Human factors in the digital world enhancing lifestyle—the challenge for emerging technologies

LEELA DAMODARAN
HUSAT Research Institute, Loughborough University, Leicestershire LE11 3TU, UK.
email: l.damodaran@lboro.ac.uk

(Received 8 April 2001, and accepted in revised form 11 May 2001)

Life at the beginning of the 21st century is characterized by the ever-increasing pace of technological development and the associated changes in patterns of communication, work and leisure. This paper comments on some of the benefits and limitations of current technology, the potential of emerging technologies to deliver enhanced quality of life for all on a global basis, and the role of human factors in enabling such a vision to become a reality. The author presents an integrative framework for the human factors (HF) domain. In this framework the key HF inputs to be made at each stage of the innovation design life cycle are identified, as well as the crucial enabling processes associated with change management necessary for HF to have a significant impact. Combined together, these elements constitute a human factors strategy. The author suggests that such strategies have a powerful capability to harness information and communications technologies and to ensure the delivery of wide-ranging benefits.

KEYWORDS: human factors strategies; design for all; human centred design.

1. The promise of emerging technologies

Harold Varmus, Director of the National Institute of Health in the USA observed that “There are three great themes in Science in the 20th century—the atom, the computer and the gene” (Kaku, 1998). The focus of this paper is on one of these great themes—the computer, its impact on our lives now and into the future, and the potential we have for influencing that future. Further, it modestly follows from and is inspired by Gaines (1999) “… we will need greater understanding of the operation of our societies, their economies, politics and cultures, and how these evolve under the influence of environmental factors including advances in information technologies.”

There is abundant evidence of the pervasiveness of information and communications technologies (ICT). Recent additions to everyday vocabulary reveal the extent to which use of these technologies already permeates our lives. Phrases such as, “what’s the URL?” “text me” “the GPS says we’re going the wrong way” reflect normal discourse amongst regular users of the internet, mobile phones and in-car navigation systems. Further evidence from an in-depth survey by the Institute for the Future (Institute for the Future, 1998) about household use of technology worldwide shows that in “connected” households a rich infrastructure of information technologies is evolving within the home. Such
evidence reveals the existence of a privileged category of citizens who have access to much that is offered by state-of-the-art technology in both their personal and their professional lives. Routinely, they use a multiplicity of systems and services that together offer many significant advantages to professional activity, learning, leisure, entertainment, travel, health and every other aspect of human life. Being connected means you have ready access not just to information but also to other people across the globe. Another analysis by the Institute for the Future (1997) shows the major shift which has already taken place since 1980 regarding the availability and usage of ICT and presents the projections for the future (see Figure 1).

This figure shows how the initial use of computing power was primarily to process data and information. Then, as a consequence of the spreading availability of the Internet, the primary use became that of sending and receiving information. More recently, we have begun to use it increasingly to network with people—a multiplicity of “chat” lines, special-interest groups, and religious and political movements have spawned connections globally. Current research and development is making it possible to embed intelligence in our surroundings and in the objects or artefacts that surround us, which has led to the term “smartifacts” being coined to describe items that have embedded intelligence and sensors enabling them to detect changes in their environment. Computing, communication and intelligent user-friendly interfaces are converging to create the “ambient intelligent landscape” where intelligence will be embedded in our phones, in our clothes, in our pets (exemplified by the recently introduced “pet passports”) and in our household appliances. This is characterized in Figure 1 as the “interaction” phase we have now entered which offers opportunities that extend beyond our imagination for easing the demands of daily living, promoting communication with others and enhancing our leisure opportunities.

So there is evidence that emerging technologies are indeed enhancing lifestyles—but only for those who can access them. Studies of technological penetration suggest that 3.6 billion people are not yet connected to the Internet and related technological infrastructures (Institute for the Future, 1997). Thus, the existing divide between materially rich and poor is now exacerbated by the related divide in information rich and information poor. A challenge for all of us in a democratic society is surely to ensure that it is not just the privileged few who enjoy the benefits of connection—but that the whole of the world’s population can do so. So the first major challenge for global society is to deliver universal access.
Achieving connection to the Internet is the first requirement and this will be accomplished for the most part through the drive of commercial interest committed to boosting profits through e-business. But electronic connection does not of itself guarantee a blissful, trouble-free experience; there are many serious barriers to overcome before there can be access to universal benefits. These barriers include a skills gap, limitations of current search engines, inadequacies of speech technology, techno-task overload, information overload and the prevailing trend to design only for the “average” user (Parker & Wall, 1998).

Some of these acknowledged difficulties will soon be eased by the emergent technologies. For example, software tools known as “intelligent agents” are now under development (Chester, 1999); these will search, filter and categorize information tailored to our requirements, guiding our decisions. Speech recognition technology is improving; up to about 100 simple commands can now be recognized almost perfectly (Noyes, 2001). But the critical challenges posed by the skills gap and usage problems are not amenable to purely technological solutions—they require human and organizational issues to be addressed (KPMG Consulting, 2000). In other words, socio-technical solutions are required. Such solutions, or the methods, tools and techniques for developing the required solutions, already exist in mature, validated and evolving forms. But technological development will not pause for us to reflect for long on the implementation of appropriate solutions. Already on the market are digital televisions and wireless application protocol (WAP) phones, both providing Internet access without the need for a personal computer. Although there are many barriers to overcome before these are widely used, there are enthusiastic “early adopters” already exploiting these capabilities despite the limitations and frustrations of the current technology. Computing power, cable transmission capacity, the mobile phone network and the number of people connected to the internet are doubling every 6–18 months (Figure 2).

Collectively, these ICT developments offer the tantalizing promise of enhancements to our lives. The emerging technologies are transforming business, communication and lifestyle; they have the potential to enrich human life in innumerable ways, many of

Figure 2. To show doubling rates for web-related technologies. Source: EU Commission Information Society Technologies Advisory Group Report 2000.
which we cannot yet imagine; they can simplify the mechanics of daily life, prolong independent living with smart homes and with “obedient” domestic appliances, assist our learning, extend our skills and capabilities and enhance our leisure.

So is this scenario of enhanced lifestyle really possible for all instead of just a privileged few—or is such a vision merely a Utopian dream?

Certainly, there are significant barriers to achieving this vision. With the burgeoning of technologies we could be overwhelmed by choices, and by arrays of confusing and incompatible new systems, services and products. Again, many aspects of the ubiquitous internet and related ICT will require international collaboration to achieve workable regulatory arrangements and compatible operating standards before the barriers can be overcome. Similarly, much will need to be done to improve all the human, user, socio-technical aspects. This paper aims to review the potential of exploiting the knowledge and expertise within the domain of human factors to facilitate the realization of the vision.

2. The human factors domain

Human factors, also called Ergonomics, is a branch of applied science concerned both with the study of human behaviour in the context of technology and with the application of the knowledge gained from such study to real-world needs. For HUSAT it is centred on the characteristics and needs of people in complex systems using advanced information and communication technologies. Human factors is fundamentally about human-centred design (HCD). It offers the principles, techniques and tools to ensure that, whatever technologies are used at work, in the home and in public, they are suited to their purpose—which is serving human needs and wants. The human factors domain draws upon a range of well-developed theoretical frameworks, which are relevant to the complex relationships between people and technology. The most pervasive of these are socio-technical systems theory and system theory both of which emphasize the way that elements of systems are highly interconnected (Von Bertalanfly, 1950; Trist & Bamforth, 1951; Katz & Kahn, 1978). These theories shape and determine decisions regarding the content of any human factors intervention, i.e. they guide WHAT is done and WHY it is done.

To achieve effective application of theory requires a methodological framework (see Figure 3), which guides the process of the intervention, i.e. HOW, WHO, WHEN and WHERE. In the human factors domain the methodological framework includes field research, often in an action research model, as well as controlled experimentation.

First introduced by Lewin (1946) and Bradford, Gibb and Benne (1964), action research is defined as the application of scientific method to simplify and provide solutions to practical problems and as a course of action to be taken to achieve planned personal and/or social change. Facilitated by extensive teamwork between the researcher and the target organization, attention is directed to the collection and use of relevant data and to its significance for necessary courses of action. Following this stage, actions taken are evaluated, and these evaluations provide the essential data for the next set of interventions. Thus, this approach to research can be described as a “catalytic intervention”, largely similar to the process adopted when conducting qualitative research such as interviews or any type of survey research. The major advantage of action research over
qualitative approaches used alone is that action research involves the researcher and client organization working together in planning the cycle of activities and the development of an implementation strategy (Blake & Mouton, 1983). The essential elements of action research are as follows.

**Diagnosis.** As the initial step this involves the researcher and senior management within the organization reaching a joint assessment of the problem. Supplemental information may also be obtained from lower management levels. In addition, questionnaires and survey feedback may also be used to help complete the diagnosis.

**Information gathering.** Following the initial problem identification, interviews are conducted and more specific, targeted, questionnaires are used to obtain more specific facts.

**Feedback and discussion of priorities and alternatives.** Feedback sessions to report the findings from data gathering are arranged, usually in the form of team development sessions. The action researcher will also summarize common problems and undertake participant observation.

**Action planning, implementation and evaluation.** Establishing the format of further objectives for the organizational development programme, including further elements of data gathering, team building and evaluation of the intervention process and outcomes (Lewin, 1946).

The iterative nature of the action research approach makes it particularly appropriate to the application of human factors since it is a powerful tool that can be used to achieve both research and practical objectives in complex real-life contexts.

### 2.1. THREE PREREQUISITES

Before HF strategies can come into play, *electronic connection to the internet* is of course a prerequisite for access. The cost of connection is an important consideration. In the
USA local telephone calls have long been unmetered. With the advent of the internet this has meant local Internet Service Providers (ISPs) can offer unlimited access via a local telephone number at a very low monthly tariff compared with that in many European countries. This is recognized as a primary enabling factor, which sparked the explosive expansion of web-based commercial activity. Not surprisingly, given the implications for the economy, there are governmental and commercial initiatives underway in the UK to promote low-cost or free connection to the internet via digital devices designed to reduce the complexity of current usage through a personal computer.

Beyond the requirement for electronic connection is the more problematic issue of how to enable the vast majority of the population to enjoy effective access to the facilities and services available. **Closing the skills gap is therefore the second challenge** to address. Here developments in ICT offer boundless possibilities for promoting human learning and for knowledge sharing. Interactive digital television is one important development with potential for closing the skills gap by providing wider access to education/training programs that exploit multimedia capabilities. Other digital communication devices, now being piloted with potential users, offer simplified access to internet facilities. This reflects growing recognition of the potential for innovative user interfaces that will allow many, including the severely impaired, to gain access to the internet. There will of course be some people who cannot be helped in this way; for them, there is an important role for "human interfaces", i.e. trained, sympathetic people in the public sector to assist those with literacy problems and other special needs to use the internet and to conduct web searches, etc. Sociotechnical solutions will thus be required to close the skills gap.

A **third challenge** to address in order to achieve extensive ICT penetration is the need for **high levels of usability** (i.e. user-friendliness). The concept of usability is soundly based (Shackel, 1981, 1984) and has been extensively researched. It has long been recognized that to achieve the success of interactive systems and products, one requires high levels of usability (Eason, 1984; Whiteside, Bennett & Holzblatt, 1988; Nielsen, 1993; Shackel, 1997). Such success results from application of a human-centred design (HCD) approach.

Over the past two decades the human factors community has devoted significant resources to the development of HCD design guidelines, methods and methodologies. These all aim to incorporate human-centred design principles into the design processes for the development of ICT products, systems and services. As a result of these extensive efforts there are now complete methodologies, such as "soft system methodologies", (Checkland & Scholes, 1990) and HUFIT PAS (Taylor, 1990). In addition, there are well-developed human-centred approaches, tools and methods to apply to each part of the development cycle. These include guidelines and principles to support user interface design and evaluation (e.g. Smith & Mosier, 1984; Nielsen, 1993; Shneiderman, 1998). Concepts of usability and HCD have now been codified (Shackel & Richardson, 1991) and developed into international standards, which specify minimum usability standards. The recent publication of the standard "Human Centre Design Processes for Interactive Systems" (ISO 13407, 1999) should help to institutionalize HCD (Earth, Sherwood Jones & Bevan, 2001).

It will be clear from the contents of this Special Issue that the human factors domain now has many established as well as evolving tools, techniques and methods. This paper suggests that, when used as part of a coherent strategy, these offer the means of addressing problems hitherto regarded as intractable. The rest of this paper makes the
3. Innovation life cycle

There are human and organizational issues to address at every stage of the innovation cycle. For each stage there is an extensive body of human factors knowledge and literature available, often in mature and usable form. In the earliest stage of the cycle the focus is on exploring and defining human needs and requirements. The next step is to identify the different ways in which these requirements can be met, i.e. identifying the design options (alternative design solutions). Then follows the design and implementation of the selected design option and finally evaluation of the human and organizational impact of the resultant system, product or service. Typically, the stages of the innovation design process can be represented as an iterative cycle of continuous improvement, refining and updating every part of the product or system—see Figure 4.

While comprehensive coverage of each of these components is entirely beyond the scope of this paper the following sections indicate the nature and purpose of the human factors input involved at each stage—and its role in delivering the vision of enhanced quality of life.

3.1. Definition and prediction of need

Documented reports of underperformance of ICT systems over several decades reveal that a major factor contributing to the disappointing outcome is the inadequate understanding of the user requirements and thus failure to design new technologies to meet those requirements. To address this problem it is important early in the innovation cycle to identify and predict human needs and wants. An extensive capability has developed over more than three decades to understand better the requirements of potential users in order to develop user-centred design specifications. There is a considerable body of knowledge represented in the academic literature and many methodologies (e.g. Maguire, 1998; Robertson & Robertson, 1999). Olphert and Harker (1994) describe the changing focus of requirements capture in the systems design literature: they observe that from an initial emphasis on requirements analysis, the focus switched to the notion of
requirements elicitation, and then over the last decade to the concept of requirements generation. This progressive shift in terminology and focus reflects a progressive growth in understanding. The early notion, that requirements were attributes just waiting to be collected and classified, gave way to the realization that requirements may exist but not be easy to discover or extract from the user, and finally led to the recognition that while some requirements may exist others will only emerge when potential users have seen (and had the opportunity to experience) visions of future ICT applications.

It is not just future ICT systems but the organizational context of their usage that is being transformed. Through the use of scenarios, prototyping and simulations, human factors has the capability to go beyond offering solutions to the problems of today. Anticipating future needs for a product or service, or predicting the future impact of a technology, has considerable value to commercial enterprises and public sector organizations as well as to policy makers. The need to recognize and collect “undreamed of requirements”, as well as conscious and unconscious requirements, is emphasized by established practitioners (e.g. Robertson & Robertson, 1999), who have developed successful tools and methods to trawl the requirements of all the people who are stakeholders in a design project (Robertson, 2001). Clarity of requirements provides the foundation for exploration of relevant design solutions and is therefore crucial to achieving human-centred design.

The exploration and definition of human needs has application beyond specifying the design of future consumer products, systems and services; there are clearly deeper psychological needs to consider as the digital world becomes a reality. Societal interest needs to be reawakened in positive ways of exploiting technology, to enable the full expression of human capability and to meet human needs and aspirations identified by investigators such as Maslow (1959). In his forward-looking book, Sackman (1967) anticipated a world in which people would be freed from the drudgery of routine tasks and empowered by computer technology to expand their horizons and creativity. This vision seems to have been sidelined by the proliferation of call centres and tele-sales centres which, far from promoting creativity, restrict the individual to performing a highly restricted and closely prescribed set of activities. The adverse effects of boredom and lack of opportunity for learning and growth are well documented in the job design literature (e.g. Kroemer & Grandjean, 1997). But such an outcome is a consequence not of technological determinism but of human decision-makers. Promoting human-centred policy making will be considered in a later section of this paper.

3.2. IDENTIFICATION OF OPTIONS

From an early stage in any innovation design process there will be ideas in the minds of the designers or developers regarding design solutions. Although there is usually a variety of ways to achieve any given goal or objective, it is often the case that just one design solution is developed. The reasons for this are generally more to do with the familiarity of the solution to the designer than with its relevance to user requirements. The HF tool kit offers a very extensive range of techniques and methods for developing and testing alternative design options. Scenarios are one example of the important tools in the human factors toolbox for such a process (Olphert & Damodaran, 1991). They are basically mental models of the future and their use has a long history of evolution,
pioneered by the RAND Corporation in the 1950s and adapted and developed extensively in many organizations worldwide.

In a study of the organizational implications of CSCW systems (Eason & Olphert, 1995), the investigators created usage scenarios in order to conduct early evaluations of a planned IT application and asked potential users, and other stakeholders, to review the implications of the scenarios and evaluate them from their perspectives. The investigators explain that the approach requires some initial analytic work to create the scenarios but relies after that upon the expert knowledge and cultural values of the user community to detect the organizational implications and the value of outcomes. Used in this way, early evaluation methods serve to inform the stakeholders of the opportunities that exist and thereby empower them in the decisions to be made during design and implementation.

Prototyping is another technique which gives life to ideas: people can get a feel of how it might be to have a new facility in their lives. New ideas are stimulated, knowledge and understanding of the technological possibilities are gained, thus meeting one of the requirements for effective participation of stakeholders in design decision-making—namely access to relevant information (Kensing, 1983). Prototypes, used with appropriate usage scenarios, allow alternative designs to be rated and prioritized before significant investment is committed (Hall, 2001). With skilled management of a simulation or prototype the stakeholders involved in its testing generally respond not just with adverse criticisms but with ideas for how it might be improved to better meet their needs. This offers a powerful way of empowering stakeholders in the design process (Allen, 1992), allowing them to influence the decision on which option to take forward to the design and implementation stage of the innovation process.

In a later section of this paper, the use of scenarios will be discussed as ways for policymakers to anticipate the human and societal consequences of different design options and for society to demonstrate its support or rejection thereof.

3.3. DESIGN AND IMPLEMENTATION

Once a design option has been selected (desirably with active engagement of all relevant stakeholders) a full design process can begin. Typically, the chosen design will be developed and then implemented, after a series of design iterations which will vary in formality depending on the design context. With emerging technologies the design requirement increasingly is to meet users’ needs to perform a multiplicity of tasks in ever more varied contexts. To meet this goal, one requires a human-centred approach to design which takes into account the user, task, tool and environment. To inform the process there is now a plethora of validated research, sound good practice and established international standards which are exemplified by other papers in this volume.

Another increasing trend in design as we enter the “Digital Age” is towards greater inclusion or Design for All. The concept of Design for All or Inclusive Design is gradually gaining currency but is still a long way from being applied in normal practice. The key to providing accessible systems is to satisfy the needs, desires and expectations of all users through a real understanding of the various user groups within the context of their activities, capabilities and aspirations. To quote a leading practitioner in this domain “Anything less is almost certain to lead to exclusion” (Hitchcock, Lockyer, Cook
Inclusive design has become a focus for considerable debate and discussion and a number of influential initiatives have been funded in this area by the European Commission. For example, the USER project (Poulson, Ashby & Richardson, 1996; Poulson & Richardson, 1998) led to the development of the USERfit handbook of tools, methods and techniques to facilitate user-centred design in the European Assistive Technology sector. It also emphasized the inappropriateness of designing for the “average” user (see Figure 5) and the importance of user involvement throughout the design process. Another influential project was INCLUDE (Gill, 1997; INCLUDE, 1998), which provides a website (www.stakes.fi/include) for public access to information about all aspects of telematics and design for disabled and elderly people.

Various approaches to Design for All are now being explored; for example, within the EU project FORTUNE the approach was to provide users with disabilities trained to be able to help design teams via direct participation (Bührer, 2001). Again, from the work of IFIP TC.13 WG13.3 (International Federation for Information Processing Technical Committee 13 on Human–Computer Interaction Working Group 13.3 Human–Computer Interaction and Disability) there has been developed a book gathering all the recent HF guidelines for inclusive design (Nicolle & Abascal, 2001).

An excellent example of the successful involvement of users in a design and development process is provided by the EU ATTACH Telematics project (Fitzpatrick, 1999). This project was commissioned to develop and to demonstrate the use of public access information kiosks in sites based in the UK, Scotland, Greece, Sweden and the Netherlands. The project site based in the town of Roosendaal in the Netherlands is a particularly good example of how to ensure that the needs of elderly and disabled people are adequately considered. Older people were actively consulted from the beginning of the project, using interviews and focus groups to gain their input. Prototype testing also took place with older people, including wheelchair users, to ensure that they could gain access to the kiosk and could use the developing information system. By taking the needs of this
group of users into account from the beginning, easy-to-use applications were developed which have been shown to benefit all.

Key design features include a custom-designed kiosk (see Figure 6) that is easily accessible by wheelchair users and other disabled people. The angled screen makes it easy to operate the touchscreen for a range of users, and the casing is also designed to provide physical support to the frail elderly, allowing them to lean on it for support. Accessibility has not been neglected in the interface design, with large-size character fonts being selected as standard for displaying information, and a careful choice made between the use of colour for text and background. The design has also been refined through careful user involvement; for example, during prototype testing it was discovered that too high a contrast between text and background made the text difficult to read for elderly users, and so a pastel shade of background colour was subsequently adopted.

Experiential learning about the intended user population has a place alongside the active engagement of target users in the design process. The development of innovative ways of achieving effective communication between stakeholders and designers has a significant part to play, as exemplified by the use of the “Third Age” suit (Hitchcock et al., 2001) to promote experiential learning on the part of the designer regarding the constraints experienced by older people.

It seems that at last the gap between users and designers is recognized to be thoroughly unhelpful. Leading practitioners report the growing acceptance of the importance of requirements management (Robertson & Robertson, 2000). This is a welcome reversal of the trend fostered by the emphasis on user modelling through the 1980s and early 1990s which widened the already significant gap between these key stakeholders. A decade of effort to develop an analytical model of users, which would allow interaction with a user interface to be predicted without the participation of real end-users in testing and trials,
gave little of value to designers working in commercial design contexts (Karat, 1997). So the gap between designers and users is now closing. Reflecting a growing recognition that design should involve the user, the international standard ISO 13407, with its related document ISO TR 18529, now describes the essential steps required to achieve human-centred design (Earth etc., 2001). For this to have the desired impact, one requires institutionalization not just of the concepts and practice of human-centred design but also of the values and principles that underlay them. In other words, widespread cultural change is required. The role of Change Management in achieving this will be addressed further in a later part of this paper.

3.4. EVALUATION

Evaluations are conducted at a number of different points in the innovation cycle to achieve different objectives. For example, the role of early evaluations in empowering users to select design options which are best suited to their requirements and task context has already been described (Eason & Olphert, 1995). An added benefit of early evaluation is that it supports iterative design because changes are more easily and cost-effectively carried out in the early stages of development. This has been an important change from previous practice. In the past, evaluation has been used primarily at the end of the design process, as Karat (1997) describes his experience of the mid-1980s: “evaluations of software systems were generally part of system tests conducted late in the development cycle and generally followed good experimental design as practised in academic behavioural science. Evaluations of that kind were not intended to inform design as much as they were intended to validate it (often by passing or failing it compared to some alternative)”.

The academic rigour and theoretical nature of evaluation became out-of-step relative to the practical needs in most business settings. For most commercial purposes the main concern is to achieve the benefits of ICT for the organization as a whole rather than to have rigorous validations of specific hardware or software interfaces. The perceived high cost of usability evaluations, their practical utility and added value in a competitive business context began to be questioned (Bias & Mayhew, 1994). In response, Nielsen (1993) developed “guerilla HCI” or the “discount usability” approach which adopted a more pragmatic set of techniques for design and evaluation. These included the use of scenarios, simplified thinking aloud and heuristic evaluation. Such methods, along with expert reviews, have been widely accepted as fast and low-cost methods of assessment. Where more thorough investigation of user perceptions and performance is required, user trials provide the necessary data. Thus, the position has now been reached where, in a human-centred approach to design, evaluations are frequently conducted to inform design (cf. Hall, 2001) rather than simply to provide an assessment of the design product.

Usability of the interface is generally only one component, albeit a crucial one, of the complex socio-technical systems of which ICT systems are a part. To promote uptake and diffusion of emerging technologies, one requires evaluation not just of the interface characteristics but also of the wider actual and potential impact of ICT. Impact analysis and post-implementation reviews provide data on interface issues as well as the related education and training, system procedures, policies and practices, implementation strategies and prevailing business culture (Damodaran & Olphert, 2000).
These adaptations in evaluation and design methods to meet the needs of the business context show that Human Factors expertise can be applied flexibly. Techniques and tools are often tailored to meet commercial and competitive pressures and with recognition that the products, systems and services we use in our lives impact in a variety of interconnected ways. To ensure that human-centred design outcomes are achieved, human factors techniques for evaluation can be applied at every stage of the innovation life cycle.

4. Embedding human-centred design in an integrative human factors strategy

The brief overview given above of the role of human factors in achieving clear definition and prediction of needs, improved design and more effective involvement of end-users throughout the innovation cycle is elaborated in other papers in this volume. Despite the existence of an impressive array of validated tools and methods and their proven utility, the history of the HF domain makes it evident that the application of HF continues to have limited impact. Indeed, in many cases the impact of HF interventions has been confined to the locus of individual projects. Some companies, such as IBM, Microsoft and Philips, have made significant investments to extend the impact through the design process and thus achieve usability of their products. There is evidence that a convincing business case can be made for the cost-effectiveness of HCD methods (Bias & Mayhew, 1994). Yet it seems that few companies apply HCD in a systemic and strategic way. Aucella (1997) reported that whilst HCD methods have been applied in an ad hoc fashion in computer systems development for more than 15 years, they have not become a standard part of the development process.

More generally, impact on governmental procurement strategies, and on information technology strategies for businesses and public sector applications, has yet to be achieved beyond specific projects or programmes. The piecemeal application of human factors expertise within the confines of specific projects does little to achieve broader societal goals of inclusion and accessibility of ICT. Therefore, the case seems compelling for an integrated Human Factors Strategy to link micro and macro aspects of HCD so as to ensure effective impact at institutional and societal levels (Damodaran, 1991, 1998).

5. Key enabling processes

This paper thus far has outlined the contributions to be made by the application of human factors expertise throughout the innovation life cycle. It has also been emphasized that the application of such expertise to specific development projects is essential but not sufficient to deliver widespread inclusion in the digital world and enhancement of the quality of life. For this to become possible, one requires a global context and culture in which HF expertise is directly and widely used to promote inclusion. To achieve this, we must also include in our strategy the processes by which people learn, change and embrace new technologies and new ways of living and working. These processes include change management, knowledge sharing, fast track implementation and, lastly, influence on policy—see Figure 7.
In the next part of the paper, the role of each of these processes is discussed briefly. The intention is to show that, as part of an HF strategy, integrated together with the essential human factors inputs to the innovation cycle, these key enablers offer the potential to facilitate change in the public and private sectors and in society at large. Our governments and businesses must work in new ways if the uptake and effective exploitation of technology in the digital world is to succeed. It is only through such transformations that a wide range of new products, systems and services can become truly accessible to a large proportion of the population.

5.1. CHANGE MANAGEMENT

5.5.1. Change management to institutionalize HCD. The preceding sections have described the essential HF inputs to the innovation cycle. For these key components of human-centred design to become routine in design and development, one requires that they become an integral part of normal procedures. Such “institutionalization” involves change for individuals, organizations and societies. Evidence suggests that such change is proving slow to happen. Investigations, using the concept of human factors maturity modelling, reveal that little such institutionalization has actually taken place (Earthly, 1998) despite the ample guidance and expertise now available. This should perhaps not surprise us since institutionalization involves culture change which has to be manifested in the values, attitudes, beliefs and behaviour of relevant stakeholders. Great transformation may be needed to take on board new ways of thinking, working and relating to others; such transitions are far from easy or straight-forward.

The traditional assumption has been that organizational change management is evolutionary and diffuses gradually through the organization, affecting and changing substantial parts (Krovi, 1993). Current research shows that organizational change management must be part of a continuous business improvement with many driving forces including ICT, the re-engineering of business processes, cultural change, the shift from vertically integrated hierarchies to networks of specialists and downsizing to smaller companies that employ fewer staff (Cascio, 1995; Kotter, 1998). In the light of these research findings it should be no surprise that examples of genuine
institutionalization of HF are exceptions to the norm. It is reasonable to conclude that reliance upon diffusion of good practice, the availability of an extensive HF “tool kit”, and the dissemination of guidelines will not be enough to achieve institutionalization. Instead, proactive change management is required.

5.1.2. Change management in the wider context. Thus far, change management has been addressed primarily with the perspective of institutionalizing HF principles and practice. The need for effective management of change extends far more widely. There is extensive evidence that individuals and societies are not coping well with the pace and magnitude of change affecting every aspect of life as we enter the digital world. Mumford (2000) observes that “the relatively mild organizational change that industry has experienced in recent years through down-sizing, flatter hierarchies and short term work contracts has already started to create a great deal of employee dissatisfaction”. She questions whether modern organizations can handle revolutionary change without motivated workers and inspired leadership. She makes a strong case for the application of socio-technical design competence to change management, since it incorporates knowledge of how to achieve social and organizational as well as technical goals.

Change and the human response to it have been researched extensively for many years. Adaptation to change is shown to be long and slow and often resisted when imposed, for a variety of reasons including perceived or actual negative effects, such as exclusion from planning of the changes (Krovi, 1993; Hart, 1996). Findings show consistently that for a planned change to be successful it is crucial to engage within the planning of that change those who will be affected by it (Bennis, Benne & Chin, 1985; Bradley, 1998; KPMG Consulting, 2000). Other factors identified in the literature (e.g. Allan, 1997; Bradley, 1998; Duck, 1998) as important to consider in planning organizational change include compatibility of the proposed change with current work styles of individuals and teams, and the likely impact on social and organizational norms. The need to modify attitudes, motives, behaviour, knowledge and skills on an on-going basis, to enable people to adjust to changing demands, is also indicated by some investigators (Goldstein & Burke, 1991).

5.1.3. Critical success factors for change management. These factors and a number of others have been shown to influence the dynamics of business as well as society. Extensive research effort by a range of investigators (e.g. Krovi, 1993; Packard, 1995; Hart, 1996; Kotter, 1998; KPMG Consulting, 2000) indicates that critical success factors (CSFs) for successful management of change include the following.

- Effective communication of the vision to all stakeholders.
- Creation of a sense of empowerment and teamwork.
- Valuing individuals and recognizing their human rights.
- Effective education and training.
- Promotion of widespread participation and inclusion.
- Sustaining the change process constantly.
- Building the change process into the day-to-day lives of people.
- Supporting the culture change.
- Leadership to champion new ideas and facilitate a shared vision and goals.
In the HF domain we need to see the identifiable pockets of effective uptake of human-centred design as important models of good practice, and to use them to identify the critical success factors for institutionalizing HF.

However, although the CSFs for managing change are well documented, there are few major change initiatives that are regarded as really successful (Bridges & Mitchell, 2000). The evidence is that mismanagement of any one of the CSFs can undermine and compromise the utility of a change initiative. Thus effective change management remains a major challenge in the digital world.

5.1.4. An example of success. Difficult though it may be, we have at least one example of success in change management, which was enabled through these very Digital World facilities and provides a lesson for the future. It is a major challenge to engage large numbers of stakeholders on a global scale to agree on policy and practice on any issue, yet technology now provides the means to do so and has been used with great success by the international efforts to ensure better accessibility to ICT. These efforts began with the discovery that documents being created through HTML for the web presented severe difficulties to visually impaired individuals. Since the World Wide Web was being heralded as a key enabling technology for increasing access to information for people with special needs, this was cause for grave concern. The concern led to unprecedented collaboration, using the web itself, across disciplines and across continents (Engelen, 2001). The Web Accessibility Initiative (WAI) began, like many projects before it, with examining the possibilities for developing guidelines. But unlike many other initiatives, project members recognized that guidelines alone do not achieve social and political change. Instead, a number of individuals from the US and from Europe worked at all levels—establishing user requirements, developing design guidelines, involving and educating key stakeholders (including the President of the US and the Prime Ministers of Europe). All this work yielded highly positive results. The salient points from a change management perspective is that a very wide range of stakeholders were involved, including world-leading technologists and visually impaired persons, throughout the 10-year period.

This example of the successful accessibility lobby shows the value of investing resources over a long period of time to persuade, to convince, to communicate principles and to demonstrate the means to translate the concepts into practice. One important lesson to be learnt from this example is that having the building blocks of relevant HF research findings, the metrics for measuring usability, and the international standards and guidelines, will have significant impact only when we change the prevailing culture by changing the behaviour of a wide range of stakeholders including powerful and influential leaders. The other lesson to be learnt is that there needs to be a powerful motive for making such significant and sustained investment in achieving change. In the case of the successful accessibility lobby, the stakeholders saw clearly the magnitude both of the potential loss, if the visually impaired were to be disenfranchised by the wrong web design decisions, and of the enormous potential gains which will result from getting it right. Such deeply rooted commitment to change comes from recognition of intrinsic needs to be met.

A high level of motivation to achieve a specific outcome is thus a crucial CSF that is insufficiently highlighted in the academic literature to date. Such motivation comes from
a personal as well as a professional understanding of the possibilities and potential gain to result from human-centred design of emerging technologies. The role of HF in promoting such understanding has been described in Section 3.2.

Thus, in this section the case has been argued for the change management process to be recognized as a key component of effective human factors strategies.

5.2. KNOWLEDGE SHARING

Knowledge sharing is key to bridging the skills gap that exists between different populations and groups, between generations and between different sections of the same population, e.g. in a workforce (Nonaka & Takeuchi, 1995; Bukowitz & Williams, 1999). It is an essential process to be achieved through education and training in computer systems usage (Scott, 1998) and in new ways of working.

As work roles become more complex, specialized knowledge is recognized as a crucial asset—often called intellectual capital (Drucker, 1998; Hildreth, Wright & Kimble, 1999). The drive is to ensure that knowledge flows and is exploited rather than hoarded and guarded by individuals. In recent years, “knowledge economies” have emerged, where the effective exploitation of knowledge, expertise and innovation is widely recognized as the primary asset and key to competitive success (Drucker, 1998). This realization has heightened organizational interest in the topic of knowledge management (KM) (TFPL, 1999; Hildreth et al., 1999). KM is the practice of capturing, preserving, developing, sharing and using an organization’s knowledge assets (Bukowitz & Williams, 1999). The theory is that, by efficiently managing and exploiting its knowledge assets, an organization can create new capabilities and superior performance, encourage innovation and enhance customer service, now or in the future (Nonaka & Takeuchi, 1995; Teece, 1998; Srikantaiah & Koenig, 2000). In practice, knowledge sharing is fraught with difficulty as individuals struggle with new ways of working and distrust the notion of knowledge sharing. Thus, in general efforts to share knowledge through formal KM systems have had disappointing results.

It has become evident that KM is not exclusively concerned with technology but also involves people, individual learning and growth, and the organizational processes and infrastructure which facilitate corporate learning (Argyris & Schon, 1978; Scott, 1998; TFPL, 1999). Mastery of KM requires a skilful blend of effective change management, organizational learning (Schein, 1993), business processes and IT (Kotter, 1998; Hildreth et al., 1999; Chauhan, 2000). This is far from easy to achieve and thus knowledge sharing remains elusive in many commercial settings.

By contrast, there are many applications of technology in leisure and education where the interaction with computers is already highly rewarding for the individual and promotes learning and knowledge sharing. However, there is enormous further growth potential. Knowledge sharing is essential to create the global culture of inclusion. Only through sharing experience can there be shared envisioning of desirable futures. Such sharing of aspiration and vision is essential before national and international policies can win the support necessary to implement them. To this end, there is vast as yet untapped potential for envisioning techniques, simulations and virtual reality to be used to help people, with very different life experiences and of differing ages, religions, cultures and creeds, to share and shape visions of the future. Through the explosion of capability in
multimedia, technology now offers opportunities for promoting understanding of new concepts and knowledge and for achieving real communication across educational, linguistic, geographical, religious and cultural divides. Research and development in diverse aspects of human factors is needed to realize this potential and to succeed in closing the skills gap.

5.3. FAST TRACK IMPLEMENTATION

Most new technologies will eventually gain acceptance as a consequence of technology pull—and the absence of any other viable alternative—provided that they operate with a reasonable degree of reliability and have some utility. But, generally the uptake is slow—sometimes because it is actively resisted but far more often because of other factors such as the need to adapt to new ways of working, poor support for learning, inadequate communication and, most frequently, because there is a failure to create an organizational culture conducive to technology acceptance (Seybold, 1993; Cooper, 1994; Ruggles, 1998; Bukowitz & Williams, 1999; KPMG Consulting, 2000).

Attempts to force the pace of change are generally unsuccessful for two important reasons identified by Kotter (1998), the first being “that change involves numerous phases that, together, usually take a long time. Skipping steps creates only an illusion of speed and never produces a satisfying result”. The second lesson is “that critical mistakes in any of the phases can have a devastating impact, slowing momentum and negating previous gains”. Thus, change efforts fail frequently, creating cynicism, loss of motivation and lowered morale. Such findings do not mean that it is impossible to accelerate the rate of adaptation to change. The evidence suggests that assiduous attention to all the elements of adaptation can indeed speed up a change process to achieve a good result. To achieve such a positive outcome requires differentiation between “change” and “transition”, which helps to clarify the contribution that can be made to the speed of diffusion and take-up of emerging technologies: change is situational; thus it is instantiated by, for example, the new boss, the new site, the new policy or new team roles. Transition is the psychological process people go through to come to terms with the new situation.

The process of transition can be eased and greatly accelerated if the barriers to change are identified and addressed systematically by the application of relevant HF expertise. There are well-developed participative processes which together with effective communication have been shown to assist transition and ease the pain of change, even creating enthusiasm (e.g. Kotter, 1998). It is possible to design and deliver carefully tailored change strategies that reflect a socio-technical systems approach (Mumford, 2000). Such strategies will tackle directly the barriers caused by the unnecessary degree of uncertainty that often prevails regarding not just the new technologies but new policies, new procedures, new ways of working and altered hopes and expectations. Key elements of a fast-track implementation strategy include mechanisms for developing trust, aligning individual and corporate performance objectives, an extensive communication plan, the availability of models of good practice and experience of early success (“Quick Wins”).

Thus implementing change as part of a human factors strategy offers a fast track to rapid uptake of new technologies—instead of the gradual process of “osmosis”. The fast track approach requires substantial investment in tackling “soft issues”. Such investment
has often been resisted on grounds of cost and uncertainty regarding the financial value of a successful transition. There is now much evidence to suggest that neglect of these human and organizational issues proves far more expensive in the long term than addressing them carefully and appropriately as part of the socio-technical system design process. Since speed of successful exploitation of emerging technologies offers significant competitive advantage in a business context, there must surely be a worthwhile trade-off which a thorough cost–benefit analysis would reveal.

5.4. INFLUENCE ON POLICY

The vision of the inclusive digital world where ICTs have broken down barriers of distance, isolation and disability to empower those who have been disadvantaged in the past, assumes equality of opportunity in access to these technologies. It is for policy makers to make this happen—the application of human factors expertise as an integral part of strategic initiatives offers the capability to achieve it.

The reality of increasing globalization suggests that it is important for governmental strategists and policy makers worldwide to share their respective visions of global society. There are many ways in which the human factors domain can facilitate this crucial communication. Scenarios represent one tool in the human factors toolbox for such a process: they can be used to promote understanding across national, linguistic and cultural boundaries. For example, the potential exists for the emergent technologies to lead to pervasive and sinister negative developments. Imaginative scenarios included in the important consultative document (Electronic Commerce Task Force, 2000) recently published by the UK e-Commerce Task Force gives a glimpse into the lifestyles of five (fictitious) 21-year-old individuals living in 2010. The scenarios depict a typical day in the lives of these individuals who are strangers to each other though connected by the internet. Their daily existence is characterized by the challenge of beating off electronic surveillance and industrial espionage in the struggle to protect their means of making a living. These scenarios do not suggest the enhancement of the lives of the characters portrayed—on the contrary they suggest an atmosphere of fear and alienation, where the need for self-preservation is the highest priority. Thus, the scenarios succeed in conveying a compelling vision of what might result if we, as informed citizens, fail to encourage our politicians and leading businesses to take account of human needs for security, belonging and self-actualization in the development of the brave new digital world. The authors are to be commended for the insights they have revealed in the report and are sharing through a consultative process. The document provides a platform for a process to develop understanding of the possibilities in the digital age and to engage society proactively in formulating policy at all levels.

However, alerting people to the possibility of undesirable outcomes of the digital world is only helpful if it encourages society to work towards averting these through developing appropriate legislation and social policies. Exclusively emphasizing potential dangers could be alarmist and damaging if it leads people to believe only negative outcomes are to be expected from increased use of ICT. It is therefore essential to develop equally powerful positive and desirable scenarios, which will create shared aspirations for a socially desirable future. Such scenarios would portray the opportunities afforded by the internet to enhance quality of life in innumerable ways, enabling the forging of
new relationships, offering solutions to problems of everyday living, meeting educational needs and facilitating scientific endeavour, to name but a few of the benefits accruing already to those who have access.

People learn through observing models, and policy makers therefore need to find ways to promote widespread aspirations for an inclusive global society with enhanced lifestyles for all in the digital age. Publicizing best practice, promoting flagship initiatives and showing the benefits of inclusion are some of the ways of achieving this. It is only through a shared envisioning of desirable futures that national and international policies can win the support necessary to implement them. Widespread exploitation of existing tools, as well as further development of tools and techniques to promote experiential learning and the sharing of concepts, is needed to realize the visions of the future.

Psychological research provides us with a vast repertoire of knowledge about human needs and behaviour. In some areas research makes it possible for policy and strategy makers to predict from existing knowledge very accurately indeed; for example in job design there is an abundance of evidence of the poor quality of working life created when people are paced by technology (Trist & Bamforth, 1951; Trist, Higgins, Murray & Pollock, 1963; Buchanan & Boddy, 1983; McLoughlin & Clark, 1994; Parker & Wall, 1998). Despite this evidence, machine pacing was a dominant feature of data entry rooms for several decades and in some call centres is a fact of life today. High-profile cases highlighting the negative effects of pacing upon individual people have resulted in substantial costs of compensation for repetitive strain injury or stress (e.g. Walker Vs Northumberland County Council in Gibb, 1994; Dalrymple, 1994). The importance of job design has long been recognized. The coal-mining studies of the 1940s (Emery & Trist, 1960; Katz & Kahn, 1966, 1978), which were conducted to develop multi-skilling and organizational flexibility, identified key job design criteria to be met in socio-technical systems. Later work (e.g. Klein, 1976) cited many examples of job design processes in the manufacturing sector which continue to have relevance today. If lives are to be enhanced in the Digital Age we must develop policies on a national, European and eventually international basis regarding the pacing of work and the loss of autonomy and discretion of people in many work settings.

Finally, to work towards the vision, policy makers need to take the following steps.

1. Encourage the application of international standards on usability and on HCD processes where relevant, for example, to all public access information systems.
2. Introduce policies to promote people-friendly practices, throughout society, by requiring all products and systems for human use to be designed under contracts specifying compliance with ISO 13407: Human Centred Design Processes for Interactive Systems.
3. Offer rewards and prizes to promote good practice.
4. Use legal sanctions to achieve change where persuasion fails.

6. Human factors strategies and wealth creation

Thus far, this paper has advocated the application of state-of-the-art human factors within the framework of a human factors strategy and has suggested that such a strategy has the potential to make a major contribution to meeting the challenges facing the
information society. Each of the eight constituent elements described has a track record of effective application, using proven techniques and methods. Application of the available expertise has usually taken place within the context of specific technology implementation projects and has generally involved only a small subset of the eight elements identified as essential components of a human factors strategy. An exception to this general pattern is the unique example of the success that can result from adopting a strategic approach to the promotion of Design for All which has already been cited (Engelen, 2001).

For more than a decade, champions and supporters of inclusive design in the US and in Europe collaborated to promote widespread accessibility to the web. More important, they worked on a broad front involving social and political leaders (including the US President and European Prime Ministers), educating other stakeholders, identifying user requirements, developing guidelines, testing possible solutions, etc. The breadth of this WAI initiative contrasts sharply with the narrow, piecemeal application of human factors that has characterized so many technology-centred projects. Without such a strategic approach, it is difficult to see how significant change can be achieved towards delivering enhancements to the quality of life of the world’s citizens.

That there is a pressing societal need for a strategic approach to respond to the serious threats and opportunities posed by emerging technologies is argued most convincingly by Mumford (1999). If we accept this argument, then the next crucial step towards achieving a dramatic growth in our capability to harness the emerging technologies is to develop and to publicize some further significant exemplars of good practice, incorporating several if not all eight elements of the strategy (Figure 7). Given the major difficulties faced by most if not all sectors to remain competitive in the global economy, there are excellent and compelling reasons for businesses and government departments to wish to engage with such social experiments. Desirably, public–private partnerships will decide to incorporate a human factors strategy within their strategic plans for forthcoming joint developments, for example in healthcare, education and telecommunications.

Of course, there are always risks associated with new ways of doing things. However, given the tried and tested nature of the separate elements of the proposed human factors strategy, the likelihood of adverse outcomes resulting from applying this strategy must be small; compare that small risk with the virtual certainty of negative outcomes from persisting with current practices which fail to take adequate account of human and organizational issues. On the positive side, enormous gain and substantial competitive advantage can result from the application of human-centred design throughout the innovation cycle, coupled with effective change management and knowledge sharing. For an individual business operating within a human factors strategy there are gains to be made at every stage and in every aspect of business operation—from improved communication, better knowledge sharing, better usability of systems, products and services, through to enhanced customer service.

Enhancing competitiveness is a significant attribute of a human factors strategy since wealth creation is critical to the implementation of ambitious policies of inclusion. Harnessing the emergent technologies to deliver an improved quality of human life worldwide requires a long-term agenda. To accomplish it, the success of businesses and of economies is critical and thus the contributions of human factors to performance and profitability are crucial contributions, since the creation of wealth is fundamental to
positive social change. The human factors domain, interpreted at its broadest and encompassing many disciplines, must be able to achieve a “feel good” factor on a global basis—only when this becomes a reality can we claim to have delivered enhanced lifestyles for all.

But of course human factors by itself does not generate wealth—technologies are needed to do that. Nations are predicted to rise and fall by their ability to master the engines of wealth of the 21st century. These are identified as micro-electronics, biotechnology, new material science industries, telecommunications, civilian aircraft manufacture, machine tools and robots and computers (Kaku, 1998). Those businesses, public sector organizations and governments worldwide that can harness the state-of-the-art capability in human factors to these scientific, engineering and technological capabilities of their nations, will have the competitive edge in wealth creation as well as the power to deliver widespread access to the benefits of future technologies, as represented in Figure 8.

This powerful capability is just beginning to be recognized. There are therefore rich prizes for institutions that have the vision to exploit the power of human factors. To be taken up and exploited fully, one requires widespread understanding of human and organizational issues. The so-called “soft issues” are not an add-on extra but integral to every part of the innovation cycle from conception to implementation to continuous use.

To deliver the vision of enhanced lifestyle for all, HF strategies must be applied to innovations in the key scientific and engineering domains of the 21st century and to educational and social policy. It is through these means that the needs for access, closing the skills gap, seamless ease of use and maximizing the potential of individuals can be met.

Failure to meet these needs would exacerbate social exclusion, multiply the frustrations and hindrances in the mechanics of everyday living, and ensure that the universal enhancement of lifestyles remains a utopian ideal. Success, on the other hand, offers rich rewards to governments, businesses and individuals who seize the available human factors expertise to ensure the delivery of human-centred ICT systems, services and products to as large a proportion of the world’s population as possible.
Examples of progress to date

1990: Americans with Disabilities Act (ADA) in USA requires manufacturers to design for all user groups—vigorously enforced by legal action.
1991: Web Accessibility Initiative
1999: Usability design process standards established (ISO 13407)

| FIGURE 9. Key milestones towards enhanced lifestyles for ALL. |

There is already progress to report in many of these areas. Some particularly influential achievements are noted in Figure 9.

To develop a coherent strategic approach, one will need to involve very many stakeholders, including those who shape our society as well as individual citizens and consumers. Thus, to name but a few of the relevant groups—users, consumers, citizens, developers, investors, manufacturers, government officials, policy makers and politicians—all have significant parts to play in developing an inclusive digital world.

The contents of this paper and the rest of this volume offer the means to deliver important benefits to all these stakeholders and many others. This Special Issue endeavours to identify and describe some of the key areas of Human Factors relevant to the 21st Century. The breadth and depth of knowledge and expertise now available in the Human Factors domain suggests that the achievement of the vision of improved quality of life globally is not beyond the bounds of possibility. The challenge now is to exploit the capability offered by this expertise within strategic frameworks to enhance lifestyles for all citizens of this world.

I wish to express my thanks to all my colleagues in HUSAT and to my family who have helped me in a wide variety of ways to complete this paper. I appreciate very much their many contributions and encouragement. Especial thanks are due to Wendy Olphert for her inspiration and assistance throughout, to Seetle Chauhan and Kathy Phillips for careful compilation and checking of the references and to Sharon Want and Jayshree Lakha for their patience and capable handling of the many drafts and revisions. Finally, I am very grateful to Dr John Spackman for the invaluable opportunities to develop and to apply the concept of a human-factors strategy in the context of large-scale complex ICT systems.

References


