Socio-technical systems and interaction design – 21st century relevance

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A B S T R A C T

This paper focuses on the relationship between the socio-technical system and the user–technology interface. It looks at specific aspects of the organisational context such as multiple user roles, job change, work processes and workflows, technical infrastructure, and the challenges they present for the interaction designer. The implications of trends such as more mobile and flexible working, the use of social media, and the growth of the virtual organisation, are also considered. The paper also reviews rapidly evolving technologies such as pervasive systems and artificial intelligence, and the skills that workers will need to engage with them.

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1. Introduction

When a new system is being designed the main focus may be on specifying a logical entity that works reliably and accurately on a high specification computer in the software development lab. But when deployed, the system may fall short of expectations. It may not run as efficiently as expected on the local platform, the users might feel that it does not support the way they work, while the user interface may seem to offer a poor match with the requirements of the task. Researchers such as Enid Mumford (1987) were among the first to show that even when the underlying technology was adequate, a failure to address the social needs of the organisation could result in an unsatisfactory outcome. To address this problem, the 'socio-technical systems' approach, a term coined by the Tavistock Institute of Human Relations in London (Trist, 1981) was developed. Its aim was to help achieve the effective blending of both the social and technical sub-systems of an organisation, including any new technology that may be introduced into it. Ken Eason, while at the Tavistock Institute and at Loughborough University, has been one of the leading researchers in understanding the difficulties encountered when trying to harness information technology and in developing tools and techniques to help achieve quality in people's work lives (Eason, 1988). Case studies of socio-technical considerations in practice may be found in Klein and Eason (2010). This paper focuses on one part of the socio-technical system – the interface between the user and the technology. If this is designed without consideration of socio-

technical issues, it can lead to problems for the user and the organisation.

Research into the operations and structures of organisations has identified the *main elements* that make up the socio-technical system (Eason, 2010). These include:

1. *The collective operational task* where the system undertakes the operational delivery of the overall task objectives.
2. *Social and technical sub-systems* in which the complete task performance is undertaken by human resources in the social system using technical resources in the technical system and where the two are ideally co-optimised.
3. The attribute of being an '*open system*' which is influenced by the environment and so has to adapt as environmental conditions change.
4. The idea of being an *unfinished system* that needs to be flexible enough to deal with new demands in the short term and where there is provision to review and refine the system as these demands become confirmed as new requirements.

An example, from the author's experience, is the design of a new offender case management IT system for a national prison service, an organisation engaged in the collective task of looking after offenders. The social sub-system is made up of work roles (prison reception, censors, custody and supervising officers, wing staff, security staff, and finance personnel). The processing of the offender case data is performed through the technical sub-system. Each person in a particular role is assigned with some parts of the collective task which had to be coordinated if the collective task was to be accomplished. However as the organisation is an open

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system it, has to adapt to changing demands, for example, new forms of offender risk assessment or new procedures of operation within the prison. So there are many challenges for user interface design to make sure the technical system maps onto user needs.

Fig. 1 is a diagrammatic representation of the socio-technical factors that influence the design and implementation of a new system, including factors relating to the design strategy, the social sub-system and the technical-sub-system. These are also important considerations when the user interface to the technology is designed. Each of these factors is discussed in the following sections of the paper and how they might influence the design of the user interface to the technology.

2. Design strategies and context

When a new IT system is to be developed, the design strategy will affect the outcome for the users and their work. This section discusses some of these aspects of strategy and the implications for user interaction with the system.

2.1. User involvement in system design

The importance of user involvement in systems design is well established by Eason (1982), Shackel (1985) and Damodaran (1996). Although strategic design decisions will drive the overall concept of a system, Harris and Roland Weistroffer (2009) report that users may have little involvement in the fundamental design and may only have limited influence on the technical functions. Yet it is the users who will know the practicalities of the task and be able to make suggestions to ensure that the design is feasible. Attarzadeh and Ow (2008) state that one of the main causes of IT systems failure has been of a lack of user input into the systems design process and the specification of requirements including user requirements.

To maximise the benefits of user involvement, representatives need to be given the confidence to critique the current design and knowledge to appreciate the potential of technological innovation. For the offender management system, it was proposed that prison staff record onto the computer all movements of prisoners from one location to another. The users thought this was an additional labour intensive task for staff that already have a high workload It was suggested that a more practical alternative was a scanner system where tags worn by prisoners could be recorded automatically which would make tracking them more accurate and efficient.

2.2. Designing for usability and accessibility

When designing for usability it is particularly important that this be related to the socio-technical context. What is usable for some users in the organisation may be difficult for others so mapping the usability needs across the organisation is necessary. This is particularly true when comparing users who have a good knowledge of the task domain and IT systems with those who require more support in performing the task and in operating the system. Writers such as Tognazzini (1992), Nielson (1999), Norman (2002) and Shneiderman et al. (2009) and have established principles and guidelines for user interface design in order to achieve usability. Many of these have been captured within the ISO 9241-110 standard, 'Dialogue Principles' (2006). These include: suitability for the task, suitability for learning, suitability for individualisation, conformity with user expectations, self-descriptiveness, controllability and error tolerance. Other parts of the same standard cover specific topics such as menus, forms, software individualisation and accessibility. While such guidance is useful it should always be interpreted for the socio-technical context. For example, when the usability of a system is being evaluated this should take place following consideration of the context of use ISO 9241-11 (1998).

Equal opportunities regulations in many countries mean that organisations are required to employ people with disabilities as well as serving customers who may have disabilities. Partly because of such regulations, the importance of accessibility within work systems to achieve inclusive design for users is now recognised. The move towards systems based on internet browser technology allows benefits to be gained from the standards for accessibility and assistive technology support established by the World Wide Web Consortium (W3C-WAI, 2012). In December 2010, the British standard BS 8878 (2010) was launched to address web accessibility and the challenge of digital inclusion which can apply to workers as well as customers.

2.3. A more technology savvy workforce

In the past, when a new IT system was introduced, workers often felt daunted by it and reluctant to use it. Some would need extra training in the use of basic computer facilities such as mice and keyboards. With the widespread ownership of home computers, smart TVs, tablets and mobile phones, people are now generally
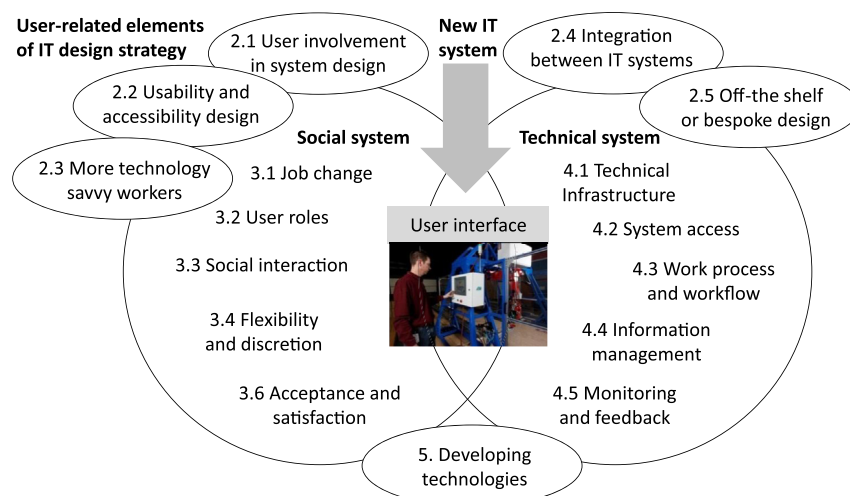

Fig. 1. Elements of the IT introduction and socio-technical system that may affect or be affected by the user-interface.

comfortable with new technology and feel comfortable with interaction. The problem of user take-up of new IT has shifted to one of meeting user expectations. Typically people now own technology that may be more advanced, flexible, faster, and having more scope for customisation than their new work system. Touch screen interaction used to be based simply on the idea of 'point to select' using specialised hardware. This has now evolved on consumer devices to include multi-touch gestures and becoming a gesture language. Automatic speech recognition which was limited to professional systems in high tech environments (such as in military and air traffic control systems) is now common on mobile phones, in gaming environments and voice response systems. Human expectations of how they should be able to interact with technology have increased and may not be met by the computer they use at work, either because of resource limitations, security restrictions or capabilities of the software application environment. Even simple customisation such as changing screens backgrounds and colours may not be possible. This presents a challenge to the system design team to try and meet these new requirements in order to provide a more satisfying user experience.

2.4. Integration between IT systems

A common goal of organisations aiming to rationalise its operations or following a merger, is to try and achieve convergence of computerised information systems to form a single system for all users to access. This can bring efficiencies in terms of system maintenance but may result in more complex user requirements and functionality. The objective of the NHS National Programme for IT was to ensure that every patient had an individual electronic care record which could be accessed by NHS staff within any part of the service when required. However to achieve this, the patient record needed to be extended considerably to include all the categories of data and data fields that all medical staff required. The complexity of this requirement led to reservations on the part of staff and criticism that the system did not deliver clear clinical benefit beyond the existing diversified specialist systems (House of Commons Public Accounts Committee, 2011).

A related issue is highlighted by Nielsen's heuristic: 'The system should speak the user's language' (Nielsen, 2013). During systems integration, there is a need to rationalise the vocabularies used by different user groups. A key aim for development of the offender management system was to merge it with the case records of the probation service. As part of this innovation some terminology across the two organisations had to be unified on the system including the names of specific offences or crimes, symbols for risks such as 'potential hostage taker' or 'drugs trafficker', and the term 'offender objectives' rather than 'offender targets'.

System performance may be reduced if the system integration process results in an increased number of users trying to access the same database. For some organisations this could be several tens of thousands of users, potentially making the system slower to respond or making response times more variable. The computerisation of the London Stock Exchange in 1986 (where trading was first conducted via computer rather than face-to-face on the market floor) was an example where the technology became overloaded and the system stopped temporarily. Modelling of the future demand for a new system is thus important to ensure that enough processing power and resources are provided.

2.5. Off-the-shelf software versus bespoke design

When developing a new system, an organisation may have to decide whether it should design its own application to meet business and user requirements or whether to obtain an off-the-shelf application and adapt it for their needs (Davidson, 2006; British Computer Society, 2013). The benefit of bespoke system design is that functions can be specified precisely to reflect user and task requirements. Screens can be designed to match the required task processes, paper forms, and terminology. However the costs may be relatively high in terms of system design, programming effort and testing, to make sure the system is reliable and meets requirements.

In contrast, off-the-shelf systems tend to be well-established and tested for reliability and can be customised. Examples of off-the-shelf database management systems include: Oracle, SQL Server, IBM DB2, and SAP Sybase. However such systems may be designed around a certain organisational structure and culture and have certain design features that are hard to change. Fig. 2 shows a command line from an SQL system. While symbols for 'save' and 'print' and the navigation arrows seem intuitive, others such as the three database search icons and the 'exit' icon may require familiarisation.

The creation of early prototypes can be used to help decide which basis for system development will better match user and task needs. They can also be used to help establish ground rules for user interface design for the full application.

3. Social sub-system factors

This section describes how the introduction of a new IT system may be affected by social sub-system factors — people's jobs or roles, relationships and communication between them and the management structures that are in place.

3.1. Job change and user interaction

The widespread use of computer systems within organisations often leads to jobs being restructured or redesigned. In doing so, the intrinsic value of each task may be reduced or made less obvious to the person doing it. An employee who previously had a diversified activity may have their job restricted to a small number of activities performed through the system. As computers have become pervasive in the workplace, it is recognised that the computer system can shape and constrain work practices (Eason, 1997). Principles of job design therefore remain important, for example, summarised by Kirk (1983) and Eason (1984) while a well-designed user interface will help support the implementation of these principles.

Harrison et al. (2007) provides case studies where the introduction of new health information technology (HIT) had unintended consequences. In one study, a physician order entry system led to reduced communication between physicians and nurses about critically ill infants. It also caused delays in delivery of orders, uncertainty over whether they had been initiated, and sometimes divergent orders being produced. A simple status check function for nurses would have enabled them to check whether orders had been made while a messaging facility could have allowed them retain some level of interaction with the doctors.

One principle of job design is that tasks should form a coherent job that makes a significant and visible contribution to the overall

Fig. 2. Icon command line for database management system.

output. The user interface may support this in a number of ways, for example, by showing how the different tasks link together on screen rather than just providing the user with random entry points to a system. A company website might also help to emphasise the role of individual workers by presenting a high level description of its process of operation or each of its departments, allowing workers to see that their contribution to the organisation is recognised.

Another principle is to give users some discretion in carrying out their work, and to take responsibility for their work outcomes. Here the system should allow flexibility in the way computer-based tasks are achieved. Some systems are organised to provide users with a list of tasks to perform, giving them the responsibility to plan the work and the flexibility to carry them out in the order they wish or to perform tasks concurrently.

3.2. User roles and role based access

An IT system may need to support multiple users with different jobs, roles and task requirements, and will have a set range of screens that each user needs to interact with. Within the offender management system there were specific screens for the roles of security, reception and custody staff, and for specific tasks such as entering information about a new prisoner, maintaining medical records and assigning prisoners to activities. Role-based access was integrated into the system infrastructure so that when users logged on, they would only see screens related to their own role. This generally makes for efficient working but users should also have knowledge of the system for other people so they appreciate how their inputs may affect others and if they need to cover for them. Role-based access is also concerned with defining the 'read' and 'write' privileges for each role in the organisation. These need to be carefully thought out if they are not to cause inconvenience for users. For example on a hospital records system, while a nurse would not be able to change a patient's diagnosis, they should be allowed to record any concerns that might question it. In an online learning support system, the teaching role which involves uploading learning materials for students should also provide an option to view this resource as the student will see it, to make sure that the layout of materials appears as intended and is satisfactory.

The nature of the work in some organisations particularly public services, may involve the user assembling data for a single case and then locking it so that it cannot be changed. This is to prevent others altering the records that the user is responsible for and to provide an audit trail so that queries can be referred back to the original case holder or account manager. While this is a logical development, it can lead to inconvenience and backlogs if a user discovers an error and cannot amend it without referring back to the IT department or their manager to 'rollback' or unlock the record. Some flexibility in implementing such a process is therefore helpful to assist these situations.

3.3. Social interaction

User-system interaction can often be affected by social interaction. In a busy working environment users may be interrupted and may have to switch their attention between using the terminal and interacting with others. An open-plan office may also be distracting for workers. If a user is interrupted they may require a facility to save information halfway through their task to complete later. Some computer systems require users to share the same computer workstation if resources or work space is limited or if it provides access to a sensitive database. This may mean that individuals have to reserve time slots when they can use the system. Computer-mediated group working may also cause people to adapt their

communication behaviour which can impact social and working relationships (Bannan-Ritland, 2002). Another area for consideration is people's use of their work computer for personal use. According to surveys, the average employee spends between one and two hours each day using the internet for social networking or online browsing (wiseGEEK, 2013). Employers may wish to be helpful to employees and allow them to use their work computer for these activities during breaks and lunchtime but this increases the danger of breaching IT security and impinging on work time.

3.4. Discretion and flexibility of use

Systems within an organisation that incorporate defined processes are normally non-discretionary unlike consumer computing where people have the choice of whether to use a software application or not. Since poorly designed user interfaces may affect user efficiency, morale and safety, it is arguable that systems that are an integral part of the job need to be just as usable as applications that are discretionary.

A lack of flexibility, autonomy and control over work tends to amplify the experience of work stress (Gunnarsson and Östberg, 1977). Similarly, a lack of appropriate design flexibility in the user interface is often the cause of user frustration leading to misuse of a system or working around it. It may also prevent a user from dealing effectively with unexpected situations leading to negative or even unsafe consequences, for example, in a command and control system, a process control environment, or a medical setting. Call centre operators, may also work under high pressure conditions with calls being forwarded to the next free operator. Therefore user interaction with the call-centre support system needs to be able to deal with a wide range of customer queries and allow rapid access to information in different ways (e.g. by account number or name and address). User interface flexibility also helps make the interaction more efficient. In the offender management system, if a person was not a drug user or a sexual or violent offender, then during the data entry phase of the case, these categories could be excluded at the start which cut a number of data entry screens.

3.5. User acceptance and satisfaction

Whatever resources are dedicated to the development of a new IT system, it will only be successful if it is accepted by its operators or users. The technology acceptance model (TAM) helps to explain the main factors that contribute to the acceptance of an IT system, i.e. perceived usefulness and perceived ease-of-use (Davis, 1989). The unified theory of acceptance and use of technology (UTAUT) also aims to explain user intentions to use a system and subsequent usage behaviour (Venkatesh et al., 2003). Based on a review and consolidation of eight existing models, the four key constructs behind UTAUT are performance expectancy, effort expectancy, social influence and facilitating conditions (cost, availability, and user support).

Jones' (2013) recipe for successful implementation and acceptance of a system includes: giving all users a greater understanding of the project, ensuring they can all see some benefits for themselves, designing the software to be simple, fast and intuitive, ensuring that users master the relevant skills and having full commitment from management. This is essentially a process of user participation and co-design which not only helps to establish the most useful functions and usability features but also by stimulates users to feel ownership of the system (Eason and Damodaran, 1979).

The importance of user satisfaction with their interaction with a system is recognised in the ISO 9241-11 (1998) standard on usability and may be measured using rating scales, for example, the Software Acceptance Questionnaire (Maguire, 1998). User satisfaction with the whole system or the user experience (UX) of it is

now much more of a focus in system development. This is defined as: '*all-aspects of the end-user's interaction with the company, its services, and its products*' (Nielsen Norman Group, 2013). Spool (2007) gives a good example of the difference between usability and user experience based on a person who successfully orders a camera online (good usability) but when she arrives at the shop finds it is out of stock and must claim a credit for her purchase by telephone (poor user experience). Guo (2012) defines four elements of user experience design: value (is it useful?), usability (is it easy to use?), adoptability (is it easy to start using?), and desirability (is it fun and engaging?). The last of these seems more relevant to consumer products than traditional systems although the 'gamification' of work systems is now a hot topic for research.

4. Technical sub-system factors

This section discusses how the introduction of a new IT system may be affected by technical sub-system factors. Note that 'technical' does not necessarily mean physical technology but also software, work procedures, data structures and related technical knowledge.

4.1. Technical infrastructure

Generally the technical infrastructure includes the platform on which the new system is hosted including the IT hardware, operating system software, network, reference materials and telephones. It may also include user training and technical support. When a new system is released and delivered, standard training and documentation should be given to all users with the objective of ensuring that they can operate it effectively (Damodaran et al., 1980). A well trained multi-skilled staff team is also usually better able to cope with any limitations in the system until they can be addressed by technical system updates or developments. User training for the offender management system highlighted the danger that if, following staff training, technical problems delay release of the system this might result in the knowledge fading, and the need for system practice facilities to be available outside of the training sessions.

A recent trend is for employees to use their own personal computer for their work, either at home or at work, connecting it to the company's resources such as email, file servers, and databases. Known as BYOD, Bring You Own Device (Anderson, 2012), employers may accept and even encourage this way of working as it saves money in terms of technology outlay and maintenance and enables workers to feel more comfortable and productive using technology they are familiar with. However possible disadvantages are: incompatibility between the employee's own computer and the organisation's system, lack of protection against viruses or malware, and possible liability if the computer suffers damage at work. The development of personalised homepages (for example, iGoogle) and online creation and sharing of documents (e.g., Google Docs and Docs.com) may encourage a person's professional and personal data and services start to merge. IT support is thus needed to help employees manage these two worlds on one computer.

4.2. User-system access

For systems that contain private or sensitive information, users will often need to access it by entering multiple passwords, for example, to access the computer, network, operating system, or application. Multiple passwords become complex to remember, especially if frequently changed. While single password access may seem desirable from a user's point of view, IT technical staff may prefer to maintain security by requiring different user code and password entries at each level. System generated passwords tend to

be hard to remember and are often written down thus compromising security. However user generated passwords are open to being guessed with some knowledge about the user.

The use of biometric identification such as finger print or face recognition offers a simpler method of system access and are more difficult to forge, share, misplace or guess, and are being taken up on laptops, mobile phones, passports, ATMs and to enter buildings (Jain and Pankanti, 2008). Some organisational disadvantages are: possibly needing to access the system from a workstation without a reader, and difficulty in allowing a colleague to access the system on a user's behalf, if required. However with inexpensive sensors and powerful microprocessors now available, biometric technology is certain to become more pervasive.

In general as the regulations that govern public sector services evolve (possibly as a result of errors in the delivery of public services) this tends to lead to the tightening of rules for who can access a system and how it must be done, thus making for a more complex system. Avoiding too many rules on user access helps to maintain efficiency and limit frustration for the users.

4.3. Work process and workflow

Established work processes can be disrupted when a new IT system is introduced. User navigation may be less straightforward than previously or information may be presented in a different form than workers are used to. Workflow software is designed to give structure and order to the unfolding of work activities, routing documents through the organisation and allowing users to gain an overview of the work process they are part of (Benyon, 2010a). It allows supervisors to assign work tasks to others and to monitor progress. Workflow applications tend to be limited to routine oriented rule-based processes often within government agencies, banks and insurance companies. This requires detailed process modelling and capture of individual skills so that work may be assigned to the appropriate person. However, if such systems expand to other fields, where work processes are less structured, new more flexible modelling techniques may be needed.

Many computer systems are designed to represent lengthy and complex processes with multiple stages. The offender management system contained over two hundred different screens spread across the prison and probation services. While these were split up into different worker roles, it was still seen as a more complex system by staff in comparison with what they had before. One way to cope with the complexity is to take a conservative approach to system design and try and minimise the functions that are computerised initially to allow both phased learning and for the system adapt to changing needs. It is often stated by authors such as Eason (1988) that leaving more aspects of computer-based tasks flexible or delaying decisions on how parts of the design are implemented will lead to a potentially a simpler system more suited to user needs. Norman (2011) has written extensively about complexity within systems. He believes that in the rush to computerise processes and organisations, the value of the human experience has tended to be overlooked. While measurement of critical variables is good, the human element must not be forgotten.

4.4. Information management

With the easier transmission of information through different channels (email, file transfer, and social media) a major issue for workers is how to manage the vast amount of information they receive or is available to them. The term 'information overload', popularised by Toffler (1971) refers to the difficulty a person can have in researching a topic or making decisions caused by the presence of too much information. Typically workers may start off

producing a manageable structure for their data files but this can soon become unwieldy without constant manipulation as the amount and variety of information grows. Users then have to rely on searching to find data which depends on appropriate naming and tagging of files and documents. One approach is for an organisation to offer a standard comprehensive file structure for projects or departments to use. In future, support through intelligent agents may be needed to assist with a person's information storage and retrieval activity.

4.5. Monitoring and feedback

Many organisations have the capability to monitor performance at an individual, team and company level, for example, "Your call may be recorded for training or monitoring purposes". Electronic monitoring of a person's use of the web, email, data entry, phone calls and video-surveillance are well established. Although invasive, tne advantage of such methods is that they offer objectivity in performance evaluation at work without a manager's personal feelings affecting process (Misra and Crampton, 1998). The US Bill of Rights and EU laws and directives provide some protections against monitoring a person for those aspects not related to their work.

Providing feedback on work performance has long been known to have a positive benefit on worker productivity (Matsui and Okada, 1983). Computer-based systems are ideally suited to providing automatic feedback and it is the first of Nielsen's rules for interaction design, that '*The system should always keep users informed about what is going on, through appropriate feedback within reasonable time*' (Nielsen Norman Group, 1995).

5. Developing technologies

As technology develops, this will undoubtedly have a strong influence people's relationships with those systems. Fig. 3 contains a map of technological areas that will have a growing impact on socio-technical systems in the future. The technologies are grouped into six categories: social media, pervasive systems, multimodal interaction, cloud computing, information integration and artificial intelligence.

5.1. Social media

Use of social media has become a modern phenomenon allowing individuals to establish and maintain relationships with each

other and for many has become part of their everyday lives. In discussion forums, the 'avatar' is a graphical representation of the user which enables them to project an alter ego or character while protecting their privacy. Social networking is now so much a part of people's lives that they will expect to use similar facilities in conducting their work. Customers are likely to expect professionals to be more accessible through social media and to engage with them through it (Kaplan and Haenlein, 2010). A 'sense of presence' is a key component of social interaction and some video-telephone systems can offer a sense of presence where participants may forget that they are communicating through a system and feel like they are meeting face-to-face (Benyon, 2010b). The concept of computer supported co-operative work (CSCW) systems is well established and includes functions for shared document creation, whiteboards and workspaces. Grudin (1994) and Ackerman (2000) highlight key challenges for co-operative work systems, including: having a critical mass of people to participate, users feeling restricted by established hierarchical or organisational boundaries, and the need for technical support so that users with less technical knowledge can switch fluidly between individual and co-working modes.

5.2. Pervasive systems

This is a form of human–computer interaction in which information processing is integrated into everyday objects and activities (Korhonen et al., 2013). For example, a pervasive system might connect lighting and environmental controls with biometric monitors woven into clothing (a form of wearable technology) so that illumination and heating in a person's home or office is controlled continuously and imperceptibly. Wearable technology may be attached to the person (for example Google Glass) or embedded into clothing allowing the user convenient access to IT on the move or in difficult environments (Martin, 2007; Baber, 2001). A smart garment to promote healthy exercise by the wearer has been created (Burns et al., 2012) while a lady's dress that can receive messages has been demonstrated (Katz, 2012). A challenge of pervasive systems is how to design user computer-interfaces for them.

It is suggested that there is an on-going shift from already-decentralised technology towards entirely pervasive computing — a system where billions of miniature, ubiquitous, connected devices will be spread worldwide (Castells, 2000). This concept, the 'Internet of Things' (IoT), refers to uniquely identifiable objects (things) and their virtual representations in an internet-like structure through technologies such as RFID tags and QR codes (Council, 2013). Remote sensing of activities such as taking medicine, monitoring sporting performance, and use of energy are commonly cited everyday applications. A further development is near field communication (NFC) and location awareness — a set of standards for smartphones and mobile devices to establish radio communication with each other by bringing them into close proximity for contactless transactions or data exchange. This can allow a user to pick up NFC enabled information on their phone from an advert on an underground station escalator, special offers when passing supermarket shelves, or patient information when performing a ward round. In the workplace, pervasive technologies will provide users with new forms of advanced and flexible interaction but will also provide further opportunities for discreet surveillance and monitoring.

5.3. Multimodal interaction

Multiple modes of interaction provide the user with a wide variety of means of input and output in addition to a computer display, keyboard and mouse. Voice control, for example, integrated into a bank machine (Hone et al., 1998; Johnson and Coventry, 2001) and
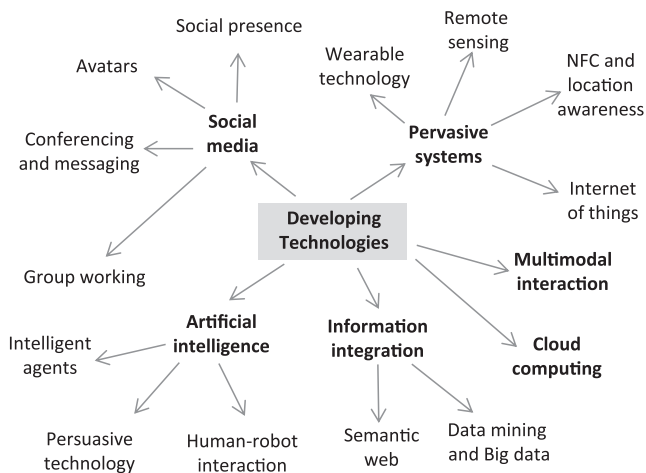

Fig. 3. Diagram of technologies that are developing and which may become commonplace in socio-technical systems design.

haptic feedback, possibly through driving controls, are becoming common especially within 'hands and eyes busy' environments. Other modalities such as pen or gesture-based input may also supplement keying and mouse movement. These different forms of interaction will require user adaptability, appropriate training and careful fitting to the environment if they are to be used effectively within an organisation (Benyon, 2010a).

5.4. Cloud computing

Cloud computing is the delivery of IT resources over a network (typically the internet) at a remote location rather than via a local server (Armbrust et al., 2010). It is a way to increase capacity or add capabilities on the fly without investing in new infrastructure, training new personnel or licensing new software. It allows companies to get their applications up and running faster, with less maintenance, and with the ability to rapidly adjust resources to meet variable business demand. Users access cloud-based applications through a web browser, light-weight desktop or mobile application. This development will allow workers to operate in more flexible ways and be less dependent on companies being based in their home location. However organisations will need to trust cloud based services to safely maintain their data and software while workers will rely on receiving sufficient support in accessing them.

5.5. Information integration

Information integration is the analysis or merging of data from different sources. This might be structured or unstructured data with the aim to create new knowledge or derive insights — an area of research known as data mining or big data. To assist this process, the International Society of Information Fusion (http://www.isif.org) is dedicated to advancing the knowledge, theory and applications of information fusion while the 'semantic web' is a collaborative movement led by the World Wide Web Consortium (W3C) to promote common data formats on the web so data can be shared more easily and reused across applications, enterprises, and communities. While such developments can achieve great benefits it also creates problems of available storage space, ensuring data security, and protecting privacy as the information multiplies and is shared ever more widely around the world (Economist, 2010). These developments are likely to require information workers to acquire new competencies in data structuring, integration and analysis, and appropriate skills to work with the data formats of the semantic web.

Information integration may also arise when two organisations merge and combine their data records (e.g. customer accounts) and create common procedures. Migration of information from one system to another can cause problems particularly for an organisation's customers. With the offender management system, case records for the prison and probation services were combined and integrated into a new system. However there were some glitches as a result. It was reported that one prisoner was 'a risk to females under 16' on the old system but 'a risk to females over 16' on the new one. This was thought to be due to only part of the data field being read after the transfer from the old system (a problem that was rectified).

5.6. Artificial intelligence

Artificial intelligence (AI) is the theory and development of computer systems able to perform tasks that normally require human intelligence. One example is the 'intelligent agent' — software that assists users in sophisticated ways possibly acting on their behalf. A typical application for an 'agent' is to support a customer help desk by providing automated answers to queries. Another is to assist research by automatically downloading relevant web pages and browsing offline. The agent may also present themselves to the user as a human-like character or avatar which can cue responses, e.g., through their use of language, assumption of social role, or physical presence (Reeves and Nass, 1998). This is just one form of 'persuasive technology', which is designed to change attitudes or behaviours of the users through persuasion and social influence but not through coercion (Fogg, 2002). While intelligent agents have the potential to empower human beings, incorrect actions could cause problems while poor decisions made by humans advised by agents or expert systems raises ethical issues (Liu, 2010). A further development is human–robot interaction. Here the ability to interact with people in an entertaining, engaging or seamless way is part of a robot's functionality. They might take the role of museum tour guides, hospital assistants, giving support to children with autism, or robotic pets (Brezeal, 2003). New forms of interaction or even etiquette will be needed to make the interaction with these intelligent creatures effective. More generally users will need to learn the skills to make the best use of AI developments to appreciate the benefits they offer and their limitations.

6. Making the socio-technical approach effective

It might be questioned why, since socio-technical systems analysis has existed for so long, poor systems are still being designed. Based on the literature and the author's experiences, it seems that simply conducting a socio-technical analysis will not be able to change the outcome of a system design if some fundamental decisions have already been made that limits how the system can develop. Some key ones are: (1) having an over ambitious system concept without appreciating the difficulty in achieving the technical design or the complexity that may result for users; (2) not realising what level of change the new system might mean for the users and existing procedures, and using the IT system to push them through; and (3) having fixed system requirements written into contracts and employing a phased development with too little time to incorporate feedback after the initial phases.

Some steps to addressing these problems can be offered. One strategy is to start with a more modest system concept and building upon it after user feedback. This is likely to lead to easier implementation and a more manageable system for the users to learn. Another step is considering what organisational changes the innovation might require and planning for them rather than just concentrating on the technical development. An agile systems approach advocates the development of more frequent iterations of the system based on the appropriate selection of functions to implement at each stage, in consultation with the users. Agile development is also open to user requirements changing and the specified functions being amended prior to the development of the next version of the system. This style of development fits in well with the principles of user-centred design (ISO 9241-210, 2010; Stewart, 2012; Maguire, 2013).

Another problem is (4) selecting a software environment that is not flexible enough to deliver the system functions and features in the way users might want. Then, although human factors experts may be employed to comment on a design prototype, it may not be possible to implement the suggestions they make to address any problems identified. A further limitation of current practice is including only some user representatives in the design process but (5) not involving sufficient user types early on and learning what they value about the existing system. This can lead to the system failing for various practical reasons that with wider user representation could have been foreseen.

Despite these continuing problems, it may still be argued that by taking a socio-technical systems approach will help to achieve the

high quality system that designers envisage. However this needs to be carried out in a context where the benefits of the approach can be realised i.e. allowing the requirements to evolve, retaining flexibility to change the design with a more agile approach, and making the effort to recruit a wide range of users and allowing them to influence the fundamental design concept. This will require the managers of a project to buy into these ideas and allow the socio-technical process to help guide system development.

7. Conclusions – user interaction and the virtual organisation

New ways of working are defining new socio-technical situations that need to be considered and which may impact on the person interacting with the system. The internet has stimulated the creation of new forms of human community through social networking and while they will require new forms of interaction to support productive working, traditional principles of user interface design will still apply. If a company starts to sell and promote products through a social media website, users still require good navigational tools to find the articles they are interested in, browse customer comments on them, and obtaining support if they cannot find what they want.

It is widely believed that the business organisation of the future will be virtual, a style of working which can have a great variety of structures, all of them fluid and changing (Jackson, 1999). A virtual organisation relies mostly on a network of part-time electronically connected freelancers, sometimes referred to as 'e-lancers' who concentrate on the company's core competences leaving other functions to external providers. Linked to the idea of the virtual organisation is the virtual office where people work as and when they need to at the most convenient location. This style of working is flexible and cost effective but makes it difficult to form close relationships with colleagues. As Eason (2010) points out, the most obvious feature of virtual organisations as socio-technical systems is that most social communication and task sharing activity is mediated through the technology. Since face-to-face communications has always been seen to be an important part of creating common understanding, shared values and objectives, and of co-ordinating work, this presents new challenges for user–system interface design. If all of the functions have now to be performed through the technology, what are the implications for the socio-technical system, for how people communicate or even how they think? Studies into use of email and texting illustrate the misunderstandings that can occur and the adaptations that people have to make to maintain effective communication (Maguire et al., 2012).

As well as carrying out tasks effectively, how well in the virtual organisation can total system performance be monitored to enable problems to be identified and appropriate modifications made? How well can a lack of access to face-to-face technical support be replaced by the provision of new forms of online technical help, possibly through an intelligent agent? What new skills will be required by workers to manage the new forms of internet-based interaction or use interfaces that will look and act very differently to what people know today? These and other questions created by the growth of the virtual organisation seem to herald a new era for socio-technical systems thinking and new challenges for user interface design.

Acknowledgement

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