' being associated with, well, nothing really).

Health and safety specialists will empathise with these issues ...

LACK OF AMBITION

A second reason may be a failure of ambition and lobbying. In his blog, Brian Sherwood-Jones (2009) argued that "*many ergonomists are committed to an entirely technical career and have no aspirations to management. … The consequence of staying technical is of course that you will be ignored, overruled and brought in when it is too late to do anything useful, but not too late to demonstrate that ergonomics can fail.*"

There are few (often no) qualified and experienced HF/E specialists on company boards, in national regulators (even aviation), or policy makers, let alone governments. It seems that HF/E specialists have been happiest at the micro and meso levels of interaction design, and not at the macro level, despite the systemic adverse influence of top-down interventions on system and human performance (eg when governments set performance targets).

SHORTAGE OF PEOPLE

A third reason is a shortage of qualified HF/E professionals (accredited, certified, registered or chartered), which is also associated with limited demand and a shortage of HF/E courses. In many countries, there are few or no HF/E professionals even – or especially – in sectors with the highest number of 'avoidable deaths'.

In England, there are 233 National Health Service providers of urgent and planned health care ('secondary care'). NHS England is an organisation of over one million staff, with a planned expenditure for 2017/18 of over £123bn. It espouses a focus on 'patient safety', and its focus areas for 2017/2018 clearly require HF/E expertise, including improving investigations, reducing medication error, and "*an approach to patient safety is widely recognised as world-leading*" (NHS England, 2018). The number of qualified full-time HF/E specialists in NHS England care providers can be counted on one hand.

Despite this shortage of HF/E specialists, HF/E is becoming more popular, and is booming in certain sectors, where success seems to have begat success. 'Ultra safe' sectors such as air traffic management, rail and nuclear power in the UK have well developed HF/E capabilities. The human factors department of NATS – the UK's en route air traffic control provider – has been staffed by 20-30 full time HF/E specialists (a mix of HF/E and psychologists) over the past 15 years or so. This is, however, more than the rest of all other European air navigation service providers combined.

GAINING CURRENCY

Over the last decade or so, the term 'human factors' and HF/E issues have gained currency with an increasing range of people, professions, organisations and industries. This is a significant development, bringing what might seem like a niche discipline to a wider set of stakeholders. In healthcare, there is now significant participation in discussions about 'human factors', which can be seen especially on Twitter. The same can be seen in other industries, especially new sectors such as web operations and engineering. Front-line workers know that HF/E is relevant. The difficulty seems to be in getting commitment at upper levels.

The criticality of HF/E is not in dispute. So how to gain more traction on designing for human wellbeing and system performance? One way is of course more training opportunities. Another is more lobbying for HF/E posts in commercial, governmental, and inter-governmental organisations. Certain roles, typically involving a wide and deep level of content and method expertise, will always require highly qualified and experienced HF/E practitioners (eg certified, registered, chartered). But this has been tried for decades, with limited success.

So the other half of the solution is to spread HF/E to others, who might be familiar with certain aspects of HF/E theory and method, practising certain aspects of HF/E design, or advocating or evangelising HF/E principles, but who are not HF/E specialists as such. (The founders of HF/E were not HF/E specialists then, and some were probably too specialised to qualify as HF/E specialists today!)

This is where health and safety practitioners come in. If the idea of designing for human use to optimise performance and human wellbeing appeals to you, then now is a good time to think about how you might learn more, and integrate HF/E into your practice. ■

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