Introduction

WHY HUMAN–COMPUTER INTERACTION?

In the first edition of this book we wrote the following:

> This is the authors' second attempt at writing this introduction. Our first attempt fell victim to a design quirk coupled with an innocent, though weary and less than attentive, user. The word-processing package we originally used to write this introduction is menu based. Menu items are grouped to reflect their function. The 'save' and 'delete' options, both of which are correctly classified as file-level operations, are consequently adjacent items in the menu. With a cursor controlled by a trackball it is all too easy for the hand to slip, inadvertently selecting delete instead of save. Of course, the delete option, being well thought out, pops up a confirmation box allowing the user to cancel a mistaken command. Unfortunately, the save option produces a very similar confirmation box – it was only as we hit the 'Confirm' button that we noticed the word 'delete' at the top . . .

Happily this word processor no longer has a delete option in its menu, but unfortunately, similar problems to this are still an all too common occurrence. Errors such as these, resulting from poor design choices, happen every day. Perhaps they are not catastrophic: after all nobody's life is endangered nor is there environmental damage (unless the designer happens to be nearby or you break something in frustration!). However, when you lose several hours' work with no written notes or backup and a publisher's deadline already a week past, 'catastrophe' is certainly the word that springs to mind.

Why is it then that when computers are marketed as 'user friendly' and 'easy to use', simple mistakes like this can still occur? Did the designer of the word processor actually try to use it with the trackball, or was it just that she was so expert with the system that the mistake never arose? We hazard a guess that no one tried to use it when tired and under pressure. But these criticisms are not levied only on the designers of traditional computer software. More and more, our everyday lives involve programmed devices that do not sit on our desk, and these devices are just as unusable. Exactly how many VCR designers understand the universal difficulty people have trying to set their machines to record a television program? Do car radio designers

actually think it is safe to use so many knobs and displays that the driver has to divert attention away from the road completely in order to tune the radio or adjust the volume?

Computers and related devices have to be designed with an understanding that people with specific tasks in mind will want to use them in a way that is seamless with respect to their everyday work. To do this, those who design these systems need to know how to think in terms of the eventual users' tasks and how to translate that knowledge into an executable system. But there is a problem with trying to teach the notion of designing computers for people. All designers *are* people and, most probably, they are users as well. Isn't it therefore intuitive to design for the user? Why does it need to be taught when we all know what a good interface looks like? As a result, the study of human–computer interaction (HCI) tends to come late in the designer's training, if at all. The scenario with which we started shows that this is a mistaken view; it is not at all intuitive or easy to design consistent, robust systems

Design Focus

Things don't change

It would be nice to think that problems like those described at the start of the Introduction would never happen now. Think again! Look at the MacOS X 'dock' below. It is a fast launch point for applications; folders and files can be dragged there for instant access; and also, at the right-hand side, there sits the trash can. Imagine what happens as you try to drag a file into one of the folders. If your finger accidentally slips whilst the icon is over the trash can – oops!

Happily this is not quite as easy in reality as it looks in the screen shot, since the icons in the dock constantly move around as you try to drag a file into it. This is to make room for the file in case you want to place it in the dock. However, it means you have to concentrate very hard when dragging a file over the dock. We assume this is not a deliberate feature, but it does have the beneficial side effect that users are less likely to throw away a file by accident – whew!

In fact it is quite fun to watch a new user trying to throw away a file. The trash can keeps moving as if it didn't want the file in it. Experienced users evolve coping strategies. One user always drags files into the trash from the right-hand side as then the icons in the dock don't move around. So two lessons:

- designs don't always get better
- but at least users are clever.

Screen shot reprinted by permission from Apple Computer, Inc.

that will cope with all manner of user carelessness. The interface is not something that can be plugged in at the last minute; its design should be developed integrally with the rest of the system. It should not just present a 'pretty face', but should support the tasks that people actually want to do, and forgive the careless mistakes. We therefore need to consider how HCI fits into the design process.

Designing usable systems is not simply a matter of altruism towards the eventual user, or even marketing; it is increasingly a matter of law. National health and safety standards constrain employers to provide their workforce with usable computer systems: not just safe but *usable*. For example, EC Directive 90/270/EEC, which has been incorporated into member countries' legislation, requires employers to ensure the following when designing, selecting, commissioning or modifying software:

- that it is suitable for the task
- that it is easy to use and, where appropriate, adaptable to the user's knowledge and experience
- that it provides feedback on performance
- that it displays information in a format and at a pace that is adapted to the user
- that it conforms to the 'principles of software ergonomics'.

Designers and employers can no longer afford to ignore the user.

WHAT IS HCI?

The term *human–computer interaction* has only been in widespread use since the early 1980s, but has its roots in more established disciplines. Systematic study of human performance began in earnest at the beginning of the last century in factories, with an emphasis on manual tasks. The Second World War provided the impetus for studying the interaction between humans and machines, as each side strove to produce more effective weapons systems. This led to a wave of interest in the area among researchers, and the formation of the Ergonomics Research Society in 1949. Traditionally, ergonomists have been concerned primarily with the physical characteristics of machines and systems, and how these affect user performance. Human Factors incorporates these issues, and more cognitive issues as well. The terms are often used interchangeably, with Ergonomics being the preferred term in the United Kingdom and Human Factors in the English-speaking parts of North America. Both of these disciplines are concerned with user performance in the context of any system, whether computer, mechanical or manual. As computer use became more widespread, an increasing number of researchers specialized in studying the interaction between people and computers, concerning themselves with the physical, psychological and theoretical aspects of this process. This research originally went under the name *man–machine interaction*, but this became *human–computer interaction* in recognition of the particular interest in computers and the composition of the user population!

Another strand of research that has influenced the development of HCI is information science and technology. Again the former is an old discipline, pre-dating the introduction of technology, and is concerned with the management and manipulation

of information within an organization. The introduction of technology has had a profound effect on the way that information can be stored, accessed and utilized and, consequently, a significant effect on the organization and work environment. Systems analysis has traditionally concerned itself with the influence of technology in the workplace, and fitting the technology to the requirements and constraints of the job. These issues are also the concern of HCI.

HCI draws on many disciplines, as we shall see, but it is in computer science and systems design that it must be accepted as a central concern. For all the other disciplines it can be a specialism, albeit one that provides crucial input; for systems design it is an essential part of the design process. From this perspective, HCI involves the design, implementation and evaluation of interactive systems in the context of the user's task and work.

However, when we talk about human–computer interaction, we do not necessarily envisage a single user with a desktop computer. By *user* we may mean an individual user, a group of users working together, or a sequence of users in an organization, each dealing with some part of the task or process. The user is whoever is trying to get the job done using the technology. By *computer* we mean any technology ranging from the general desktop computer to a large-scale computer system, a process control system or an embedded system. The system may include non-computerized parts, including other people. By *interaction* we mean any communication between a user and computer, be it direct or indirect. Direct interaction involves a dialog with feedback and control throughout performance of the task. Indirect interaction may involve batch processing or intelligent sensors controlling the environment. The important thing is that the user is interacting with the computer in order to accomplish something.

WHO IS INVOLVED IN HCI?

HCI is undoubtedly a multi-disciplinary subject. The ideal designer of an interactive system would have expertise in a range of topics: psychology and cognitive science to give her knowledge of the user's perceptual, cognitive and problem-solving skills; ergonomics for the user's physical capabilities; sociology to help her understand the wider context of the interaction; computer science and engineering to be able to build the necessary technology; business to be able to market it; graphic design to produce an effective interface presentation; technical writing to produce the manuals, and so it goes on. There is obviously too much expertise here to be held by one person (or indeed four!), perhaps even too much for the average design team. Indeed, although HCI is recognized as an interdisciplinary subject, in practice people tend to take a strong stance on one side or another. However, it is not possible to design effective interactive systems from one discipline in isolation. Input is needed from all sides. For example, a beautifully designed graphic display may be unusable if it ignores dialog constraints or the psychological limitations of the user.

In this book we want to encourage the multi-disciplinary view of HCI but we too have our 'stance', as computer scientists. We are interested in answering a particular question. How do principles and methods from each of these contributing disciplines in HCI help us to design better systems? In this we must be pragmatists rather than theorists: we want to know how to apply the theory to the problem rather than just acquire a deep understanding of the theory. Our goal, then, is to be multi-disciplinary but practical. We concentrate particularly on computer science, psychology and cognitive science as core subjects, and on their application to design; other disciplines are consulted to provide input where relevant.

THEORY AND HCI

Unfortunately for us, there is no general and unified theory of HCI that we can present. Indeed, it may be impossible ever to derive one; it is certainly out of our reach today. However, there is an underlying principle that forms the basis of our own views on HCI, and it is captured in our claim that people use computers to accomplish work. This outlines the three major issues of concern: the people, the computers and the tasks that are performed. The system must support the user's task, which gives us a fourth focus, usability: if the system forces the user to adopt an unacceptable mode of work then it is not usable.

There are, however, those who would dismiss our concentration on the task, saying that we do not even know enough about a theory of human tasks to support them in design. There is a good argument here (to which we return in Chapter 15). However, we can live with this confusion about what real tasks are because our understanding of tasks at the moment is sufficient to give us direction in design. The user's current tasks are studied and then supported by computers, which can in turn affect the nature of the original task and cause it to evolve. To illustrate, word processing has made it easy to manipulate paragraphs and reorder documents, allowing writers a completely new freedom that has affected writing styles. No longer is it vital to plan and construct text in an ordered fashion, since free-flowing prose can easily be restructured at a later date. This evolution of task in turn affects the design of the ideal system. However, we see this evolution as providing a motivating force behind the system development cycle, rather than a refutation of the whole idea of supportive design.

This word 'task' or the focus on accomplishing 'work' is also problematic when we think of areas such as domestic appliances, consumer electronics and e-commerce. There are three 'use' words that must all be true for a product to be successful; it must be:

useful – accomplish what is required: play music, cook dinner, format a document;

usable – do it easily and naturally, without danger of error, etc.;

used – make people want to use it, be attractive, engaging, fun, etc.

The last of these has not been a major factor until recently in HCI, but issues of motivation, enjoyment and experience are increasingly important. We are certainly even further from having a unified theory of experience than of task.

The question of whether HCI, or more importantly the design of interactive systems and the user interface in particular, is a science or a craft discipline is an interesting one. Does it involve artistic skill and fortuitous insight or reasoned methodical science? Here we can draw an analogy with architecture. The most impressive structures, the most beautiful buildings, the innovative and imaginative creations that provide aesthetic pleasure, all require inventive inspiration in design and a sense of artistry, and in this sense the discipline is a craft. However, these structures also have to be able to stand up to fulfill their purpose successfully, and to be able to do this the architect has to use science. So it is for HCI: beautiful and/or novel interfaces are artistically pleasing *and* capable of fulfilling the tasks required – a marriage of art and science into a successful whole. We want to reuse lessons learned from the past about how to achieve good results and avoid bad ones. For this we require both craft and science. Innovative ideas lead to more usable systems, but in order to maximize the potential benefit from the ideas, we need to understand not only that they work, but how and why they work. This scientific rationalization allows us to reuse related concepts in similar situations, in much the same way that architects can produce a bridge and know that it will stand, since it is based upon tried and tested principles.

The craft–science tension becomes even more difficult when we consider novel systems. Their increasing complexity means that our personal ideas of good and bad are no longer enough; for a complex system to be well designed we need to rely on something more than simply our intuition. Designers may be able to think about how one user would want to act, but how about groups? And what about new media? Our ideas of how best to share workloads or present video information are open to debate and question even in non-computing situations, and the incorporation of one version of good design into a computer system is quite likely to be unlike anyone else's version. Different people work in different ways, whilst different media color the nature of the interaction; both can dramatically change the very nature of the original task. In order to assist designers, it is unrealistic to assume that they can rely on artistic skill and perfect insight to develop usable systems. Instead we have to provide them with an understanding of the concepts involved, a scientific view of the reasons why certain things are successful whilst others are not, and then allow their creative nature to feed off this information: creative flow, underpinned with science; or maybe scientific method, accelerated by artistic insight. The truth is that HCI is required to be both a craft and a science in order to be successful.

HCI IN THE CURRICULUM

If HCI involves both craft and science then it must, in part at least, be taught. Imagination and skill may be qualities innate in the designer or developed through experience, but the underlying theory must be learned. In the past, when computers

were used primarily by expert specialists, concentration on the interface was a luxury that was often relinquished. Now designers cannot afford to ignore the interface in favour of the functionality of their systems: the two are too closely intertwined. If the interface is poor, the functionality is obscured; if it is well designed, it will allow the system's functionality to support the user's task.

Increasingly, therefore, computer science educators cannot afford to ignore HCI. We would go as far as to claim that HCI should be integrated into every computer science or software engineering course, either as a recurring feature of other modules or, preferably, as a module itself. It should not be viewed as an 'optional extra' (although, of course, more advanced HCI options can complement a basic core course). This view is shared by the ACM SIGCHI curriculum development group, who propose a curriculum for such a core course [9]. The topics included in this book, although developed without reference to this curriculum, cover the main emphases of it, and include enough detail and coverage to support specialized options as well.

In courses other than computer science, HCI may well be an option specializing in a particular area, such as cognitive modeling or task analysis. Selected use of the relevant chapters of this book can also support such a course.

HCI must be taken seriously by designers and educators if the requirement for additional complexity in the system is to be matched by increased clarity and usability in the interface. In this book we demonstrate how this can be done in practice.

DESIGN FOCUS

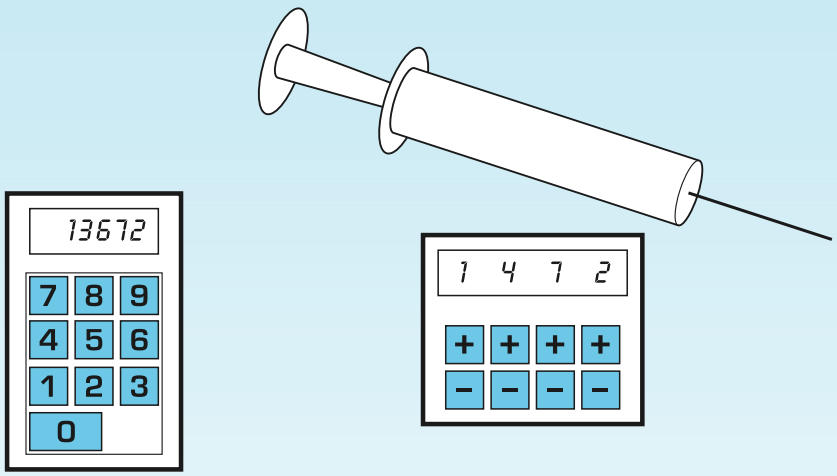
Quick fixes

You should expect to spend both time and money on interface design, just as you would with other parts of a system. So in one sense there are no quick fixes. However, a few simple steps can make a dramatic improvement.

Think 'user'
Probably 90% of the value of any interface design technique is that it forces the designer to remember that someone (and in particular someone else) will use the system under construction.

Try it out
Of course, many designers will build a system that they find easy and pleasant to use, and they find it incomprehensible that anyone else could have trouble with it. Simply sitting someone down with an early version of an interface (without the designer prompting them at each step!) is enormously valuable. Professional usability laboratories will have video equipment, one-way mirrors and other sophisticated monitors, but a notebook and pencil and a home-video camera will suffice (more about evaluation in Chapter 9).

Involve the users
Where possible, the eventual users should be involved in the design process. They have vital knowledge and will soon find flaws. A mechanical syringe was once being developed and a prototype was demonstrated to hospital staff. Happily they quickly noticed the potentially fatal flaw in its interface.



Before consulting users

After consulting users

Figure 0.1 Automatic syringe: setting the dose to 1372. The effect of one key slip before and after user involvement

The doses were entered via a numeric keypad: an accidental keypress and the dose could be out by a factor of 10! The production version had individual increment/decrement buttons for each digit (more about participatory design in Chapter 13).

Iterate

People are complicated, so you won't get it right first time. Programming an interface can be a very difficult and time-consuming business. So, the result becomes precious and the builder will want to defend it and minimize changes. Making early prototypes less precious and easier to throw away is crucial. Happily there are now many interface builder tools that aid this process. For example, mock-ups can be quickly constructed using HyperCard on the Apple Macintosh or Visual Basic on the PC. For visual and layout decisions, paper designs and simple models can be used (more about iterative design in Chapter 5).