Electronic Performance Support

Using Digital Technology to Enhance Human Ability

Edited by
PHILIP BARKER
and
PAUL VAN SCHAIK

GOWER
This initial chapter of the book is intended to provide an introduction to the basic nature of performance support systems (in general) and electronic performance support systems (in particular). The chapter begins by introducing and describing the ideas underlying the use of the term ‘system’. It then identifies human-activity systems as being an important issue in relation to the material covered in subsequent chapters of this book. All humans have innate limitations; some of the major causes of these limitations are discussed and some of the consequences of these are illustrated using a selection of anecdotal evidence. Human behaviour and performance in any given task domain is critically dependent on the knowledge and skills that individuals possess. Because much of the work that is undertaken in the area of performance support relates to skill improvement, the chapter discusses the basic nature of skills and skilled performance – and how this may be improved through the use of different types of supportive intervention and/or performance aid. Consideration is then given to the importance of knowledge in relation to skilled performance.

Systems Orientation

In my introductory lectures on the subject of human-computer interaction (HCI), I tell my students that ‘everything is a system’. Indeed, according to many theorists, ‘the Universe consists of a set of interacting systems’. So, what exactly is a system? According to Ackoff (1972: p. 84), a system is a ‘set of interrelated elements’. In his definition, however, Jenkins (1972: p. 60) emphasises the role of people when he states that a system is a ‘complex grouping of human beings and machines’. Checkland’s view (1972: p. 52; 2001) is that a system is ‘a structured set of objects and/or attributes together with the relationships between them’. Systems and their properties are examined in greater detail as part of the ‘soft systems methodology’ described by Checkland and Poulter (2006: p. 7).

Bearing in mind what has been said above, we consider a system to be some part of a physical or abstract universe that has been ‘set aside’ for the purpose of study. Items that make up the identified system are delineated from items that are not within it by means of the system’s boundary. Everything that is not within the system itself is said to

---

I often use the term ‘we’ in my writing to refer to myself and my readers, as a group of people, who are sharing the content of the book. I also use this pronoun to refer to: either (a) myself and my co-editor or (b) to myself and the other contributing authors. In situations where ambiguity may arise, I will make clear my usage.
constitute the environment in which the system exists. Thus, in Figure 1.1, items A, B and C each form part of the system ‘X’ while objects P, Q and R are not within the system. These latter objects form part of the environment in which the system exists. The line that surrounds the three objects A, B and C is the system boundary.

The environment of a system is important because it can influence both the properties and the behaviour of a system. Similarly, the system itself can have an effect on its environment. The extent to which a system and its environment influence each other will depend upon the ‘permeability’ of the boundary. That is, how easily energy, material or information can pass through it. Depending upon the relative ease with which this can happen, systems can be broadly classified into two basic types: open and closed.

Any given system can usually be visualised in terms of the various sub-systems from which it is composed and the ways in which these interact with each other. In Figure 1.1, for example, the objects labelled A, B and C could be regarded as the three sub-systems that make up the system X. In a motor-car, three of the important sub-systems are: the electrical sub-system, the steering sub-system and the propulsion sub-system. Similarly, in a human being, three examples of sub-systems would be: the digestive system, the respiratory system and the cognitive system.

Different systems (and sub-systems within a given system) will normally interact with each other by means of the sets of inputs and outputs associated with them. In Figure 1.2, the three systems X, Y and Z influence each other’s behaviour by means of the input and output channels that interconnect them. One of the outputs from system X appears as an input to system Y; X can therefore influence the behaviour of Y. Both X and Y can influence the behaviour of system Z. System Z can influence X but cannot influence Y nor can Y directly influence the behaviour of system X.

In a human-computer system, for example, the human component can influence the computer by using its keyboard and its mouse – sometimes speech interaction is also possible. Similarly, the computer component can influence its human user by means of

![Figure 1.1 A system, its boundary and its environment](image-url)
its visual display unit and the various audio effects that it can produce. Special forms of tactile interaction are also possible.

At any given instant in time, a system will exist in a particular state. A system could change its state (and hence its behaviour) as a result of interaction with other systems or as a result of internal events that take place within its internal sub-systems. For example, a computer could influence its user's state of knowledge as a result of material displayed on its screen. Similarly, the type of action a computer performs could be influenced by what a user types at his/her keyboard.

Systems are an important concept which we will use quite extensively in subsequent parts of this book. We will be particularly concerned with the design and development of Electronic Performance Support Systems. Such systems – often referred to by the acronym ‘EPSS’ – are computer-based systems that are intended to improve the performance of human beings within some particular task domain. An EPSS is an example of a human-activity system. The origin and nature of human-activity systems are briefly discussed in the following section.

**Human-Activity Systems**

Bearing in mind that ‘everything is a system’, there is obviously a very large number of systems in existence. It is therefore very important to have a mechanism by which systems can be classified into different types. Again, Peter Checkland comes to our aid (1972; 2001). He proposed a taxonomy containing five basic types of system: natural systems, designed physical systems, designed abstract systems, human-activity systems and transcendental systems. The latter category refers to systems that are beyond our current state of knowledge – systems that do not currently exist but will exist in the
future. Within the context of this book, the most important type of system is the human-activity system.

A human-activity system is defined as one that involves an individual (or a group of people) participating in some form of activity. Most human activity can be interpreted in terms of goal-seeking or problem-solving behaviour. Naturally, individual people undertake a wide range of activities – some are quite trivial while others are more complex. For example, an individual can think, sing and walk (or run) from one location to another. These are referred to as individual activities. In many situations there is a requirement for a group of people to undertake an activity in a collaborative way – thereby functioning as a team. Typical examples of collaborative activity involving a team of people are: a game of football, an army defending (or invading) a country, a surgical team conducting an operation in a hospital and a management team within a company or organisation.

The importance of activity in human goal seeking and/or problem solving is illustrated schematically in Figure 1.3 which shows how a set of activities can lead a system from some initial state towards a (possibly different) final state.

In Figure 1.3, the initial state is the state that our system exists in before we undertake any activities. The target state is the state we want our system to be in after we have undertaken a set of activities that (we hope) will transform the system into its new target state. Three sets of activities are depicted in Figure 1.3. The first of these (Activity Set 1) leads to a target state that we are trying to achieve. The second activity chain leads to a final state that is not the target that we are trying to achieve while the third activity set has no effect in moving the system out of its initial state.

As was mentioned above, there are many different types of activity. There is a need therefore to have a method of classifying these. One useful approach, from the perspective of this book, is to divide activities into two broad categories: aided and unaided. These terms are defined and described below.

![Figure 1.3 System state transitions achieved through activity chains](image-url)
UNAIDED ACTIVITY

An unaided activity is one which does not require the use of any other form of tool or support aid to facilitate its completion. Nowadays, there are not many activities that we conduct in an unaided way. Some simple examples are: thinking, speaking, walking and reading. The last of these is an interesting one for two reasons. First, an additional system component is needed – namely, something to read (such as a book or newspaper); second, unaided reading assumes that the person who is doing the reading has ‘good’ eyesight. As people age, their near-vision capability decreases and some form of optical aid is needed to facilitate the reading process – such as spectacles or a magnifying glass. In this situation the reading process has now become an aided activity.

AIDED ACTIVITY

Bearing in mind what has been said above, we can now define an aided activity as one that requires the use of some form of aid, tool or machine in order to complete it satisfactorily. Most of the activities that we now undertake are aided activities. For example, cleaning one’s teeth requires the use of a toothbrush – be this of the simple variety or an ‘electric’ one. Writing a letter or an essay requires us to use a pen, a pencil or a computer-based word-processing system. Similarly, it would be totally impossible to make a telephone call without the use of a mobile phone or a conventional telephone handset.

The concept of aided activity is fundamental to subsequent sections of this book. It is important because we shall be concerned with the design of aids (tools and machines) that will help a human operative to improve his/her performance within some activity that he/she has to undertake. However, before such aids can be designed, it is important to understand the nature of the factors that influence and/or inhibit optimal performance within a given task activity. Some of the limitations that we need to consider are briefly introduced in the following section.

Human Limitations

For a variety of different reasons, and to various extents, human beings are constrained by a range of different kinds of limitation. Some of these are innate or ‘inherent’ while others are ‘acquired’. This section discusses the basic nature of human shortcomings and the sources from which they originate. A number of generic shortcomings are identified as a basis for the development of some of the performance aids that are identified and described in later parts of the book.

INHERENT LIMITATIONS

An inherent limitation is one that originates either from some natural cause or arises as a result of a disability that a person may be born with. For example, the distance that an individual can reach with his/her arm (a roughly spherical or cardiod ‘touch space’ of about three feet in diameter) is a natural innate limitation. Of course, the extent of a person’s reach will depend upon the length of that individual’s arm when it is fully extended. Naturally, the exact shape of the touch space will vary from one person to
another – thereby allowing a range of reach possibilities. An individual’s reach limit could be extended by the design of appropriate ‘reaching tools’.

Another important source of inherent limitation is that derived from the numerous types of disability from which people may suffer from birth. Thus, people who are born blind, for example, have a very distinct visual limitation compared with those that are born with ‘normal’ vision.

**ACQUIRED LIMITATIONS**

Limitations arising from disability can also be ‘acquired’ as a result of some form of accident or as a result of the natural aging processes. For example, a person who is involved in an accident that subsequently necessitates the amputation of a limb will suffer from quite severe limitations in comparison to what he/she was capable of before the accident. In this type of situation, support aids can be designed to compensate for the loss of the limb but these may require the acquisition of new skills.

**THE AGING PROCESS**

As people grow older, significant changes can take place in their bodies. These changes will, quite naturally, influence what they are able to do and achieve in later life. Therefore, as people with perfectly ‘normal’ health profiles grow older, they will begin to develop age-related (acquired) disabilities. Two of the most obvious changes that people notice as they grow older are the deficiencies that arise in their visual and aural systems. Of course, these degradations can be compensated for and corrected by means of appropriately designed ‘performance interventions’ – spectacles and hearing aids, respectively.

**DISABILITY**

There is a tremendous range of both physical and mental disability\(^2\) that can afflict the human species. Needless to say, a considerable amount of research has been undertaken in relation to the design and fabrication of performance support aids that allow different types of disability to be overcome or, at least, coped with. With many types of disability, the use of an appropriate performance intervention can restore the victim of disability to ‘near normal’ health again. In lots of other situations, such interventions may not restore full ‘normality’ but can be used successfully in order to improve the sufferer’s ability to cope with his/her predicament.

**HUMAN LIMITATIONS – SOME EXAMPLES**

In order to demonstrate the existence of innate limitations, four simple examples will be used. These will illustrate the natural limits that are placed upon our ability to do things – and how these limits can be overcome through appropriate aids and tools.

---

\(^2\) The word ‘disability’ is used here in a generic way to reflect any sort of human shortcoming such as impairments and handicaps of various sorts.
Example 1: Ambulation

As a person who enjoys walking and running, I have often pondered about people’s limits in terms of the distance and speed with which the unaided human species can ambulate from one location to another. Of course, there will be innate limits on both the maximum speed and distance that can be covered. In order to overcome these physical barriers to movement, performance aids are often used; a scooter, a bicycle, a car, a ship, a train and an aeroplane are typical examples of the ‘aids’ that we employ in order to move ourselves around. For people who are disabled, various kinds of disability aid can be used to support their ambulation processes – such as crutches, artificial limbs, wheelchairs and mobility scooters.

Example 2: Sound production

The range of sounds that the human voice can produce is very impressive. However, the number of different sounds each individual can achieve varies considerably from one person to another. Despite what it can do, the human voice is very restricted in terms of the range, quality and intensity of the sounds that it can produce. Therefore, in order to extend the repertoire of human sonic ability, a wide range of musical instruments have evolved. These have been based on different physical principles for sound generation – for example, percussion and string or wind vibration. The range of sounds that can be produced by human effort can also be augmented through the use of computer-generated digital music and sound effects.

Example 3: Simple arithmetic

The human mind is quite a remarkable ‘machine’ in terms of what it can do – particularly in terms of its ability to reason things out – in both inductive and deductive ways. It is also quite good at doing simple arithmetical computations – provided the numbers involved are not too complex. For example, by the time they leave school, most people can add together a list of simple numbers (such as, 23+13+16+17) or multiply two numbers together without the need for pencil and paper. However, if the numbers become more complicated, the computational limitations of the human mind soon become apparent. Consider, for example, adding together a string of numbers such as 23.582+13.738+16.949+17.697, or multiplying 389 by 986. These computations are too difficult for most people to do ‘in their head’. Consequently, an electronic calculator or a procedure involving the use of pencil and paper would be needed.

Example 4: Remembering things

As well as its computational ability, the human brain is also quite good at remembering things and making associations between different events and the various phenomena to which it is exposed via our sense organs. However, it has severe limitations both with respect to how much it can remember and to the level of detail that can be recalled. For example, there are very few people who could recall, without the aid of a diary, what they were doing on their tenth birthday – or, for that matter, any of their other birthdays. Sadly,
human memory shortcomings are a major limitation in relation to human behaviour – especially in situations where ‘remembering things’ is of prime importance.

Major sources of natural human limitation

We have already mentioned some of the human species’ natural limitations earlier in this section. These were specific examples that apply to most people. It is important to consider the ‘deep-rooted’, underlying causes of the limitations from which we suffer. Obviously, there will be a number of sources that are either singularly, or in-combination, responsible for our shortcomings. Some of the most often cited sources of our limitations are listed in Table 1.1.

<table>
<thead>
<tr>
<th>Perceptual Limitations</th>
<th>Lack of Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attentional Limitations</td>
<td>Laziness</td>
</tr>
<tr>
<td>Processing-speed Limitations</td>
<td>Clumsiness</td>
</tr>
<tr>
<td>Memory Shortcomings</td>
<td>Carelessness</td>
</tr>
<tr>
<td>Problem-solving Limitations</td>
<td>Reaction-time Limitations</td>
</tr>
<tr>
<td>Decision-making Limitations</td>
<td>System Overload</td>
</tr>
<tr>
<td>Language Limitations</td>
<td>Distractions</td>
</tr>
<tr>
<td>Physical Limitations</td>
<td>Physical Disability</td>
</tr>
<tr>
<td>Lack of Knowledge</td>
<td>Mental Disability</td>
</tr>
<tr>
<td>Lack of Skills</td>
<td></td>
</tr>
</tbody>
</table>

Cognitive limitations arise from our inability to perform cognitive processes – such as mental arithmetic and decoding material that we read from books or on the Internet. Many of the errors or mistakes that a human being makes can often arise from either memory or perceptual causes. That is, an inability to remember something or to be able to understand the meaning of an event or issue. In addition, there can be limitations which arise from cognitive and/or physical problems. Physical limitations arise as a result of limits that our bodies place on the activities we undertake – for example, how far we can run or walk and how quickly we can write or type at a keyboard.

Sometimes, a plain lack of knowledge can be the cause of a poor performance in the things that we do – or would like to do. For example, when driving a car, not knowing which route to take when going from one place to another can result in getting lost – unless the vehicle being driven is fitted with a ‘sat-nav’ facility. Similarly, a lack of requisite skills can also be a source of poor performance which thereby imposes limitations on what we can achieve or undertake. For example, a person who cannot swim could not participate in water-sports such as water polo or scuba diving. Motivation is another important factor that influences and places limits on what an individual can achieve.

Many human limitations can often be overcome by means of an appropriately designed performance support intervention – like the satellite-navigation system that was mentioned above. We shall discuss the nature of these performance interventions in subsequent parts of this book.
Anecdotal Evidence

In order to illustrate some of the ‘unusual’ behaviour that can be caused by the human shortcomings identified in the previous sections, one of us (PGB) sat down and thought about a number of different events that happened to him during a recent period of time (the summer of 2007). Some of these are briefly described below; each event is a consequence of some of the human limitations that were listed in the previous section.

LOST CABLES

I recently made a business trip to Taiwan. When my travel requires absence from home for more than a day or two, I usually take with me a number of ‘power sources’. Normally, I take a battery charger for my iPod, one for my digital camera and yet another for my mobile phone. Some days into my visit (and now in my third hotel), I needed to charge my iPod. I looked in my baggage for the cables but I could not find them. I then wondered whether or not I had actually packed these cables before leaving home. Maybe I had put them ready to be packed and then, for some reason, forgot to put them into my suitcase? When I got back home from my trip, I searched everywhere in my house for the missing cables – but I was unable to find them. Where could they be? I then sat quietly and reflected on my trip; suddenly, with a ‘flash of inspiration’, I remembered what I had done. I had taken the cables out of my suitcase and put them in one of the drawers of the dressing table at the first hotel that I stayed in. When I left that hotel, I forgot to retrieve the cables from the drawer and pack them into my baggage. I immediately e-mailed my host and explained what had happened; he rang the hotel. The hotel staff found my cables in the location that I described in my e-mail and they were eventually returned to me.

LOST RAILCARD

Within the UK it is possible to get reductions in the cost of personal rail travel provided one is in possession of a railcard. Some time ago I lost mine. I remember using it to make a travel booking but subsequently could not find it anywhere. I therefore had to buy a new one – some three months before my old one was due to expire. Not only was I irritated by the fact I could not remember where I put it, I was also upset by the extra financial burden I had to bear. Several weeks after this event, I had to replace the toner cartridge for my laser printer. As I was withdrawing the expended cartridge, I found my lost railcard sitting inside the printer on top of the paper contained within the input tray. How on earth did it get there? Well, I can only think that I placed the railcard on the paper tray (see Figure 1.4) and then, forgetting that it was there, printed out a document. As the paper fed into the printer, so my railcard went with it! Of course, I had forgotten where I had ‘temporarily’ placed the card and so did not think of looking inside my printer. Mystery solved!

AN EARLY BIRTHDAY CARD

One morning in mid-August I received a telephone call from my sister. I had recently sent her a birthday card and was about to arrange to have some flowers sent to her. She
thanked me for the card and commented on how nice it was. She then explained that it was just a little early – in fact, two months early! So, I thanked her for reminding me and told her that this year she would get two birthday cards from me – I would send another in October (along with the flowers that I was just about to send but then rescheduled). How did this happen? On reflection, I realised that I had confused my (now deceased) mother’s birth date with that of my sister. This event shows just how easily one can get confused. Of course, had I checked in my diary, this would not have happened. I was ‘negligent’ and paid the price – an incorrectly sent birthday card.

A LOST SOCK

I belong to a rambling club and do quite a lot of walking over rough terrain. I usually wear two pairs of socks with my walking boots: a thin pair next to my skin and a thick pair on top. Every weekend, we hire a coach to take us to the location where we are going to walk. I usually put my walking socks on while travelling on the coach. One day I took two thin socks and two thick socks out of my bag. I successfully fitted my thin socks but found that I was short of a thick sock. I got on my hands and knees and crawled around the area where I was sitting in order to search for my missing sock – but could not find it anywhere. A friend said that he had a pair of socks I could borrow. So, I proceeded to take off the thick sock from my left foot – only then to find that I had (inadvertently) fitted two thick socks to my left foot! Why was this? I guess I was distracted and lost my concentration. I was so busy talking to people as I was putting on my socks, I failed to notice that I had put two thick socks on one foot.
DUPLICATE PURCHASES

Like many other people, I have quite a sizable collection of music CDs. Naturally, because of my memory limitation, I am always at a loss with respect to being able to recall the details of any particular CD that I own. Of course, I have a good idea of which composers are in my collection and I have a general ‘feel’ for the material that I have from each composer and artist. Despite this, on numerous occasions I have made CD purchases in music shops only to find when I get home that the purchase I made is already present in my collection. Consequently, I then have to take my purchase back to the CD shop and exchange it for something else. Incidentally, I have exactly the same problem with my large collection of paperback books that I use for light reading, entertainment and relaxation!

KNOWING WHERE TO GO

Quite often, when I travel to a new city or town that I have not previously visited, I am ‘at a loss’ in knowing where things are and how things are done. Although the meta-knowledge that I have gained from previous similar situations and experiences is useful, I lack the detailed local knowledge needed to handle my new situation. As I spend time exploring the city, I gradually acquire the knowledge that I need in order to locate things (such as the local supermarket) and how to get things done (for example, travelling from one part of the city to another). This knowledge, once acquired, will usually ‘stay with me’ for the duration of my visit – and can normally be recalled on subsequent visits. However, the amount I retain and the ease of recall invariably depends upon how often I visit the city and the frequency between the visits that I make.

KNOWING WHAT TO DO

For many years I have been a very keen photographer. I recently purchased a new digital camera. This camera had considerably more functions than any of the previous ones I have owned. Of course, the problem was there were so many potentially useful facilities (and so many buttons to press) that I did not know what to do in order to take, and subsequently manipulate, my photographs. Indeed, it took me quite a while both to figure out how everything worked and to gain the skills needed in order to take respectable photographs. Of course, my meta-knowledge of digital cameras was a useful starting point. However, learning ‘what to do’ required some investment of time in terms of reading both the paper-based and electronic manuals that accompanied my new camera. Of course, some considerable practice was needed before my skills developed.

On the Nature of Skills

In any human activity, success (or failure) depends very much on the amount of knowledge that an individual (or team) has and the level of skills that he/she/ (or it) possesses (Barker, 1990: p. 130). Much of our research into performance support is concerned with helping people to develop and/or improve the skills that they have. It is therefore important to understand the basic purpose and nature of a skill.
Essentially, a skill is a physical or mental ability (or dexterity) that a person has and which enables some task or goal to be achieved. More precisely, a skill (or set of skills) is essentially a collection of one or more executable procedures that an operative uses in order to successfully complete a task or job in an effective and/or efficient way, thereby producing some desired outcome or artefact. Skills are often associated with some particular domain of expertise. Table 1.2 lists some examples of different skill domains.

Table 1.2  Examples of types of skill domain

<table>
<thead>
<tr>
<th>Mathematical</th>
<th>Scientific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>Management</td>
</tr>
<tr>
<td>Musical</td>
<td>Artistic</td>
</tr>
<tr>
<td>Dancing</td>
<td>Writing</td>
</tr>
<tr>
<td>Communication</td>
<td></td>
</tr>
</tbody>
</table>

Skills are used to achieve particular goals as a result of executing the different tasks involved in a given ‘doing’ activity – as depicted schematically in Figure 1.5. In this diagram, the collection of skills that is needed in order to achieve some desired outcome is referred to as a skill set.

Normally, the procedure that we would use in order to convert an intent (to achieve something) into a sought-after result would usually be as follows: (1) identify the doing activity that is required to achieve the desired goal; (2) identify the skill set needed in order to execute the tasks involved; (3) acquire the necessary skills; (4) practise the

Figure 1.5  Using skill sets to realise ‘doing’ activities
skills in order to achieve the required levels of competence; (5) use the skills within the
doing activity; and (6) create the outcome, result or product. However, in many cases,
the procedure may not be followed because of the ‘paradox of the active user’ (Carroll,
1987): first, users may not be willing to spend the time required to acquire the necessary
skills (assimilation failure) and, second, they may employ previously acquired skills that
do not apply to the current situation (accommodation failure). Thus the paradox of the
active user provides a justification for the importance of performance support discussed
later in this chapter and in the following chapters of this book. The procedures involved
in developing the skills needed to become a skilful domain expert have been captured in
the MAPARI model of skill acquisition (Barker, 1994). This model is considered in detail
later in Chapter 4.

The skills that any given individual has can be classified into two basic types: innate and
acquired. An innate skill is one which someone possesses as a natural consequence of his/her existence. Examples of innate skills include: the ability to observe one’s environment using visual techniques; the recognition of pleasant and unpleasant aromas using one’s sense of smell; the sensing of different acoustic stimuli; tactile sensing; and the generation of sonic utterances of various sorts. Acquired skills are ones that are developed through the processes of learning and training; they can usually be ‘fine-tuned’ and enhanced as a result of practice. For example, people can learn how to sing and then have their voices trained so as to produce acceptable sounds. Similarly, an individual could learn how to play a musical instrument and then practise with it in order to achieve a required level of accomplishment. The relationship between practice and increased speed of skilled performance is embodied in a famous law called the ‘Power Law of Practice’ (Card, Moran and Newell, 1983). We shall discuss this topic in more detail later in the book.

Two very important examples of acquired skills are reading and writing. These are quite complex activities that can themselves involve a variety of skill sets. For example, if we consider reading, the skills needed will depend upon the type of reading process involved – silent reading, reading aloud, reading to understand, and so on. Within the context of silent reading (for understanding), the level of skill that a person shows will depend very much upon the cognitive complexity of the material being read and the amount of experience and tuition that a person has had. The level of skill that a person shows will usually be reflected in the speed with which the material can be read, the accuracy of reading (at both the lexical and cognitive levels) and the ease with which the reader can extract the meaning that is embedded in the material being processed. Of course, reading aloud involves extra skills – for example, the vocalisation of the material as it is being read without making any mistakes (either in the reading process or in the pronunciation). Newsreaders have particularly high levels of skill when reading aloud. Skill levels and performance is considered further in the following section.

The skills that a person has will invariably influence his/her approach to problem
solving and, therefore, the nature of the activity chains that he/she designs in order to
solve a problem or achieve a sought-after goal. One possible relationship between problem-solving activity and the skill sets that a human may possess is depicted schematically in
Figure 1.6.

In Figure 1.6, we are attempting to show that humans (and hence, human behaviour)
are influenced by internal mental processes such as creative thinking and reflective
thought. These can generate ideas that can be used within a problem-solving context.
Of course, human behaviour is also strongly influenced by the wide variety of internal
and external stimuli to which individuals may be exposed; these originate from a wide variety of different sources. Depending upon their origin, these stimuli could act as a powerful source of motivation – or, contrariwise – of demotivation. People's motivation to solve any particular problem will depend critically on their having an awareness that a particular problem exists – and also, an awareness of the tools that are available for solving it. Self-realisation is also a powerful motivational force – the realisation that one has (or does not have) the necessary skills that are needed to solve a particular problem.

Figure 1.6 also shows how a skill set can be used within the context of problem-solving activity. In this context, the term is used to denote a particular collection of skills that an individual or a group of people use in order to solve problems (a ‘doing activity’) within a particular type of problem-solving environment. Notice that the skill set shown in Figure 1.6 could involve the use of appropriate devices and/or tools and/or machines as aids to help in the problem-solving activity. We have discussed the concept of aided activity earlier in this chapter. It is important to emphasise the fact that the nature of the skill sets needed in any given situation will depend critically upon the types of problem being solved and the kinds of environment within which these problems exist. The environment that hosts a given problem can be classified according to its complexity and the demands that it places on problem solvers. Three typical examples of categories of environment are: challenging (for example, flying an aeroplane), mundane (for example, washing dishes) and creative (for example, painting a picture or creating a sculpture).

From the perspective of designing performance support facilities, the relationship between devices, tools and machines and human skills is an interesting one – this is depicted schematically in Figure 1.7.

This diagram is intended to convey four important facts. First, individuals are endowed with various sets of skills. Second, humans have the ability to design and create various kinds of tools and machines. Third, human skill sets will be strongly influenced by the nature of the tools/machines available within different kinds of application domain. Fourth, human design and fabrication skills will also strongly influence the nature of the
tools and machines that can be produced. We have previously considered the difference between aided and unaided activity. Of course, tools and machines are a vital component of any sort of aided activity environment. Depending upon the application environment, the products referred to in Figure 1.7 could be a motor-car, a poem, a book, an action or just a transient thought. It is important to remember that many products (such as a motor-car or an aeroplane) could not be produced without suitable tools or machines. Similarly, we must remember that there are no tools available to create some types of product.

When people use tools and/or machines to augment their ability to solve problems, it is important to realise that there will invariably be some form of interface between the tool/machine/device and its user – as illustrated schematically in Figure 1.8.

CR = Control Requirement
CE = Control Execution
FD = Feedback Information Display
FS = Feedback Status

Figure 1.7  Relationship between tools and human skills

Figure 1.8  The basic function of a human-machine interface
There are two main purposes for a user interface: first, to enable a user of a device, tool or machine to control it; second, to provide a source of feedback information relating to the status of the artefact being used for a particular activity. Interfaces vary considerably in their characteristics, quality and capability. Some interfaces are quite simple (for example, the handle on a teacup or a mug) while others are more complex (for example, the cockpit of an aeroplane). Invariably, the nature of a human-machine interface will strongly influence the nature of the skills needed in order to use it and the quality of the outcomes that can be achieved from its use.

In situations where computers play an important part of the tool/machine architecture (as will be the case in EPSS – as discussed in this book), the design of human-computer interfaces will be an important issue to consider. We shall return to this issue later – in Chapter 3.

What is Performance?

This section is concerned with performance-related issues. It is therefore important that we clearly establish exactly what we mean by the term ‘performance’ – and the related concepts of ‘performance improvement’ and ‘performance support’. First, let us consider the meaning of the term ‘system performance’.

We can think of the performance of a system as reflecting how well its behaviour matches some required desired outcome. Even though they are very relative things, and are very context sensitive issues, most people understand the notions of good and bad. For example, having seen a play, we may describe the performance of the actress who portrayed a particular character as ‘good’. Similarly, after having experienced an orchestral concert we may say that the orchestra’s rendering of the music that it played was very ‘bad’. On the other hand, we could take a ‘middle-of-the-road’ judgement and describe something as ‘acceptable’. Figure 1.9 shows a diagram that allows us to classify certain cost-speed relationships (for a particular type of machine) into one or other of the three categories of good, bad or acceptable.

![Figure 1.9 Classification of system performance](image-url)
In most cases, a level of performance is measured against some standard that needs to be achieved. Bearing this in mind, it is possible to identify three broad levels of performance in relation to the standard: satisfactory (the standard has been achieved), below standard (the standard has not been achieved and some improvement is necessary in order to achieve it) and above standard (an individual’s performance lies above that required by the standard).

In many cases, the standards or merits by which we judge things are quite arbitrary. Coming to an agreement about things, that is, reaching a consensus view about our performance assessment metrics is therefore very important if we are truly to understand what we mean by ‘good’ or ‘bad’ performance. Obviously, in order to pass judgment on things we need to have a judgemental framework or a set of judgement values that enable us to classify something as good, bad or acceptable. The use of a judgemental framework is illustrated in some recent work that we undertook relating to the assessment of the relative quality of a series of World Wide Web sites (Barker, 2006). Each of the evaluators involved had to rate the performance of a set of ten websites by ranking them into order – best first, worst last. A quantification algorithm was then used to assess the group’s overall view about the sites that had been examined.

A judgemental framework can be regarded as a multi-dimensional space in which each dimension represents an attribute (of a performance/product) for which a good/bad decision has to be made. The summation of the outcomes for each decision then allows us to come to an overall conclusion about how we feel about something’s goodness, badness or acceptability. Of course, the decisions that we make do not have to be simple yes or no choices; a rating can be given – say on a scale of 0–10 or 0–100. Thus, the performance of a student who gains 100 per cent in an examination could be described as good while that of one who achieves 0 per cent could be deemed to be bad. Similarly, a student achieving 50 per cent could be classified as acceptable. In many cases the attributes do not represent a single underlying dimension (or ‘factor’), but each dimension represents one of two or more underlying dimensions of quality. The scores on the attributes are then added for each underlying dimension to produce a ‘quality profile’ pertaining to these (Tabachnick and Fidell, 2007).

Naturally, once we have made a decision on the merits of something, we should be able to use our judgemental framework to explain why something is good or bad. If something is not good (or not good enough), we should also be able to use our judgemental framework in order to explain why this is the case and how the situation may be improved upon. Hence, the appropriate use of a judgemental framework can be used as a basis for a performance improvement mechanism. In general, we define ‘performance improvement’ within a system as a change in its behaviour in order to achieve a more desirable state. Using the ‘examination performance’ example that was introduced above, if a student (who wants to learn about information technology, say) has done badly in his/her computer programming examination, an analysis of the relevant judgemental framework (examination question paper and student’s answer script) should enable us to recommend various activities that will lead to a performance improvement in this subject.

Performance improvement is an important requirement of performance support systems. It is therefore essential that we are able to measure the improvements that have been gained as a result of introducing a particular performance support intervention. If it is necessary, we should also be able to justify the gains that have been achieved in terms of cost benefit or an improved ‘quality of life’ for those involved in using the intervention. For example, suppose
we have a machine or process that produces a particular product at a given rate – but which fails to meet the required demand for the product. Of course, improving the performance of the machine in order to produce more items per unit time would be beneficial in terms of meeting the demand for the product. It could also lead to a financial gain in terms of greater sales and a possible increase in customers’ satisfaction in terms of product availability.

In the above example, we have introduced three basic ways of measuring the performance of a system: increased output, an increase in financial income and an improvement in customers' satisfaction with the product or service. These measures of system performance are often referred to as performance indicators. When designing and creating performance support tools it is also important that we simultaneously identify appropriate performance measures that will enable us to assess the merits of the tools that we provide – in terms of the increases in performance that can be achieved. This is especially true in the case of a complex, multi-parameter electronic performance support system of the type depicted in Figure 1.10.

In the example shown in Figure 1.10, the inputs to the EPSS will represent various constraints and variabilities (such as different levels of human performance capability) that the system will need to accommodate. Relevant control parameters will normally be available in order to ‘fine-tune’ the performance of the EPSS facility so that its overall output is optimal for the prevailing set of input variables.

This section has explained the meaning of the term ‘performance’ and how ‘performance indicators’ can be used to measure the quality of a system’s performance – and, hopefully, then improve the way in which it performs (if it is possible to do so). It is also important to consider why we need to monitor and improve performance. This issue is discussed in the following section.

Why Improve Performance?

This section addresses the question of why we may want to improve the performance of a system. We start with a personal reflection on this issue (PGB). On the top of my
computer display screen I have a banner that reads: ‘Continuous Improvement Through Positive Incremental Change’. I keep this here as a reminder, both to myself and others who see it, about the need to always achieve the best possible solution that we can when solving any particular problem that confronts us. If a problem can be solved, there will invariably be quite a wide range of solutions – but it may not always be easy to find the best one. Quite naturally, I take a pride in what I do and I always want to achieve the best possible results that I can – within the constraint limitations that are imposed upon me. I am therefore always looking for better, more efficient and more effective ways of doing things – because that’s just the way I am! In this context, I am sure that there are lots (and lots and lots...) of other people just like me.

In a broader context, let us now consider some performance improvement issues relating to the more general area of consumer products and services. Here, of course, it is important to remember that, when buying something, most people will want to achieve ‘value for money’ in terms of the purchases they make – be these ‘hard’ physical commodities (such as refrigerators or motor-cars) or ‘softer’ services (such as the provision of Internet access or a telephone service). Bearing this in mind, we have to realise that most people would like to have the best motor-car possible for the given financial outlay that they can afford to make. As well as ‘best products’, people also want to receive the best quality services within the price range they can afford. In a competitive world, products and services which do not strive to become the best available (within their price range) are unlikely to survive. In this context, ‘survival’ is taken to mean a growth in sales and high levels of satisfaction in a product’s consumer population. Achieving this usually means ongoing improvement in a product (or service) in order to meet the changing demands of its marketplace.

Bearing in mind what was said above, it is important that organisations (and the people that they employ) are mindful of the need for continual ongoing performance improvement. This point is admirably made by Gloria Gery in her seminal book on improving workplace performance (Gery, 1991). The case for this has also been made by William Bezanson (2002) in his book and in our own research (Banerji, 1995; Barker, 1995; Beacham, 1998; Flinders, 2000; Famakinwa, 2004; van Schaik, Barker and Famakinwa, 2006, 2007; van Schaik, Pearson and Barker, 2002).

From the perspective of human performance, it is well known that a person’s skill at performing a task usually improves with practice. Ackerman (2007) has examined this issue in the context of understanding the nature of skilled performance in both physical and cognitive tasks. This increase in performance with practice is summarised in the ‘Power Law of Practice’ that was described earlier in this chapter (Card, Moran and Newell, 1983). Unfortunately, due to natural and innate human limitations, a person’s performance does not improve indefinitely; there comes a point at which further practice does not produce any further substantial improvement in performance – see Figure 1.11 (Barker, van Schaik and Famakinwa, 2007).

So, when a person’s skill level plateaus out (as shown in Figure 1.11), how can his/her performance then be improved? The answer, of course, lies in the study of performance support. Indeed, one of the fundamental motivations for studying this topic is the need to discover appropriate interventions that will shift the skill bands shown in Figure 1.11 from their ‘natural’ levels (lower solid curves) upwards towards their ‘augmented’ levels (upper dotted curves). That is, in the direction of greater skill levels and, as a consequence, improved performance. As the diagram shows, appropriate augmentation through
performance support can be used to improve the quality of task execution for both novice and expert performers. This maxim also applies to people in general – and the problems they face. Obviously, the extent of the improvement that is made will depend critically upon the nature of the performance interventions that are introduced.

For various reasons, as people grow older, their skill levels can start to ‘fall off’. For example, there comes a time when their vision, hearing and information-processing speed (amongst other things) start to deteriorate. For example, older people find it increasingly difficult to read the small print instructions on medicine bottles – or to determine the denomination of coins (other than by their physical size). Failing faculties can lead to a deterioration in the quality of an aging person’s lifestyle. In order to combat this (in the context of sight and hearing), various visual and acoustic performance improvement interventions have been developed (such as spectacles, magnifying glasses and hearing aids) that enable failing faculties to be compensated for. These performance-improving aids can obviously help to restore an aging person’s quality of life. Of course, even people with normal vision and hearing will often have to use special types of aid to improve their performance. For example, an astronomer may use an optical telescope (or a radio telescope) in order to get a better view of distant stars and planets. Similarly, a doctor is likely to use a stethoscope in order to listen to a patient’s heartbeat.

Another extremely important reason for wanting to improve performance comes from a consideration of the many problems that are inherent in overcoming human disability. This area of study is not unrelated to the ‘aging problem’ that was described above. During their lifetimes people can become afflicted with a wide range of impairments, resulting in disability; unfortunately, some people are born with these. A considerable amount of research and development effort is put into creating performance aids that will help disabled people cope with the problems they have. A particularly interesting example of

**Figure 1.11 Performance plateaus and bands**
this is described in the following section; this involves combining computer and robotic technologies to create performance aids that will help stroke victims to regain the use of their limbs. Further examples of the use of EPSS in helping people overcome disabilities are discussed later in the book.

Of course, there are numerous other reasons why improving performance should be considered as imperative within many domains. Indeed, some increasingly pressing problems are to be found in the areas of resource conservation and cost minimisation – especially in the commercial and business sectors. When solving problems we always try to minimise the cost and time involved in realising a particular goal. Achieving this often depends upon minimising energy, effort and material utilisation. Invariably, improving the overall performance of a system can often lead to a reduction in its energy consumption or its material requirements – thereby leading to a subsequent reduction in the cost of running that system. A simple example can be used to illustrate this point.

Consider the amount of energy involved in heating a house; much of the heat that is ‘injected’ into a house often escapes through the walls, roof, windows and doors. By improving the thermal efficiency of the house (through the use of wall cavity insulation, loft insulation, double glazing and draft excluder) the heat loss can be substantially reduced. Less energy would therefore be needed to heat the house – thus leading to an overall reduction in energy costs.

There are, of course, many areas where a global improvement in performance is needed – for example, in reducing carbon emission in order to try to halt the process of global warming. There is a growing body of evidence to suggest that there is a relationship between the world’s carbon dioxide production and the rapid changes that are taking place in the earth’s form (melting polar ice caps and rising sea levels) and climate. There is therefore a tremendous performance support problem inherent in solving this problem – namely, finding mechanisms of energy production and use that are safe and do not generate carbon dioxide.

In this section we have tried to use appropriate examples and illustrations in order to explain some of the reasons why performance support and performance improvement are so important. The ‘bottom-line’ is, of course, that improvements in the performance of a system can lead to a reduction (either directly or indirectly) in the costs associated with that system.

The Role of Technology

In a modern, technology-driven society, much of what we do depends critically on the use of appropriate technology to support the tasks and activities that we have to undertake. For example, distant travel depends upon the use of a bicycle, motor-cycle, automobile, bus, train, ship or aeroplane. Similarly, effective communication depends upon the use of computer systems, radio, television and a telephone network. Maintaining our gardens is also very dependent upon the availability of appropriate tools and machines – such as a spade, a rake, a wheelbarrow and a motor-mower for cutting the grass. In his famous book, The Age of Automation, Sir Leon Bagrit (1965) advocated the thesis that all technology was essentially an extension of human faculties. This is a view to which we strongly subscribe.
Naturally, ‘history moves on’! It is therefore important to remember that the ways in which we lived 100 years ago are not necessarily the same as how we live today. For example, we had no television, no motor-cars and certainly no computer systems. Bearing this in mind, it is highly unlikely that today’s ways of living will be similar to those that will be experienced 100 years hence. Indeed, the kinds of problem we will face and the types of task that we will need to perform in the future will, in all probability, be very different from those which we undertake now. As an example, think of the ways in which the process of ‘writing’ has changed during the time human beings have existed – that is the transition from markings on sand or the walls of a cave to the use of electronic symbols within a computer. Bearing this in mind, it is important to realise that, as new types of problem-solving task emerge (due to the evolution of new industries and new directions of human development), so there will be an ongoing need for the development of new types of tool and machine to perform the tasks that human beings are unable to perform in an unaided way.

Within the area of performance support, technology (in the broadest sense) is extremely important because it provides the necessary resources from which many different types of internal (within the human body) and external performance aids can be constructed. From the particular perspective of this book, computers (and their related infrastructures) are undoubtedly the most important type of technology – but it is not the only technology that we need to consider. In order to produce the most effective solution to a performance support problem it will usually be necessary to seek a solution in which some form of computer technology is combined with other types of relevant technology. This is a topic which is further considered in Chapter 3.

**USING COMPUTER TECHNOLOGY**

The major thrust of this book deals with the use of computer technology for developing performance support systems. We therefore need to consider the basic nature of this technology. There are three major functions that a computer can perform: computation, data storage and communication. Computation uses the machine’s ability to perform pre-programmed mathematical calculations at high speed; it also deals with the ability of a computer to ‘take decisions’ and therefore control other devices attached to it. Data storage refers to the ability of a computer to store large quantities of data, information and knowledge in electronic form – and make this available at any particular point of need, when required, to those who need it. Communication refers to the potential of a computer system to send messages to other computers and devices – thereby indirectly facilitating human communication.

Computer technology can manifest itself in a variety of forms. The most obvious of these is the explicit form; this category is represented by such artefacts as personal desktop computers (PCs), laptop systems and hand-held devices like a personal digital assistant (PDA). A typical example of this type of device is shown in the photograph in Figure 1.12.

In the illustration presented in Figure 1.12, the ‘pencil-like’ stylus device lying beneath the PDA is used to facilitate its user’s interaction with it. This can be achieved in two basic ways: first, by means of pointing operations made on its screen; and second, using various forms of writing activity on the surface of the screen. Some PDAs are equipped with a miniature keyboard that enables its user to type in information – in much the same
way as a conventional PC or laptop computer is used.

The other major form of computer-based facility is that in which the actual computer is itself embedded within some other kind of technology. Examples of embedded applications include: washing machines, microwave cookers and mobile phones. An interesting medical application of embedded computer support (within robotic devices) has recently been described by Young (2007) in which this type of electronic performance support technology is helping stroke victims to recover from their debilitating conditions. As is the case in this example, the optimal solution to this performance support problem has been achieved by combining computer technology with other types of support technology – an important point that was made earlier in this section.

USING EXPLICIT COMPUTERS AS SUPPORT TOOLS

There are a number of ways in which explicit computer technology (both hardware and software) can improve human performance. The term ‘information and communication technology’ (ICT) is often used to describe different approaches to combining computer-related technology and communication technology in order to create different types of performance-enhancing environment. Typical examples of these include the Internet, the World Wide Web and integrated information processing packages such as Microsoft Office and its Open Source counterpart (StarOffice). Software products such as these are examples of sophisticated, integrated electronic performance systems, in that they provide a collection of software tools – each having a similar end-user interface and the ability to communicate with each other. Together, these tools enable people to enhance their performance in areas such as writing (using the word-processing facility), doing mathematical calculations (using the spreadsheet package), performing data collection, storage and recall operations (by means of the database tool), and so on. Much of the ongoing study in the area of electronic performance support is concerned with the design, development and use of software packages to enable people to improve their skills and performance and overcome their limitations in particular areas – as has been discussed earlier in this chapter. These software packages can vary considerably in terms of their sophistication and the facilities they offer. The range of capability extends from simple ‘typing tutors’ through computer games to complex, powerful and spectacular immersive virtual reality systems.
THE IMPORTANCE OF UBIQUITOUS COMPUTING

Performance support problems arise at all sorts of times in numerous different places and in very diverse situations. Characteristics of this sort place severe demands on the electronic support technology that is needed – in terms of both its global and temporal availability and, of course, its reliability. The term ‘ubiquitous computing’ is often used to refer to situations in which computer support technology is made continuously available to its users in all possible locations at any time of the day or night – in the home, at work, in shops, under the sea, on trains and aeroplanes, and so on. There are three basic requirements that need to be fulfilled in order to achieve this goal. First, there needs to be sources of electrical energy available; second, there should be appropriate communication network coverage and connectivity; and third, relevant computing equipment needs to be available at any particular point of need.

In many ways, the third of the above requirements is probably the most crucial. This requirement can be achieved through the use of ‘mobile’ or portable computing technology (such as laptop computers, PDAs, mobile phones and portable storage devices) that people can carry with them where ever they go. Ideally, these types of computing technology would normally be augmented with appropriate ICT infrastructures and the provision of suitable energy sources.

In situations where there is no computer network availability (or connectivity), through the deployment of portable storage devices (similar to those shown in Figures 1.13 and 1.14) people can take their electronic data and information with them – wherever they have to go. These types of device are therefore having a substantial effect in terms of making collections of data and information available in a ubiquitous fashion.

Devices which have no moving parts (such as those shown in Figure 1.14) are particularly useful because of their high levels of reliability. However, their storage capacities (typically, 0.25 through 64 gigabytes) do not yet match the capacity of portable hard-disk drives such as that shown in Figure 1.13 – which has a capacity of 160 gigabytes.

Computer technology of the type described in this section is likely to show growing popularity in the development of future electronic performance support systems. PDAs, for example, are finding an increasing number of applications within both educational and commercial settings. The work described by Ketamo (2002; 2003) illustrates how PDA technology is being used within an educational context. This work demonstrates how adaptive software can be employed within a PDA in order to improve and enhance students’ skills in the area of geometry study.
Human beings are each beset by the wide range of limitations that confronts them. These limitations can be of two basic types: they are either innate or acquired. Innate limitations arise from our natural shortcomings – for example, how quickly we can ambulate in an unaided fashion from one location to another, how much we can remember and how accurately we can perform mental calculations. Acquired limitations are those with which we are confronted as a result of the various goal-seeking and problem-solving activities in which we become involved. For example, suppose someone sets off to travel to a distant location using a motor-car and then, en-route, the vehicle breaks down. If the person involved in this scenario is not mechanically minded then it would not be possible for the journey to continue by motor-car since the person concerned would not know what is wrong with it and would probably not have the knowledge or skill needed to repair it. Fortunately, roadside services are often available in situations such as this – provided the person concerned has a mobile phone and knows the number to call.

During the history of the evolution of the human species, people have developed a wide range of tools and machines that can be used to enable them to overcome their difficulties and limitations. Many of these devices are also capable of providing us with opportunities for helping us to improve our performance in the tasks that we have to undertake. They can also extend the range of problems that we are able to solve. As has been stressed earlier in this chapter, the study of performance support is concerned with the design, development and use of performance aids that will enable us to improve what we do and how we do it. In many different ways, these performance aids are also likely to improve the quality of life for those involved in using them.

Because we live in a fast-changing, dynamic world, we will always be confronted with new situations and problems that we will have to solve. Of course, this will create a demand for new types of performance support intervention. Increasingly, computer-based systems are likely to figure prominently within the future systems that we build –

**Figure 1.14 Examples of memory sticks**

**Conclusion**

Human beings are each beset by the wide range of limitations that confronts them. These limitations can be of two basic types: they are either innate or acquired. Innate limitations arise from our natural shortcomings – for example, how quickly we can ambulate in an unaided fashion from one location to another, how much we can remember and how accurately we can perform mental calculations. Acquired limitations are those with which we are confronted as a result of the various goal-seeking and problem-solving activities in which we become involved. For example, suppose someone sets off to travel to a distant location using a motor-car and then, en-route, the vehicle breaks down. If the person involved in this scenario is not mechanically minded then it would not be possible for the journey to continue by motor-car since the person concerned would not know what is wrong with it and would probably not have the knowledge or skill needed to repair it. Fortunately, roadside services are often available in situations such as this – provided the person concerned has a mobile phone and knows the number to call.

During the history of the evolution of the human species, people have developed a wide range of tools and machines that can be used to enable them to overcome their difficulties and limitations. Many of these devices are also capable of providing us with opportunities for helping us to improve our performance in the tasks that we have to undertake. They can also extend the range of problems that we are able to solve. As has been stressed earlier in this chapter, the study of performance support is concerned with the design, development and use of performance aids that will enable us to improve what we do and how we do it. In many different ways, these performance aids are also likely to improve the quality of life for those involved in using them.

Because we live in a fast-changing, dynamic world, we will always be confronted with new situations and problems that we will have to solve. Of course, this will create a demand for new types of performance support intervention. Increasingly, computer-based systems are likely to figure prominently within the future systems that we build –
be these for use in the educational, medical, commercial or financial domains. Because of the future importance of ‘Electronic Performance Support Systems’, subsequent chapters of this book will deal with various aspects of the theory and practice of EPSS.

Acknowledgement

I am grateful to Paul van Schaik for his useful criticism and helpful suggestions for improving this chapter.

References


