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Principled Design Guidance for the Development of Computer-Based Training Materials

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Principled Design Guidance for the Development of Computer-Based Training Materials

This study is concerned with the provision of guidance for designers of computer-based training (CBT) materials. Four interrelated principles - *immersion, interaction, locative fit,* and *multiple representations* - are discussed. These principles draw upon research into instruction and technology and re-frame and re-interpret established instructional factors in terms of the capabilities of the interactive computer as a training delivery medium. It will be argued that the conjoining of pedagogy and technology in the principles is crucial to the effectiveness of CBT. Furthermore, this study will also argue that the form of the guidance has a direct bearing on its usefulness. The four principles are argued to represent a coherent framework which can raise the awareness of CBT designers on key instructional issues and the ways in which the delivery medium may be used to support them, and provide a resource on which designers may draw.

The relevance and effectiveness of the principles (and the issues that they address) are explored through a body of empirical work. This takes the form of two studies: a survey of designers providing comments on the content and expression of the principles and their importance to CBT design; and a series of user trials. The contrasting nature of the studies allows the comments of designers and users to be assessed and compared.

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Macredie, R. D. and Thomas, P. J. (1992a). Theory and technology *sans frontières*: principles for instructional system design. In the proceedings of the *9th International Conference on Technology and Education: Education Sans Frontières,* Paris, France, March 16-20: 927-929.

Macredie, R. D. and Thomas, P. J. (1992b). Technology grounded instruction: systematic design principles for computer technologies in education. In the proceedings and Abstracts of the *East-West Conference on Emerging Computer Technologies in Education,* Moscow, Russia, April 6-9.

Macredie, R. D. and Thomas, P. J. (1993a). Educating the educators. Presented at *STATE '93, the 4th Annual Conference of Technology and Teacher Education,* San Diego, CA, March 17-20.

Macredie, R. D. and Thomas, P. J. (1993b). Designers design technology: visions of the future for design practice. In the proceedings of the *10th International Conference on Technology and Education,* Cambridge, Boston, March 21-24: 209-211.

Macredie, R. D. and Thomas, P. J. (1993c). The theory behind the technology: rethinking the role of games in interactive system design In the proceedings of the *10th International Conference on Technology and Education*, Cambridge, Boston, March 21-24: 206-208.

Macredie, R. D. and Thomas, P. J. (1993d). Constructing a framework for instructional design: linking immersion, interaction, locative fit, and multiple representations. In the proceedings of the *10th International Conference on Technology and Education*, Cambridge, Boston, March 21-24: 203-205.

Macredie, R. D. and Thomas, P. J. (1993e). Educating the educators. *Journal of STATE* (forthcoming).

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Chapter 1

Introduction

1.1 Introduction

Training is important as a vehicle for the communication of knowledge and skills that are needed in working situations. Training can take a number of different forms, most notably apprenticeships and other forms of on-the-job instruction, or training courses away from the working environment. Recent moves to vocational qualifications (see, *inter alios,* Ainley 1990, Bees and Swords 1990, Jessup 1991, Raggatt and Unwin 1991) have further expanded the training base and created a greater demand. Other factors, such as the complexity of modern artefacts, notably those that are computer-based, have also played an important part in the creation of an increasing role for training. The difficulties in using such complex and highly functional artefacts have to be addressed, and training represents a possible solution.

In order to develop effective training materials it is important to understand the factors that have a bearing on the ways in which people learn. Several fundamental factors have been identified (Gagné and Briggs 1979): repetition and reinforcement, for example, are the mainstay of many instructional lessons, and are widely used in training courses.

Of course, issues of presentation are also important. The cost of providing training through human instructors can be prohibitive. This is especially true in the case of training in the use of computer systems (The Times 1991a). Accordingly, other ways of delivering training have been sought: media such as books, film, television, radio, and audio and video cassette have all been used (Johnston 1987). These media have different attributes that bear on the way in which training may be presented. Probably the most important of these attributes is the 'symbol system' – the ways in which the medium can convey information (Salomon 1979). A 'rich' symbol system is one that supports a range of ways of presenting information, for example through sound, and static or animated images. Media with rich symbol systems, like television and video, have greater instructional potential than those with poorer systems, like audio-based technologies.

Training materials developed for these media will obviously vary. Accordingly, different approaches to the development of training materials will be necessary to take into account the differences of media. Audio cassette is reliant on only sound, whereas video provides a richer medium, and these differences are fundamental to the scope of the training material. Skills that are highly visual could not, for example, be conveyed as easily through radio in the ways that they might be through television. The nature and capabilities of the medium are important factors to be considered when developing training materials.

Early educational television programmes demonstrate the importance of considering the medium. Johnston (1987), for example, notes that these early programmes resembled 'talking-head' instruction that was dominant in classrooms. The result was ineffective instruction. It was only when the attributes of the medium – such as the way information could be presented through its symbol system – were considered and exploited that instruction through television became more effective.

This deeper consideration hinges on making effective instructional use of the medium, primarily by considering the ways in which the medium can be used to support instructional factors. As a simple example, the possible ways in which information can be repeatedly presented and reinforced in a training lesson will depend upon the attributes of the delivery medium. Radio will be limited to using sound to present information whereas television can also use pictures. The work of the *Children's Television Workshop* (CTW) provides a clear demonstration here. Their television programme, *Sesame Street*, is an example of instructional material developed through a consideration of learning and the capabilities of the medium. This combination of pedagogy and technology has been suggested to be central to the success and effectiveness of the programme (Bryant *et al.* 1983). As Bryant *et al.* (1983) note, *Sesame Street* is the most frequently watched, discussed and imitated educational television programme in history. It is watched in the US, on average, by 12 million children each day – and reached an average 78% of the country's 2-5-year-olds in 1980-81. Unlike many other educational television programmes, it has shown to be an extremely effective educator, promoting crucial skills for pre-school children – basic literacy and numeracy – as well as developing cognitive and social skills (Ball and Bogatz 1970, Polsky 1974, Cook *et al.* 1975).

The conjoining of important instructional issues and the potential of the medium came about as a result of a close cooperation between specialists in the fields of education and entertainment, during an explicit planning stage that underpinned the programme's development and production. The mix was described by Joan Ganz Cooney, the then CTW president, as a "forced marriage of educational advisers and professional researchers with experienced television producers," a union which became a "howling success" (Lesser 1974: xv-xvi).

1.2 Computer-based training (CBT)

Rises in performance and falls in cost have helped make the computer the latest addition to the list of media used for training. Whilst many of the reasons for this are financial, the computer also has particular characteristics that other media do not. We are only just starting to explore the possibilities that these characteristics can bring, and the effectiveness of CBT lessons will depend upon making good instructional use of the capabilities of the computer.

This thesis will argue that the most common approaches to CBT design do not in fact consider the nature of the computer as medium, and there is little or no active guidance given to designers of CBT materials on how to exploit the instructional potential of the computer. As a result, CBT lessons produced following these approaches are likely to be ineffective, in just the same way as 'talking-head' television.

The most general statement of the objectives of this thesis is that it will identify the important instructional issues that are used in designing training materials, and re-frame them in terms of the possibilities of the computer as medium. It will examine the most common approaches to the design of CBT materials in order to identify and highlight important instructional factors. This discussion will seek to demonstrate the lack of attention paid to the ways in which the computer medium can be used to effectively employ these factors.

One specific objective of this thesis is to develop guidance for CBT designers. The guidance will conjoin pedagogy and technology and draw on important instructional factors. The content of the guidance will concentrate on the ways that the computer can be used to support important instructional issues in the design of CBT materials.

A further issue that will be addressed is the *form* that the guidance should take. It will be argued that guidance should be framed in the form of general principles which represent a resource on which CBT designers can draw. This will allow the most flexible use of the principles. The general role of the guidance is to raise the awareness of CBT designers on key instructional issues and the ways in which the delivery technology can be used to support and employ them. Different types of empirical work which draw on the experiences of both designers and users of CBT lessons will also be presented in support of the principles.

The following section will provide an overview of each of the remaining chapters of this thesis.

1.3 Breakdown of the thesis

Chapter 2 will establish the need for and importance of training through a consideration of the difficulties associated with using artefacts. The increasing reliance in our society on complex, highly functional artefacts will be discussed to highlight the increasing need for training. Other non-training based attempts to overcome these difficulties of use through the improved design of the artefacts will be discussed. The benefits of using the computer as a delivery medium, both in financial and instructional terms, will be introduced and discussed.

Chapter 3 will introduce and review the most common type of approach to the design of CBT materials, the *systems approach,* and its effectiveness will be assessed. Since the systems approach is explicitly based on learning and instructional theory, the review will highlight important instructional factors. These factors represent the basic instructional building blocks for the development of guidance for CBT designers that is undertaken later in this thesis.

Chapter 4 discusses in detail the shortcomings of the systems approach in terms of structure and content. The systems approach will be suggested to be restrictive and to fail to meet the needs of designers in real-world design situations. The systems approach will also be shown to be deficient in terms of a lack of active consideration of the instructional possibilities of the computer as a delivery medium. Two prominent alternatives that attempt to address some of these shortcomings will be examined.

Chapter 5 will further consider these issues, in order to frame additional guidance for CBT designers. Important criteria that guidance should fulfil will be discussed as will the need for an attempt to conjoin pedagogy and technology. This will mean making use of the basic instructional building blocks identified in chapter 3, and considering how the computer may be used to support them effectively. As a result chapter 5 will go on to present CBT design guidance through the framing of a set of four interrelated principles.

Chapters 6 and 7 will explore the effectiveness of these principles through two empirical studies. The first is a survey of CBT designers, the second a set of user trials. These studies provide a broad empirical base and provide insight into the importance of the issues covered by the principles.

Finally, chapter 8 discusses the central issues which have arisen and outlines further work in this area.

Chapter 2

Computer-Based Training

2.1 Introduction

The importance of CBT is underpinned by two areas which will be discussed in detail in this chapter. The first is the demand for training. This stems from the difficulties that we find in using artefacts. Although other ways of alleviating 'problematic use' do exist, they have not been able to wholly solve the problems. As a result, training is used extensively. The second factor in the increasing importance of CBT is the nature of the computer as a delivery medium: not only does it offer financial benefits but it also has unique instructional potential that sets it apart as a training medium.

2.2 The importance of training

The argument for training to overcome problems of use is well established (see, for example, Harrison 1988, Kenney and Reid 1988, Gleeson 1990). Training is becoming increasingly important as our society centres on the use of complex interactive products – particularly interactive computer-based artefacts with high functionality. The potential for functionality offered by these artefacts can lead to problems especially for novice users who may struggle to understand their complexity (see, for example, Carroll and Carrithers 1984, The Times 1991b). Training represents an established way of alleviating these problems.

There are, however, other approaches to alleviating problematic use. Two of these, *intelligible design* and *intelligence in design*, will be discussed in the following sections. These two approaches will suggest that they largely fail to alleviate the difficulties associated with using artefacts.

2.2.1 Intelligible design

'Intelligible design' concerns how devices can be made comprehensible to their users. This depends on designers having a clear understanding of artefacts and the ways in which they are used. This understanding can inform design by highlighting potential problem areas, and in turn can lead to designs that unambiguously convey the way that the artefact should be used.

Much work along these lines has been undertaken in the field of Human Computer Interaction (HCI). Norman (1988), for example, presents attributes that can have a bearing on the ambiguity of an artefact, and proposes 'general principles of good design':

> • *Visibility.* By looking, the user can tell the state of the device and the alternatives for action.
>
> • *A good conceptual model.* The designer provides a good conceptual model for the user, with consistency in the presentation of operations and results and a coherent, consistent design image.
>
> • *Good mappings.* It is possible to determine the relationships between actions and results, between the controls and their effects, and between the system state and what is visible.
>
> • *Feedback.* The user receives full and continuous feedback about the results of actions.
>
> (Norman 1988: 52-53).

All of the principles, when applied to a design, should lead to artefacts that the user will find more intelligible and so reduce the problems.

However, Norman notes that many designers fail to apply these simple and obvious principles successfully if at all:

> Well-designed objects are easy to interpret and understand. They contain visible clues to their operation. Poorly designed objects can be difficult and frustrating to use. They provide no clues – or sometimes false clues. They trap the user and thwart the normal process of interpretation and understanding. Alas, poor design predominates. The result is a world filled with frustration, with objects that cannot be understood, with devices that lead to error (Norman 1988: 2).

Gaver's (1991) discussion of 'affordances' provides an example of visual cues that might be used. The term 'affordance' refers to "properties of the world that are compatible with and relevant for people's interactions" (Gaver 1991: 79; see also Gibson 1979). If affordances are used they must be perceptible and convey the intended use of the artefact correctly.

A door is an example: putting a physical handle on one side and not on the other reflects the designer's intent that it should be pulled or pushed (the handle affords pulling or pushing), but its effective use depends on the user being able to understand the intent. As Gaver notes "when affordances are perceptible, they offer a direct link between perception and action; hidden or false affordances lead to mistakes" (Gaver 1991: 79).

2.2.2 Intelligible interactive artefacts

Norman's principles are extremely useful in addressing the problems of intelligible design. However, complex technological artefacts bring more acute design problems (Suchman 1987). These problems rest on the range of ways in which such artefacts are used. For example, the means for controlling computer-based artefacts are more complex since they are becoming "increasingly *linguistic*, rather than mechanistic" (Suchman 1987: 11, original emphasis). The use of such machines increasingly relies on the specification of operations and the assessment of their results through a common language, rather than on the pushing and pulling of buttons and levers to achieve a physical result. Therefore, building in cues to convey the way in which the artefact should be used may be more difficult. Unlike other artefacts whose physical appearance can convey their purpose, the computer has an "irreducibility" as an object that is unique (Turkle 1984: 272). This will mean the provision of 'conceptual' rather than 'physical' cues to convey the way that the artefact should be used. However, making such cues unambiguous is likely to be difficult, since the scope for the user's interaction with the artefact may be impoverished, and as a result it is unlikely that intelligible design will solve all of the problems of use associated with interactive artefacts.

2.2.3 Intelligence in design

Whilst the complexity of interactive artefacts makes intelligible design more difficult, it also offers an alternative solution to problems of use. This centres on the incorporation of 'intelligence' into the artefact. Whilst making artefacts 'intelligent' does not preclude attempts to make them intelligible, it does add an additional dimension to the artefact's design. This arises from the need to 'model' the user and replicate cognitive processes. Intelligent artefacts essentially have the ability to "understand the actions of the user, and to provide for the rationality of [their] own" (Suchman 1987: 17).

AI techniques of plan formulation, comprehension, and execution, often realised through a planning model which treats a plan as a sequence of actions designed to accomplish a goal have been widely used.

However, it has been noted that our actions are contextual: we act in circumstances (Agre 1988). As Agre and Chapman, writing on the planning approach, point out, "a central feature of *all* activity is that it takes place in some specific, on-going situation" (Agre and Chapman 1988: 10, original emphasis). Suchman also notes that whilst a series of actions can always be reconstructed to form a retrospective plan based on prior intentions and local situations, plans are limited because the "prescriptive significance of intentions for situated action is inherently vague" (Suchman 1987: 27).

This causes problems in using 'intelligent' artefacts since the planning model inherits the problems associated with prescribing intent to the actions of the user, and brings them to the interaction itself. If the prescription of intent does not coincide with the actual intent of the user at any point, then the user will encounter problems with the artefact. One type of problem arising from this difference in intent is what Suchman calls the "garden path" scenario (Suchman 1987: 163). This occurs when a misconception on the user's part leads to an error in her action with respect to the prescribed procedure. In terms of the design, this action may be valid, though as a result of the user's misconception it does not represent her intended action. In such cases, the problem is inaccessible to the system, although the user sees the action as non-problematic and the system's response seems to confirm this. The upshot may be a severe communicative breakdown.

2.3 Computer-based training

Problematic use is inevitable, and the problems are made more acute by the increasing use of complex interactive artefacts. This reinforces the need for training. Training offers the possibility that users can be provided with instruction to help them overcome the problems.

The remainder of this chapter will examine the benefits that can be gained from using the computer as the delivery medium for this training. Although there are many different media through which training can be delivered (Johnston 1987, Kenney and Reid 1988), there are several factors that set the computer apart.

2.3.1 Financial benefits of CBT

Unlike human instruction, CBT software offers the possibility of re-use, so that recurring training costs can be minimised. Time constraints can be alleviated as the software allows more flexible training times than scheduled courses (Hawridge *et al.* 1988). The rise in popularity of the computer as a training medium is due primarily to the relative fall in cost and rise in performance of interactive computers in the past few years (Barker and Tucker 1990). The same factors have led to the increased use of computers in the workplace, and this makes the computer even more attractive as a training medium.

The suitability of any medium for training will depend upon the particular training circumstances. As computers are increasingly used in daily work, it would also seem rational to use them as the delivery medium for the training materials. In addition, the familiarity brought to computer operators by using the computer as their training medium, and the possibilities for simulating their working environment through the CBT software as an aid to learning, is likely to make novice users more comfortable with the complex technology. As a result, training may be more effective.[1] As Dean and Whitlock note:

> in choosing the presentation method [for training] one must bear in mind the question of transferability. In order to facilitate transfer from training to job, it is usually good practice to have the instructional situation as similar as possible to the job situation (Dean and Whitlock 1988: 38).

2.3.2 Instructional benefits of CBT

In addition to these financial considerations, the instructional potential of the computer should be considered. The potential effectiveness of CBT will be dictated, to a great extent, by the capabilities of the medium. These capabilities represent the 'toolkit' of designers of CBT materials. The computer offers unique instructional possibilities that have to be exploited if CBT materials are to fulfil their instructional potential (Salomon 1985, 1991).

Amongst these are the representational capabilities of the computer medium, including the incorporation of high resolution graphics and high quality audio into CBT lessons to provide simulations of the working environment that is being taught. Such simulations are likely to facilitate the transfer between training and working environment. At

---

[1] As with any training medium, there should not be a total reliance on a single source of instruction. Learners are still likely to need some support from experienced users, even when they are competent users themselves (Sellen and Nicol 1990).

a more general level, the use of different forms of representation for information is likely to prove more motivational than purely text-based instruction.

Perhaps the most important feature of computers that make them a potentially effective medium for training is their interactive nature (Jaspers 1991). This allows CBT materials to be controlled by the learner, and this is likely to stimulate and motivate. One of the basic mechanisms supported by the computer that is central is the ability to provide fast non-linear access to information. This provides the basis for providing CBT lessons that are personalisable (these issues will be discussed in more detail in chapter 5).[2]

2.4 Summary

Whilst there are difficulties in training through any medium, CBT offers financial benefits over and above those of other non-interactive media. Moreover, it has great instructional potential owing to factors such as interactivity and representational possibilities. For these reasons, the computer represents an important medium for training. When this is

[2]There are also claims about the instructional potential of the computer medium based on proposed links between the computer and a person's cognitive structure (Salomon 1985), though there seems to be little agreement on this point (see, for example, Searle 1980).

coupled to the increasing importance of the training process, the overall importance of CBT is clear.

Chapter 3 will examine the most common approaches to producing CBT materials.

Chapter 3

The Systems Approach to the Design of Computer-Based Training Materials

3.1 Introduction and Glossary of terms

This chapter will introduce and review the most common type of approach to the design of CBT software: the *systems approach*. There are several concepts relating to learning and instruction that are used in this chapter which require clarification and definition.

Figure 1 shows some relationships between these concepts. The factor that distinguishes the different levels in figure 1 is the 'degree of prescription'. The instructional building blocks are the least prescriptive, and instructional models the most prescriptive. The lower levels provide the foundation for higher ones.

The wealth of literature on learning identifies several factors that would appear to be significant in learning. Perhaps the most obvious of these concerns the repetition of information.[1] There are a number of such factors which represent the basic *instructional building blocks* on which attempts to describe the learning process rest.

Detailed attempts to provide such descriptions may be found in *learning theories*. Learning theories draw upon basic instructional building blocks and organise them into a broader framework. These frameworks are systematic and coherent descriptions of the way that people learn (Hill 1990). Learning theories may be discussed in terms of the significance that different theories attach to the various instructional building blocks (Richey 1986).

Whereas learning theories are descriptive, *instructional theories* are prescriptive, and aim to provide designers of instructional materials with structured design guidance.[2] Instructional theories are eclectic, draw on often diverse learning theories (Reigeluth 1989), and rely heavily on the basic instructional building blocks (Gagné and Briggs 1979).

[1]Others are reinforcement, sequence, structure, motivation, and mode of representation (see section 3.3.2).

[2]The distinction between learning and instructional theories is problematic since the work of many learning theorists has led directly to theories of instruction (see, for example, Bruner 1966, Ausubel 1968).

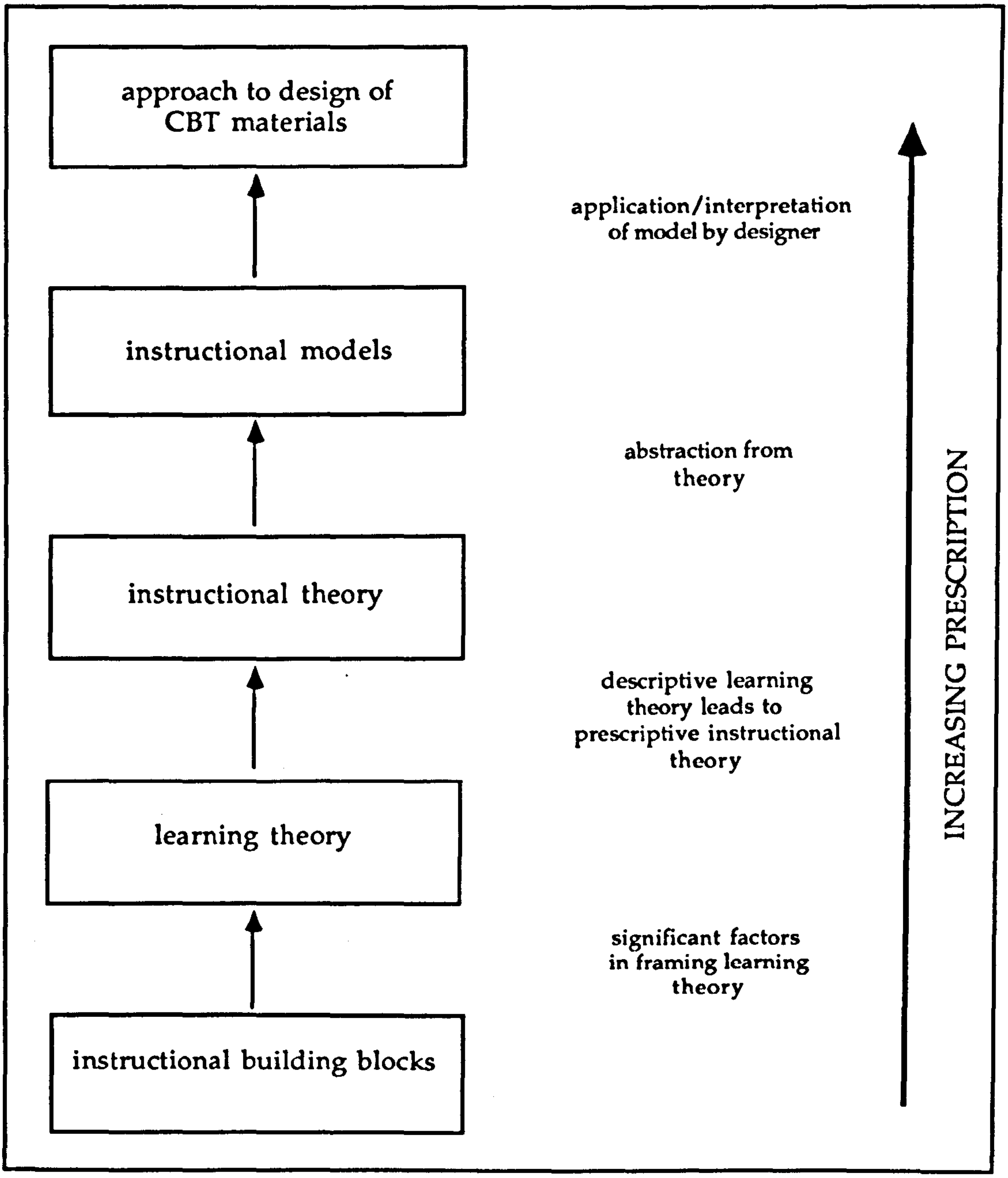

Figure 1: Relationship between key concepts discussed in this chapter

Specific *instructional models* are abstracted from instructional theories to also provide prescriptive guidance for the design of instructional materials. These models guide the design, and cover the entire design process from conception to realisation (Lamos 1984, Trimby and Gentry 1984). When applied, the models are a systematic approach to the design and production of instructional materials.

3.2 Approaches to CBT design: the Systems Approach

3.2.1 Introduction

The systems approach is the most commonly used approach to the design of CBT materials (Steinberg 1991). It relies on the basic building blocks identified in section 3.1. As shown in figure 1, these underpin the instructional models that are used in the design of CBT. The systems approach involves the application of *instructional design* (ID) models which are abstracted from instructional theory (Glaser 1976). There are a great number of models which are applicable in different design situations (see, for example, Andrews and Goodson 1980, Reigeluth 1983). Perhaps the best known examples of the systems approach are the TICCIT and MicroTICCIT projects which are used extensively in industry in the U.S. (Wilson 1984; Steinberg 1991).

3.2.2 The foundations of the systems approach

Whereas learning theories are usually self-contained, and attempt to explain the learning process and its influential factors in a single coherent framework, instructional theory tends to be eclectic, drawing on different, often diverse theories of learning. Reigeluth (1989) attributes this difference between learning theories and instructional theories to the difference between "descriptive" science – where a single theory is adopted and its limits explored – and "prescriptive" science – which has to draw on many sources in order to address practical problems.

Nevertheless, it should be noted that many different learning theories highlight the same important instructional factors. This may be seen in the behaviourist and cognitive schools (Skinner 1968; Bruner 1966). These two schools have conflicting views of the role of the learner in the learning process. Behaviourism views the learner as an organism reacting to external stimuli; cognitivism places great importance on the learner and internal mental state. Despite this, theories from both schools concentrate on many of the same issues and generally only their focus changes (Richey 1986).

These issues are the instructional factors that are most often used in instructional design models and relate to "controllable events and conditions" (Gagné and Briggs 1979: 6). Although this reflects the roots of instructional design in behaviourism, it has already been noted that the same issues are also addressed by cognitive approaches. As such, although some authors have noted that the behaviourist paradigm has passed out of fashion (Reiser 1987, Wittrock 1979, Winn 1989, Gagné 1980, Tennyson 1990), the overall effect on the validity and applicability of the instructional models that have been developed is negligible (see, for example, Hannafin and Reiber 1989a). This is borne out by Merrill *et al.* (1990a), who report that all of the instructional design theory in current use is firmly rooted in behavioural psychology, even if it now displays a cognitive orientation.

There is a core of issues identified by different learning theories that represent the basic instructional building blocks that are used throughout the models of the systems approach (Gagné and Briggs 1979). These include reinforcement, repetition, sequence, structure, motivation, and mode of representation.[3]

Common sense definitions apply: *reinforcement* is the strengthening of associations by the presentation of some form of feedback – in order to be helpful, this reinforcement (or feedback) must be made understandable to the learner and occur at a relevant time; *repetition* is the re-presentation of information to the learner – to be effective, information must be presented in a meaningful context; the *sequence* in which material is presented can greatly affect the ease with which it may be mastered – hierarchies of topics may be formed, for example, in which higher levels are prerequisite to lower ones; information should be *structured* so that it is presented in an economical and powerful way – the material should be simply expressed and easily understood; *motivation* specifies the conditions that predispose an individual toward

[3]See, *inter alios*, Bandura 1963, 1969; Bruner 1960, 1966; Skinner 1938, 1968; Piaget 1970, 1971 for in depth interpretations of the place of these issues in the learning process.

learning – there is an in-built 'will to learn', or an intrinsic motive, as well as an extrinsic motive; *mode of representation* concerns the techniques, or methods, whereby information is communicated – to be of any real use the mode of representation must be at the learner's level of experience.

The following section will discuss the ways that basic instructional factors underpin the models of the systems approach. This will not only highlight their importance to the systems approach but will also suggest their wider importance to the design of CBT software. Such a discussion will highlight important similarities and differences. This will suggest that although many different models exist there is 'general agreement' on how to produce effective instructional materials. Merrill *et al.* (1990a) specifically note that many contemporary instructional design theorists are consistent with dominant theories on the learning process and their application to instruction (such as Collins 1987, Collins and Stevens 1983, Gagné 1985, Merrill 1987a, and Gropper 1983, 1987); that these theories provide "remarkable similarity in their prescriptions"; and that this provides "some rough confirmation of the validity of the recommendations" (Merrill *et al.* 1990a: 7).[4]

These similarities show that the different models represent a single approach to CBT design, based on the same underpinnings. Having established this, criticisms may be leveled at the systems approach itself rather than at specific instructional models. This will lead to the identification of the shortcomings of the systems approach in chapter 4.

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[4]Gagné and Merrill also agree that their theories are, to a great degree, consistent with each other (see Twitchell 1990c).

3.3 The models of the systems approach

One of the difficulties in trying to provide prescriptive design guidance is that different methods of instruction are applicable for different conditions (Reigeluth 1983). Different parts of a lesson may, for example, benefit from different presentation methods. This accounts for the large number of instructional models within the systems approach (Andrews and Goodson 1980, for example, review 60 such models, see also Shrock 1991). These models provide guidance for a large number of design situations. A taxonomy of these models can be presented which is based on the way in which the instructional model makes provision for the potentially diverse design situations in which it may be applied.

Reigeluth (1989) provides one such classification which identifies common links between different models and highlights differences: (1) the intact models paradigm, (2) the variations on a model paradigm, and (3) the smorgasbord paradigm.[5] Since these three approaches encompass the range of models that make up the systems approach to the design of CBT materials, they will be discussed in more detail.

[5]It may be that Reigeluth's use of "paradigm" would be better replaced by "approach".

3.3.1 The intact models approach

The *intact models* approach attempts to overcome the difficulties of varying instructional conditions by prescribing a different model of instruction (or set of method components) for each of a variety of these conditions.

This can be illustrated by perhaps the most prominent example of this approach, Merrill's (1983) Component Display Theory (CDT). This theory prescribes different "primary presentation forms" for different performance levels, and describes various kinds of content as well as various kinds of outcomes of learning. This is achieved through a Performance Content Matrix (figure 2).

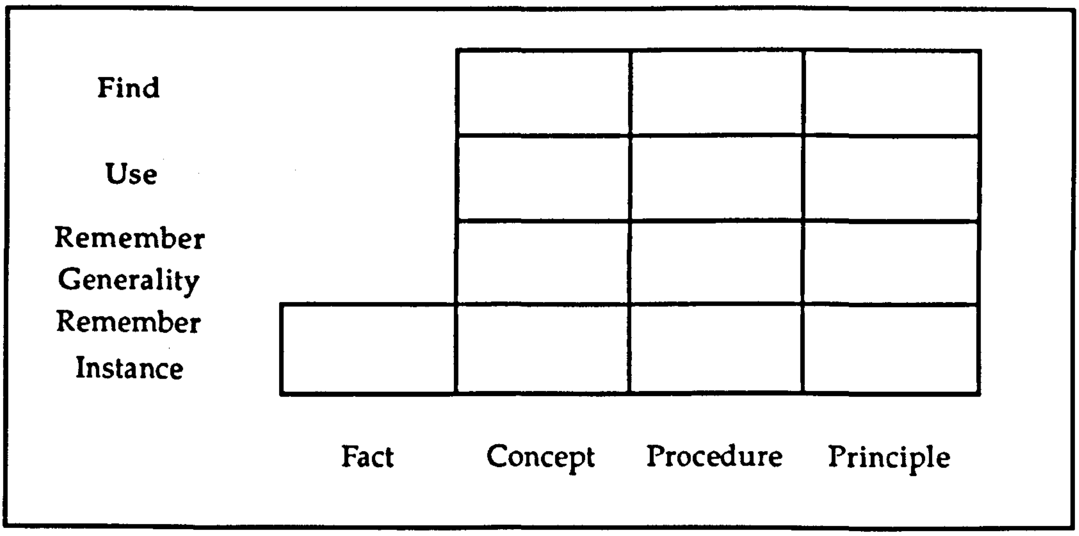

Figure 2: Performance Content Matrix

The dimensions of the Performance Content Matrix are the content involved in the instructional material – facts, concepts, procedures, and principles – and the performance of the learner (what the learner will have to achieve) – 'remember instance' (a specific case), 'remember generalities' (the general case), 'applying a generality in a specific case', and 'finding a new generality'. As Merrill notes it is the "intersection of the content and performance dimensions [that] defines the various outcomes of learning" (in Twitchell 1990b: 36). Looking at figure 2, we can see that the Performance Content Matrix defines 13 outcomes (cells in the figure) from remembering an instance of a fact (bottom left) to finding out a new principle (top right).

In order to achieve these outcomes, information is presented to the learner. There are two kinds of presentation form. The first, and most basic, are the Primary Presentation Forms (PPFs), which relate to the content of the instruction. Merrill suggests several PPFs:

- *expository generality* [EG]: presenting the general case
- *expository instance* [Eeg]: an example, or the specific case
- *inquisitory generality* [IG]: asking the student to recall a general statement
- *inquisitory instance* [Ieg]: asking the student to apply the general case or to practise

Furthermore, he contends that all instruction is composed of these PPFs. Figure 3 shows how these PPFs relate to the content of the instructional material: if the content consists of information representing an generality, then the presentation should be either the rule in question or the recall of the rule, depending on whether the presentation is expository or inquisitory.

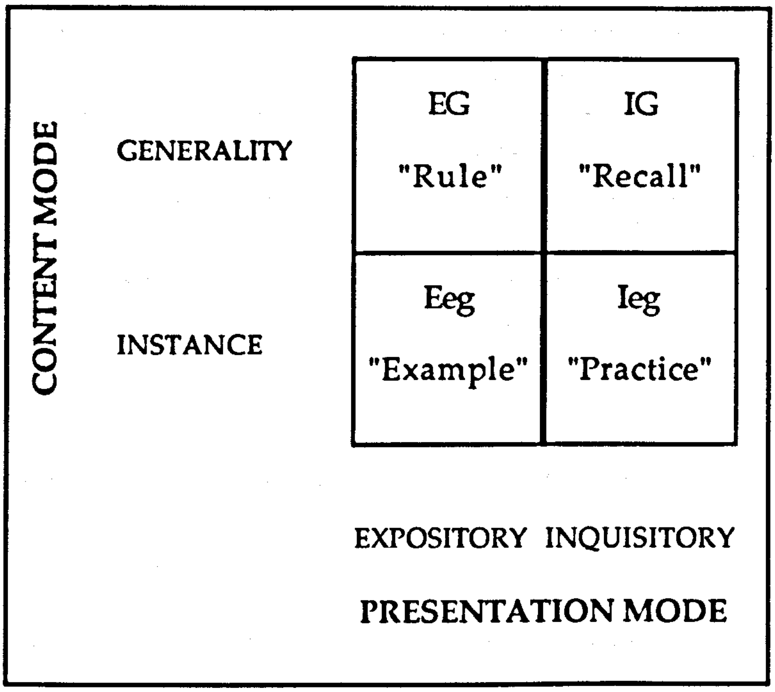

Figure 3: The Primary Presentation Forms (from Twitchell 1990a: 38)

This can be illustrated in more depth through figure 4, which links the various kinds of performance presented in figure 2 (remember instance, remember generality, use, and find), the steps in the instructional process (presentation, practice, and performance), and the appropriate combinations of PPFs that Merrill sees as necessary for the instructional material to be effective (represented by the cells of figure 4).

	PRESENTATION	PRACTICE	PERFORMANCE
If the instructional objective is classified as...	Then the PPFs required for a consistent presentation are..	And the PPFs required for consistent practice items are...	And the PPFs required for consistent test items are...
FIND		New Iegs + New IG	New Iegs + New IG
USE	EG + set of Eegs	set of new Iegs	set of new Iegs
REMEMBER GENERALITY	EG + reference Eeg	paraphrase IG	paraphrase IG
REMEMBER INSTANCE	Eeg	Ieg same eg	Ieg same eg

Figure 4: Performance-PPF consistency (from Twitchell 1990b, Merrill 1983, 1987b, 1988)

Unlike the PPFs, the other - Secondary - presentation forms are not part of the content: things like help comprised of attribute isolation or attention focussing devices. These Secondary Presentation Forms help in the direction and focussing of learners as they use instructional materials. Figure 5 prescribes the Secondary Presentations that Merrill sees as affecting the outcomes of learning.

Although CDT is more complex and has a second version (Merrill 1987a), this discussion highlights the important aspects of the intact models approach. A different model of instruction (or set of method components) is prescribed for each of a variety of learning conditions. Each of these instructional models can be seen to be different from the others, and each is prescribed for a different learning condition (Reigeluth 1989). Furthermore, even without examining CDT at a detailed level, the links to learning theory can be seen, with the use of several of the instructional building blocks, such as reinforcement (feedback), mode of representation, and repetition as secondary presentation forms.

P/C CLASS	PRESENTATION		PRACTICE	
If the instructional objective is classified as...	Then the SPFs required to augment the PPFs for an adequate presentation are...		And the SPFs required to augment the PPFs for adequate practice are...	
	(with EG)	(with Eeg)	(with IG)	(with Ieg)
FIND			feedback by demonstration	
USE	help, prerequisites, alternate representation	help, alternate representation		alternate representation, correct answer feedback
REMEMBER GENERALITY	mnemonic	alternate representation	correct answer feedback with help	
REMEMBER INSTANCE				correct answer feedback

Figure 5: The role of Secondary Presentation Forms (from Twitchell 1990b, Merrill 1983, 1987b, 1988)

3.3.2 The variations on a model approach

Unlike the intact models approach, the *variations on a model* approach provides a single general model of instruction, and variations on that model are prescribed for different learning conditions. For example, Gagné (1965, 1977, 1985) proposes nine "events of instruction" (gain attention, objectives, prior learning, stimulus, guidance, performance, feedback, assessment, and retention and transfer) which represent a general instructional model. Differences are prescribed for each of these events of instruction, depending on the kind of learner outcome that is desired (these outcomes are verbal information, intellectual skill, cognitive strategy, attitude, and motor skill).

These differences, and the outcomes to which they apply, are shown in figures 6a and 6b. Five of the events of instruction (corresponding to the columns) are shown in figure 6a, and four in figure 6b. The information in these figures outlines the important issues in the design of instructional materials. For example, Gagné's model suggests that the *objectives* of gaining an *intellectual skill* are that the learner should be able to demonstrate the activity to which the concept, rule, or procedure applies. They should also be able to provide a description and example of performance of the skill (see figure 6a, row 2 column 2).

	GAIN ATTENTION	OBJECTIVES	PRIOR LEARNING	STIMULUS	GUIDANCE
VERBAL INFORMATION	Stimulus change	Describe what learner is expected to state Indicate verbal question to be answered	Recall well organised bodies of knowledge Stimulate recall of context of organised information	Display printed or audio verbal statements, with distinctive features	Elaborate content by relating tobodies of knowledge; use images and mnemonics Provide verbal links to larger, meaningful context
INTELLECTUAL SKILL	Stimulus change	Demo activity to which concept, rule or procedure applies Provide description and example of performance	Recall prerequisite rules and concepts Stimulate recall of subordinate rules and concepts	Delineate features of objects and symbols to be formed into concept or rule Present examples of concept or rule	Give varied concrete examples of concept or rule Provide verbal cues to proper combining sequence
COGNITIVE STRATEGY	Stimulus change	Describe or demonstrate the strategy Clarify the general nature of the solution expected	Recall simple prerequisite rules and concepts Recall task strategies and associated intellectual skills	Describe problem and show what strategy accomplishes	Provide verbal description of strategy with example Provide prompts and hints to novel situation
ATTITUDE	Stimulus change	Do not state objective Provide example of the kind of action choice aimed for	Recall situation and action in personal choice Demonstrate choice using human model Recall relevant information and skills	Human model describes nature of the choice Human model demonstrates choice of personal actions	Human model describes or demonstrates action choice, followed by observation of reinforcement of model's behaviour
MOTOR SKILL	Stimulus change	Demonstrate expected performance	Recall executive subroutines and part skills	Provide external stimulus for performance including tools and implements; demo executive sub-routine	Continue practice Provide practice with feedback

Figure 6a: Main points of Gagné's Conditions of Learning
(from Gagné 1985, Gagné and Briggs 1979, and Twitchell 1990a)

	PERFORMANCE	FEEDBACK	ASSESSMENT	RETENTION AND TRANSFER
VERBAL INFORMATION	Present information Tell learner to paraphrase it	Confirm correctness of statement of information	Ask for paraphrased versions of statement Learner restates information in paraphrased form	Increased practice; spaced reviews; embed in larger meaningful context Verbal links to additional complexes of information
INTELLECTUAL SKILL	Unencountered instance Ask learner to apply rule or concept to new examples	Confirm correctness of rule or concept application	Application to a number of additional novel examples Learner demonstrates application of concept or rule	Increased practice; variety of practice; embed in larger meaningful context Provide spaced reviews including variey of examples
COGNITIVE STRATEGY	Solve unfamiliar problem Ask for problem solution	Confirm originality of problem solution	Learner originates a novel solution	Provide occasions for a variety of novel problem solutions
ATTITUDE	Observe choices in previously unencountered situation; questionnaire Indicate choice in real or simulated situation	Provide direct or indirect reinforcement of action choice	Learner makes desired choice in real or simulated situation	Provide additional varied situations for selecting choice of action
MOTOR SKILL	Execute performance	Provide feedback on degree of accuracy and timing	Learner executes performance of total skill	Learner continues skill practice

Figure 6b: Main points of Gagné's Conditions of Learning
(from Gagné 1985, Gagné and Briggs 1979, and Twitchell 1990a)

Gagné's approach can be further summarised by removing the detail (see Gagné and Briggs 1979, Gagné 1965, 1977; Briggs 1970, 1972, 1977, Briggs and Wager 1981).[6] This summary (presented here, and see also Aronson and Briggs 1983: 97) is especially effective in demonstrating the direct links between instructional and learning theory, through their use of basic instructional building blocks like structure, sequence, and motivation that were discussed earlier in this chapter:

- Different sets of conditions are required for various types of learning (attitudes, motor skills, verbal information, and cognitive strategies) to occur. Instructional objectives can be classified according to the type of learning involved
- In selecting instructional objectives to be learned in the domain of intellectual skills, learning hierarchies indicate which competencies must be acquired
- Learning hierarchies provide guidance in ways to sequence instruction so that competencies which are prerequisite to other competencies are taught in their proper order
- The events of instruction provide the external conditions of learning that are required to activate and support the internal processes of learning
- Instructional prescriptions are made to ensure that each instructional event functions to achieve the desired learning outcome

[6]Gagné and Briggs developed instructional models, representing "the first major attempt to integrate a wide range of knowledge about learning and instruction into an instructional theory" (Reigeluth 1983: 79). A good overall commentary of their work, incorporating the background to the theory from their earlier separate works, occurs in Aronson and Briggs (1983).

3.3.3 The smorgasbord approach

Reigeluth notes that, in the *smorgasbord approach,* there is "no model of instruction at all" (Reigeluth 1989: 71).[7] Instead, there are different pieces of guidance each of which is prescribed based on different learning conditions. In this way the designer of the instructional material is able to "mix-and-match" according to the particular needs of the design situation, selecting the different components as they see necessary.

An example of this type of approach is Keller's (1983) ARCS, which provides a range of motivational strategies and tactics which may be individually selected by instructional designers depending on the particular design or learning situation. Keller's model identifies four major dimensions of motivation: *interest,* which refers to the arousal of the learner's curiosity and the sustaining of the curiosity over time; *relevance,* which refers to the degree to which the learner sees the instruction as satisfying personal needs or helping achieve personal goals; *expectancy,* which refers to the learner's perceived likelihood of success and the extent to which he views this success as being under his control; and *satisfaction,* which refers to the learner's intrinsic motivation and their reaction to extrinsic motives, such as reward.

[7]By model, Reigeluth refers to "integrated set[s] of method components" (Reigeluth 1989: 71). The implication is that it is the coherence of the method components, and their interrelated nature that constitutes a model. Examples of prescriptive guidance that fall into the smorgasbord paradigm are, however, often sill referred to as models (see, for example, Reigeluth 1983, and Reigeluth 1989).

In all, Keller proposes 17 different motivational strategies (5 for interest, 3 for relevance, 4 for expectancy, and 5 for satisfaction), which are shown in figure 7.

Whilst the justification for each of these strategies is beyond the scope of this review (see Keller 1983: 386-434), it is clear that they make use of several of the basic instructional building blocks. Most obviously, motivation is the principle focus of the strategies, but the links to reinforcement (through the 'outcomes' strategies) are obvious, and others such as the issues of structure and sequence are referred to obliquely (see, for example, the strategies of 'relevance').

Since Keller's model does not cover all aspects of instruction, applying instead to only the motivational aspects, he suggests that the strategies should be mixed with other "appropriate parallel strategies" (Keller 1983: 398) from the field of instructional design. Being able to integrate these strategies with other models stems from their less prescriptive nature, and appears to make them accessible to designers of instructional materials. This lower degree of prescription is, of course, the defining factor of the smorgasbord approach, since the choice of which parts of particular models and how specifically to employ them, is left to the judgement of the designer of the instructional material.

Interest:

Strategy 1. To increase curiosity, use novel, incongruous, conflictual, and paradoxical events. Attention is aroused when there is an abrupt change in the status quo.

Strategy 2. To increase curiosity, use anecdotes and other devices for injecting a personal, emotional element into otherwise purely intellectual or procedural materials.

Strategy 3. To arouse and maintain curiosity, give people the opportunity to learn more about things they already know about or believe in, but also give them moderate doses of the unfamiliar and unexpected.

Strategy 4. To increase curiosity, use analogies to make the strange familiar and the familiar strange.

Strategy 5. To increase curiosity, guide students into a process of question generation and inquiry.

Relevence:

Strategy 1. To enhance achievement-striving behaviour, provide opportunities to achieve standards of excellence under conditions of moderate risk.

Strategy 2. To make instruction responsive to the power motive, provide opportunities for choice, responsibility, and interpersonal influence.

Strategy 3. To satisfy the need for affiliation, establish trust and provide opportunities for no-risk, co-operative interaction.

Expectancy:

Strategy 1. Increase expectancy for success by increasing experience with success.

Strategy 2. Increase expectancy for success by using instructional design strategies that indicate the requirements for success.

Strategy 3. Increase expectancy for success by using techniques that offer personal control over success.

Strategy 4. Increase expectancy for success by using attributional feedback and other devices that help students connect success to personal effort and ability.

Outcomes:

Strategy 1. To maintain intrinsic satisfaction with instruction, use task-endogenous rather than task-exogenous rewards.

Strategy 2. To maintain intrinsic satisfaction with instruction, use unexpected, non-contingent rewards rather than anticipated non-contingent rewards (except with dull tasks).

Strategy 3. To maintain intrinsic satisfaction with instruction, use verbal praise and information feedback rather than threats, surveillance, or external performance evaluation.

Strategy 4. To maintain quality of performance, use motivating feedback following the response.

Strategy 5. To improve the quality of the performance, provide formative (corrective) feedback when it will be immediately useful, usually just before the next opportunity to practice.

Figure 7: Keller's 17 motivational strategies (Keller 1983: 427)

3.4 Summary: the importance of the systems approach to CBT design

This chapter has discussed the systems approach and presented examples of instructional models that are used in the design of CBT. These models all draw on the same basic instructional building blocks – such as repetition, reinforcement, sequence, structure, motivation, and mode of representation – to present guidance to instructional designers. These common underpinnings highlight the fundamental importance of the basic instructional building blocks, and suggest their centrality to the development of CBT design guidance. The differences in the models stem from the particular ways in which these factors are used. This suggests that although the models are different they represent a general approach to the design of instructional material (see, for example, Merrill *et al.* 1990a, Twitchell 1990c).

Chapter 4

Characteristics of Approaches to the Design of Computer-Based Training

4.1 Introduction

Having established that the different models of the systems approach have similar underpinnings, this chapter will discuss the general characteristics of the approach. It will argue that the *structure* and *content* of the models of the systems approach limit their effectiveness for CBT design.

4.2 Structural characteristics

The *structural* characteristics of the systems approach are those that are inherent in any approach to design, and centre on degree of prescription. Chapter 3 suggested that different approaches reflect various abstractions from theories of instruction. As figure 8 illustrates these approaches differ in their degree of prescription. Those that are less prescriptive require interpretation by the designer and can therefore be applied in a range of design situations. This type of approach provides guidance at the 'strategy' level (as in the case of Keller's (1983) ARCS), providing designers with general help that may be useful. General 'models' to guide the development of CBT lessons, as characterised by Gagné's (1985) and Merrill's (1983) work, represent a more coherent approach to CBT design. These models can be interpreted and applied by designers in individual situations to create CBT lessons. Highly prescriptive models also exist, which are often specific applications of more general models. They leave little or no scope for interpretation, are applied more rigidly than general models, and are therefore associated with specific design situations (see, for example, Reigeluth 1987).

The degree of prescription bears on the way in which the different types of approach are used in real-world design situations (Briggs 1982). It is likely, for example, that designers of CBT software form their own approaches to design based on a synthesis of their understanding of instructional theory and models, along with the more specific factors influencing CBT design such as lesson content, target group, and their own past experience.

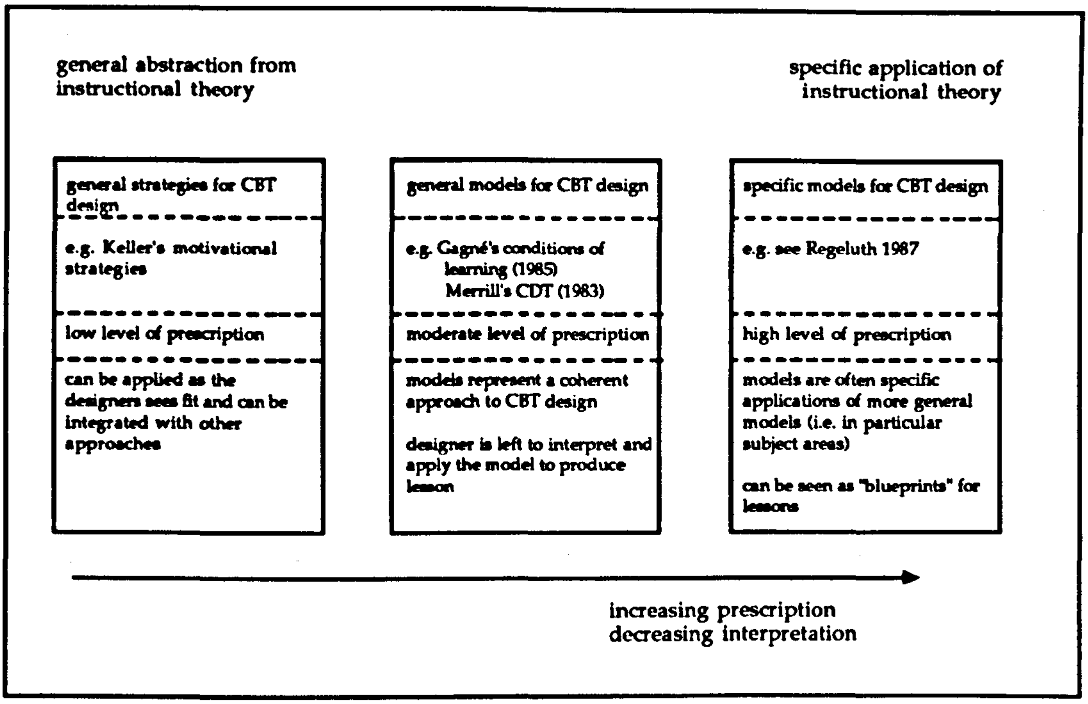

Figure 8: The relative prescription of the different types of approach to lesson design covered by the systems approach

This implies that the real value of the different types of guidance offered by the systems approach could well be at the level of Keller's strategies: allowing the designer to "mix-and-match" as context dictates (see, for example, Bednar *et al.* 1991). The importance of the models, and the systems approach that they represent, to design situations would therefore seem to be that they provide an important resource on which designers can draw in their production of CBT materials. This resource does not represent a formal systematic approach in real-life design situations, rather it raises the awareness of designers on issues that bear directly on the design of instructional software, and leaves them to make informed choices about the design of their CBT lessons.

4.3 Content characteristics

If the true value of the systems approach to design lies in providing a resource for raising the awareness of designers, then the effectiveness of that resource will depend upon the instructional issues that are addressed.

Whilst the key instructional issues of motivation, repetition, reinforcement, sequence, structure, and mode of representation are addressed in the content of the models, little if any insight is provided into their *relevance to the delivery technologies* that are used for CBT. There are two possible explanations for this. The first is that the instructional models of the systems approach pre-date the modern interactive technologies that are now used to deliver CBT materials (Hannafin and Reiber 1989b, Merrill *et al.* 1990a, Jaspers 1991). The second is that there is a tendency for instructional designers to distance themselves from the delivery medium (MacKenzie 1991), perhaps in an attempt to increase the applicability of their models, or even because the instruction is prepared with little concern for the medium, then implemented by technical staff who have no role in its design (MacKenzie 1987).

The impact on CBT materials arising from this lack of consideration of the contemporary computer as delivery medium is critical. It has already been suggested that the computer offers unique instructional potential through, for example, its representational capabilities (high resolution graphics and high quality audio), its interactive nature, and its potential to provide fast non-linear access to information. The production of effective CBT materials depends critically on the exploitation of these possibilities, which will underpin the successful instructional use of the technology. If instructional strategies are not included in the design guidance offered by the systems approach, guidance on their effective use must be found from another source. If no other guidance is available, the designer is left to draw solely on experience and in many cases this may be unsatisfactory.

4.4 Alternative approaches to CBT design

Since the characteristics of structure and content of the systems approach bear on its effectiveness for CBT design, other types of approach have been developed. This section outlines two such approaches: the evolutionary approach, and the Second Generation instructional design approach. The evolutionary approach is well established (Steinberg 1991) whereas Second Generation instructional design is just emerging. As figure 9 shows, the most striking difference between the two approaches is the influence that the designer has over the outcome of the CBT lesson. Whereas the evolutionary approach is geared towards flexibility and allows the designer to experiment with different approaches on the way to a final design, the Second Generation instructional design approach is rigid, takes the impetus away from the designer, and automates lesson production.

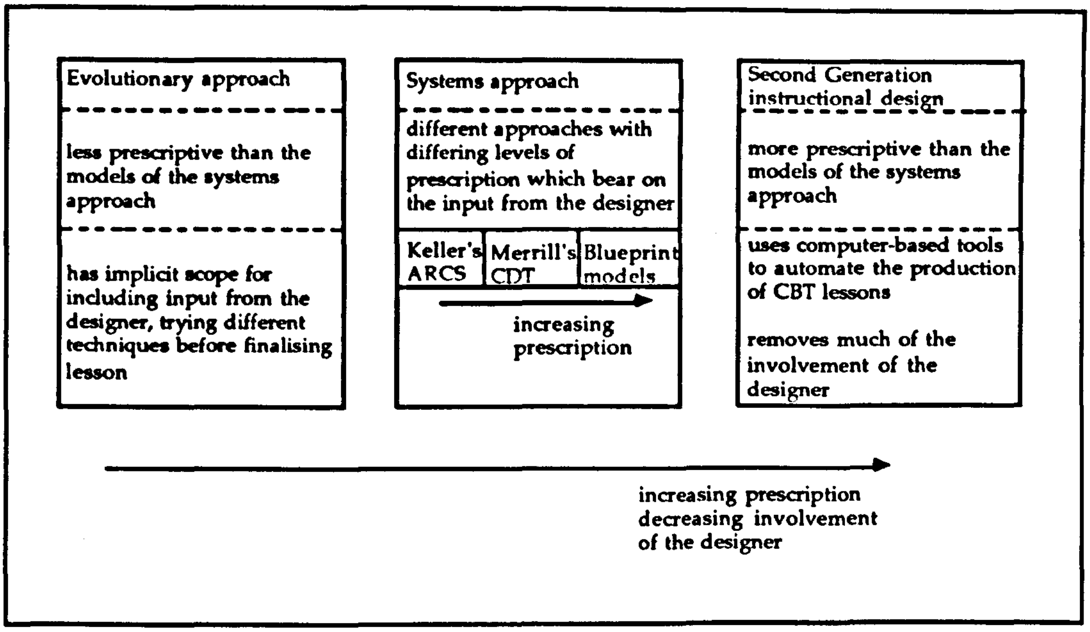

Figure 9: The characteristics of the systems, evolutionary, and Second Generation instructional design approaches to CBT design

4.4.1 The evolutionary approach

As figure 9 suggests, the evolutionary approach represents a less prescriptive approach than the models of the systems approach. Some of the prescriptive constraints are removed from the designer of the CBT material by allowing incremental as well as systematic approaches to design (Avner 1975). The evolutionary approach does not have to be followed rigidly and there is scope for the designer to draw on alternative design guidance. This affords a flexibility to the design process that can allow the designer to employ novel instructional techniques that would not be specified in the instructional models and for which no *a priori* knowledge concerning effectiveness exists. This approach is similar to the way in which the systems approach is put to use in real-world design situations. The most prominent example of instructional software produced using the evolutionary approach is the National Science Foundation's (NSF) PLATO system (Avner 1975, Steinberg 1975, Stifle 1975, Alderman *et al.* 1978).

The use of an evolutionary approach arose because of the realisation that the systems approach did not make provision for effective use of the computer technology as delivery medium (Steinberg 1991), and that following prescriptive models from the systems approach did not allow for the instructional possibilities of the medium to be addressed. Scope was therefore incorporated to allow for experimentation and iteration before the final production of the lesson.

However, the evolutionary approach does not provide *active* guidance on how to exploit the capabilities of the computer medium in the design of CBT lessons. Instead it relies on the designer's ability to provide such guidance. Whilst the evolutionary approach represents a recognition of the need for more flexible approaches to design in order to make effective instructional use of the possibilities of the delivery medium, no guidance as to how to achieve this is provided.

4.4.2 The Second Generation instructional design approach

This approach, developed by Merrill *et al.* (1990b, 1990c), is based on the development of *Second Generation Instructional Design* (ID_2) methods, built on the foundations of the instructional theories and models of the systems approach (which they class as First Generation Instructional Design (ID_1)) (Merrill *et al.* 1990a).[1]

The focus here is the removal of interpretive difficulties that may be encountered by the designer. This is achieved through the automation of CBT lesson production using 'intelligent' computer-based tools, and an intelligent on-line adviser program to dynamically customise instruction (Merrill *et al.* 1990a, 1990b, 1990c).

It is difficult to predict the effectiveness of such an approach as it is relatively new. It is however likely that the ID_2 approach may suffer from similar problems of application and complexity as the models of the systems approach. Locatis and Park (1992) support this contention when they note that the ID_2 tools "concentrate on conventional instruction" (Locatis and Park 1992: 87), suggesting that the unique attributes of the delivery medium do not assume central instructional importance. They go on to suggest that such tools and systems may lead to:

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[1]There are even those who would contest this claim for ID_2. Kember and Murphy (1990), for example, state that after studying Merrill *et al.*'s work they "fail to see how this model [ID_2] addresses [...] most significant failings of ID_1" (Kember and Murphy 1990: 45).

> look-alike, standardised, unmotivating, and unimaginative courseware reminiscent of 1960s-era programmed instruction that evolved from behavioural dogma popular at that time (Locatis and Park 1992: 92).

Rather than focussing on the potential of the medium for CBT delivery, the goal of Merrill *et al.*'s (1990a, 1990b, 1990c) system is to provide specific design prescriptions to developers of instructional software. This is achieved through the 'intelligent' aspects of the system. However, a reliance on AI techniques is likely to be problematic. As we have seen, recent devastating critiques of the cognitivist-reductionist underpinning of much AI theorising (by, *inter alios*, Suchman 1987, Agre 1988, and Lave 1988), highlight the problems inherent in the contextual nature of action, cognition, and interaction that are likely to be encountered by ID_2, and that are likely to limit its effectiveness.

4.5 Summary

This chapter has argued that the systems approach has shortcomings both in terms of structure and content. This is acknowledged in the evolutionary and Second Generation instructional design approaches which represent alternatives designed to counter these difficulties. The evolutionary approach makes provision for the integration of additional guidance through its less prescriptive nature. Conversely, Second Generation instructional design moves towards a greater degree of prescription using techniques to automate the production of instructional software.

Whilst recognising the difficulties of the systems approach, neither alternative approach proposes any specific guidance addressing the most crucial of these shortcomings - the lack of consideration of the instructional possibilities of the computer as a delivery medium for training purposes. These possibilities - representational capabilities (high resolution graphics and high quality audio), interactive nature, and potential to provide fast non-linear access to information - can support alternative interpretations of the basic instructional building blocks that underpin the systems approach.

Chapter 5 will discuss these issues in greater detail, in order to frame guidance for CBT designers that attempts to address the important issues of content and of structure.

Chapter 5

The Development of Design Principles for Computer-Based Training Materials

5.1 Introduction

This chapter is concerned with developing guidance for CBT designers. As chapter 4 noted, there are two shortcomings that must be considered in framing any additional guidance. The first of these is *structure*. This determines the applicability of the design guidance in real-world design situations (Bellotti 1988). Guidance can range from very specific guidance (a prescriptive model) to guidance that is open to interpretation by the designer of the CBT material (guidelines or principles). The second is *content*. Guidance for CBT designers must actively consider the instructional possibilities of the delivery medium, and this will mean a reconsideration of the ways in which basic instructional factors are used in the design of CBT software.

This chapter will examine the issues that are central to both structure and content and will then present a set of four interrelated principles for CBT design.

5.2 The structure of the guidance

If guidance for CBT designers that is applicable in real-world design situations is to be provided it is important that structure is considered closely. As the discussion of the systems approach suggested, there are different forms that the guidance could take: from specific models of the design process to general design principles. Figure 10 illustrates these forms, and shows their relative degree of prescription. The 'model' level shown in figure 10 is at the level of the 'intact models' and 'variations on a model' approaches of the systems approach, providing fairly detailed prescriptive guidance to the CBT designer. Keller's (1983) 'strategies' may be seen at the guidelines level, providing CBT designers with guidance that they may choose to apply as circumstances dictate. The decision as to the form of the guidance should be based on the likely requirements and constraints of commercial CBT design - if this is not the case, the guidance is likely to be ignored even if it is of potential value. These requirements can be characterised as *flexibility* and *pragmatism* (Kember and Murphy 1990).

5.2.1 Integratable guidance

One important part of this is that the guidance be *easily integratable* with the current approaches employed by designers. This will help to overcome any inertial considerations, where CBT designers are unwilling or unable (through external constraints) to alter their current design practice. If a designer were, for example, currently following some kind of general model based on instructional theory and past experience, it is unlikely that she would move to a new model immediately. It is more likely that she would examine the steps in the new model and try to identify the important points that could improve her existing approach to design. She could then integrate them into her own approach as and when she saw fit. This abstraction from the model is equivalent to that suggested in chapter 4 as being the role of the models of the systems approach in real-world design.

5.2.2 Applicable guidance

In order to be integratable across a range of existing approaches to CBT design the guidance must be general. If this is not the case, a proliferation of design models (as in the systems approach) is likely. This suggests that the guidance should have a low degree of prescription. These requirements preclude the specification of new instructional models for CBT design as a general way of overcoming the problems of the systems approach.

A rule-based approach would also be likely to suffer from similar difficulties of scope and applicability, since rules provide guidance that is unambiguous (Smith 1986). This underlines their high degree of prescription, which means that they could conflict with a designer's existing design practice. Consequently, this suggests that rule-based guidance for CBT design would also be inapplicable.

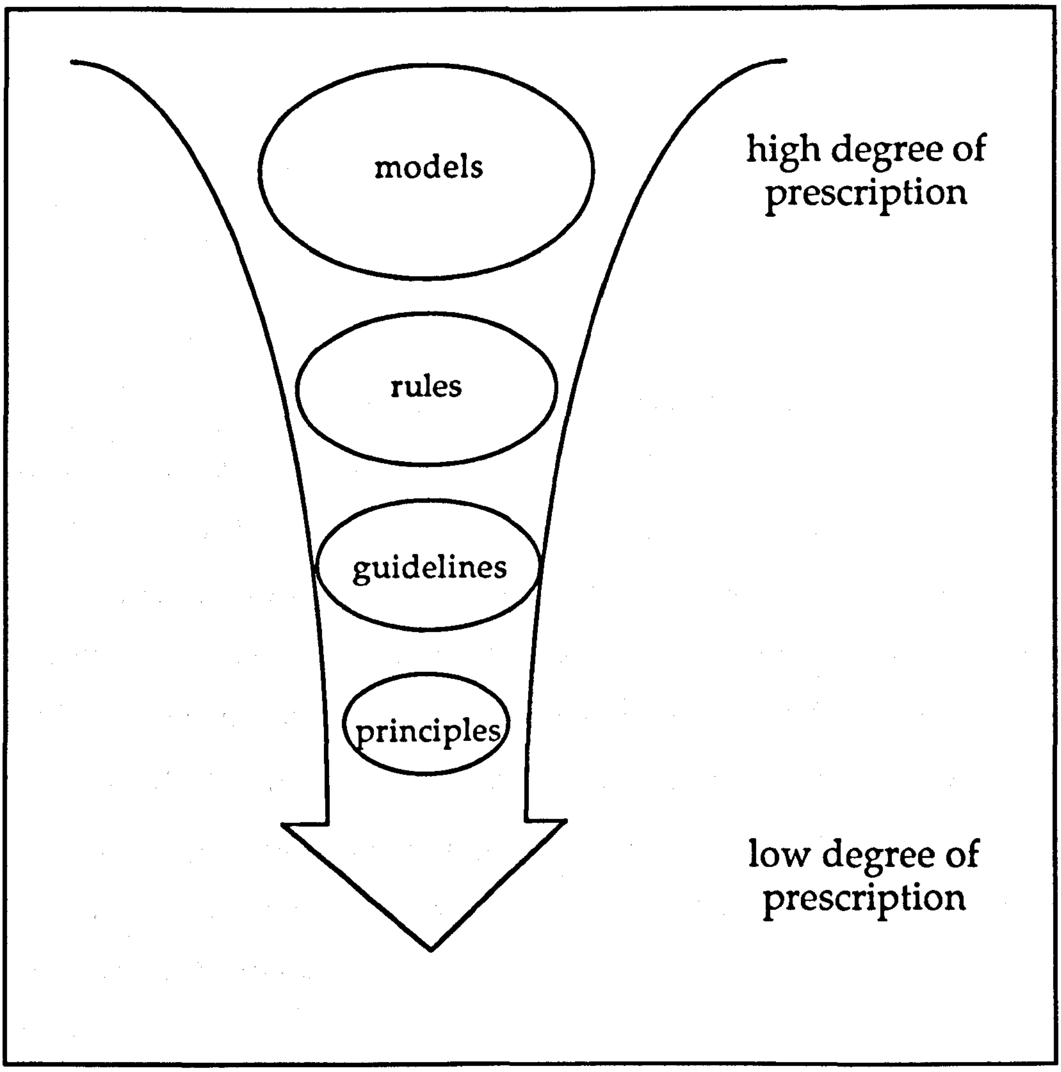

Figure 10: The different degrees of prescription of different forms of design guidance

More general forms of guidance, represented by guidelines and principles also vary in their degree of prescription, as figure 10 shows: guidelines are more specific and require interpretation by the designer, whereas principles locate the designer in some particular design philosophy (Smith 1986). Framing guidance for CBT designers in these forms would seem to address the problems of applicability and integratability suffered by more prescriptive approaches (Patterson *et al.* 1991).

5.2.3 Design principles

Whilst it is likely that additional effective guidance for designers of CBT materials could be provided in either of these forms, this study will concentrate on the development of principles. This is due to a desire to make the guidance as generally applicable as possible whilst remaining practically useful to the design of CBT software. The role of the principles will be to raise the awareness of CBT designers on key design issues. The particular design philosophy that the principles will represent will be developed in the following section, which will introduce these key issues by expanding upon the shortcomings of content of the systems approach suggested in chapter 4.

5.3 The content of the guidance

The shortcomings in content of the systems approach stemmed from a lack of active consideration of the instructional possibilities of the interactive computer medium. As Hannafin (1992) notes:

> Often we have simply "harnessed" technology, assimilating new technologies to accommodate our traditional notion of instructional design [...] there exists no obvious organised system for making judgements about technology utilisation. It is apparent that new design notions must emerge if we are to optimise the capability of emerging technologies for learning (Hannafin 1992: 55).

The content of any additional design guidance should focus on how to make effective instructional use of the computer as a delivery medium. This will mean conjoining pedagogy and technology through a consideration of the way in which the computer can support the basic instructional building blocks of repetition, reinforcement, sequence, structure, motivation, and mode of representation. The effectiveness of the principles will depend upon the re-framing and re-interpretation of these factors in terms of the capabilities of the computer. One simple example of this is the way in which the computer can provide the support for fast access to information. Such a mechanism could affect the way in which the designers of instructional materials make use of the repeated presentation of information.

5.4 Principles for the design of CBT

5.4.1 Introduction

There is a body of research material concerning the effective instructional use of the computer - as witnessed by the many international journals and conferences in this area. These provide a source of material on which to draw in framing the principles. However, within the literature there seems to be little attempt to provide coherent, applicable guidance to the design of CBT materials. The research is (necessarily) focussed, and tends to address issues at such depth that renders it unusable by CBT designers in real-world design situations. If the findings of such research are to be put to use, designers will have to interpret them so that they may be applied in their own particular design circumstances. The volume of research is also likely to affect its impact on real-world CBT design, since designers are unlikely to have the time and resources to assess its value. Finally, to gain effective guidance from the abundance of research, the findings have to be assessed and synthesised into a coherent, usable form. That such coherence is necessary is borne out by the DELTA initiative which notes that there is a need for "common unifying infrastructures" (DELTA 1990: 4) to be established, in order to make effective use of the instructional potential of contemporary technologies.

The goal of the remainder of this chapter is to discuss the central technological and pedagogical issues in the design of CBT materials, drawing on salient research in related areas in order to frame a set of interrelated principles which will be directly applicable to CBT design. In order to avoid a convoluted discussion leading to the framing of the principles, they will be presented initially and then explained and justified in detail through a discussion of their pedagogical and instructional underpinnings.

The basic instructional factors addressed by each principle and the facets of computer technology that support them are shown in table 1. A brief examination of this table shows that the instructional factors are addressed through more than one principle. The discussion of the principles will demonstrate that they are complimentary; where one principle notes that a certain instructional strategy (though of potential benefit) may be difficult to implement successfully, another principle may qualify it and suggest appropriate measures for its use.

The principles are labeled and discussed under the general headings of *immersion*, *interaction*, *locative fit*, and *multiple representations* (see Macredie and Thomas 1992a, 1992b, 1993a, 1993b, 1993c, 1993d). After their presentation, each of the principles will be discussed in terms of its constituent parts.

Immersion:

Create an environment that predisposes the user to learning through the provision of a *learning environment in which the learner is directly and actively involved.* This can be achieved through the use of the *graphical* and *auditory capabilities of the computer,* and the encouragement of *limited exploration* (through the exploitation of the abilities of the computer to provide non-linear access) to give the learner a *degree of control.*

Interaction:

The software should make use of the possibilities of the technology to monitor the *information which has already been imparted* and to present *meaningful, contextually sensitive* choices to the learner. In this way the *sequence in which information is imparted* can be related to the user's current state of knowledge about the system whilst *retaining a degree of user control.*

Locative Fit:

The information to be imparted should be structured so as to *counter the limitations of short term memory,* making use of the computer's 'ability' to *re-access* information and provide *non-linear access* to that information. The same information should be available for access from multiple points in the lesson.

Multiple Representations:

Make use of the technology's ability to provide *multiple representations* to present information in different forms related to the user's current state of knowledge about the system. This will mean using *graphical* and *textual* displays as necessary to facilitate learning. Also make use of the representational possibilities of the technology (animation, auditory, etc.) to convey ideas and information in a meaningful way and as an *elaborator* and *reinforcer*.

	Basic Instructional Factors	Important Facets of the Delivery Medium
Immersion	motivation sequence structure mode of representation	interactive possibilities of the medium representational possibilities non-linear access to information
Interaction	motivation sequence structure mode of representation	monitoring learner's responses testing representational possibilities non-linear access of information re-access of information
Locative Fit	repetition reinforcement sequence structure	re-access of information non-linear access multiple access points to information
Multiple Representations	motivation mode of representation reinforcement sequence structure	representational possibilities non-linear access multiple access points re-access of information

Table 1: The pedagogical issues addressed by the principles and the technological support provided by the medium

5.4.2 Principle I: Immersion

> *Create an environment that predisposes the user to learning through the provision of an learning environment in which the learner is directly and actively involved. This can be achieved through the use of the graphical and auditory capabilities of the computer, and the encouragement of limited exploration (through the exploitation of the abilities of the computer to provide non-linear access) to give the learner a degree of control.*

The issues that are raised and addressed by this principle may be classified as follows:

(i) interactivity;

(ii) the representational capabilities of the medium;

(iii) learner control.

As table 1 shows, the instructional factors that are considered in this principle are motivation, sequence, structure, and mode of representation. The focus is on the ways in which the computer may be used to provide a motivational learning environment for CBT software that will predispose the learner to learning. Whilst this is an obvious goal of any instructional design, interactive computers have particular attributes that make this goal more obviously attainable than through other instructional media. This provides the link to the other instructional issues: the mode of representation can be varied owing to the computer's representational capabilities, and the learner can be given control over the learning process allowing them to affect the sequence in which they encounter material in the CBT lesson as well as the overall lesson structure. All of these have a direct bearing on the motivation of the learner, and have the potential to alter the effectiveness of the CBT software.

(i) interactivity

The central technological attribute supporting the principle of *immersion* is the computer's highly interactive nature. This allows the possibility for direct interaction between the learner and the instructional medium. Various studies have suggested that the users of computer systems (including instructional software such as CBT materials) can be intrinsically motivated by this interaction (Shneiderman 1983, 1986; Hutchins *et al.* 1986), something which learning theorists from various schools have seen as imperative to the predisposition of the learner to learning (see, for example, Vygotsky 1962, Bruner 1966, Wadsworth 1989).

However, the *level* of the learner's intrinsic motivation depends on the *richness* of the interaction, the key determinant of which seems to be the degree of direct and active involvement of the learner. Showing this requires a consideration of the complex issue of interaction, both in the use of computer systems generally, and in terms of its place in CBT.

Whilst various authors have recently stressed the need to re-frame the question of what it is that constitutes interactivity (see, for example, Laurel 1991), there seems to be a general agreement that direct involvement on the part of the software's user is the fundamental requirement. Support comes primarily from the field of Human Computer Interaction (HCI), where the involvement of the user through direct manipulation interfaces and direct engagement has been seen as motivational and captivating (Shneiderman 1983, 1986; Hutchins *et al.* 1986). Both of these ways of interfacing support interaction which fosters the motivation experienced when users are involved in direct interaction with the objects in a domain. Whilst the HCI literature has generally regarded direct manipulation and direct engagement as distinct styles of interaction, Laurel has recently noted that:

> It seems likely that direct manipulation and direct engagement are head and tail of the same coin [...] one focussing on the qualities of action and the other focussing on subjective response (Laurel 1991: 8).

This suggests therefore that there is a basic issue which underpins both approaches when stripped of the "metacontext" of the interface (Laurel 1991). This issue relates to the isolation of the requirements in an interface that lead to the production of the feeling of 'taking action' within a representational world. Whilst, as Hutchins *et al.* (1986) note, it is difficult to be precise on this matter, they continue to suggest that the important motivational aspects are continuous representation, 'physical' action, and apparent 'instaneity' of response.

(ii) the representational capabilities of the medium

As Laurel (1991), Shneiderman (1983, 1986), and Hutchins *et al.* (1986) all note continuous representation relies heavily upon graphical representations. This is reflected in *Principle I*, which suggests the use of the graphical capabilities of the computer medium in the development of CBT software.

Whilst some designers of general instructional software have used graphical techniques to good effect, Pea and Sheingold (1987) note that even when graphically rich technologies like interactive video are used with instructional software, most simply "present programmed instruction with pictures" (Pea and Sheingold 1987: xv). The use of graphical images in CBT software must, therefore, be considered more deeply by designers who have tended to rely on the attributes of the technology *per se* to provide instructional effectiveness. Clark and Salomon (1986), for example, suggest that visuals and animation can isolate concepts, and can be used for modeling cognitive strategies in which learners are deficient. Strategies such as these can increase motivation (Relan 1991) which can in turn affect subsequent instruction (Keller 1983).

The mechanisms that support these new opportunities are constantly being developed. Current technologies offer possibilities for the representation of both static and dynamic information (stills and animation) which are of extremely high resolution and quality. There are also other modes of representing information that can be linked to the interactivity of the CBT lesson and that may prove motivational. Speech and other non-speech audio, for example, can be captured using digitising techniques and related to the user's actions in CBT software. These types of representational techniques are constantly improving and are more widely available due to falling hardware costs.

(iii) learner control

It has already been noted that the approach characterised by both direct manipulation and direct engagement relies on the active involvement of the user. Whilst graphical representation – to fulfil the criteria specified by Hutchins *et al.* (1986) regarding active involvement by the user – is of great importance, it is not the only issue that should be considered.

Another established issue which has been brought back into the focus by instructional design is *learner control*: giving the learner the power and freedom to make choices which direct their interaction with the CBT lesson and their instruction. Whilst allowing the learner to take control of their instruction has obvious advantages in terms of increased motivation, various authors have raised the question of whether the typical learner possesses sufficient knowledge to make effective decisions (see for example Steinberg 1977, Ross and Morrison 1989, Ross *et al.* 1989). Furthermore, in the context of instruction, decision-making may contribute to an unforeseen cognitive overload (Marchionini 1988) which will be detrimental to learning. Notwithstanding these problems, many authors still regard learner control as a powerful and necessary facet of instructional environments through the motivational possibilities that it supports (see, for example, Malone 1981, Stipek and Weisz 1981, Lepper 1985, Kinzie and Sullivan 1989, Friend and Cole 1990), and there is no reason to suppose that CBT materials should be any different.

Allowing the user control in CBT can give benefits not only through increased motivation, but also through the experiential learning (or 'learning-by-doing') that is associated with exploratory, or discovery-based learning (Salomon 1991). Gray (1987), for example, found that allowing the learner control over the sequence of material in the instructional software that she looked at had a positive effect on comprehension, though Gray realised the problems of unlimited control and suggested that learner control should be limited since too much control over the sequence of the instruction may serve to distract the learner.

Whilst Salomon (1991) is quick to point out that experiential learning is not always "better" than other modes of learning, he and others recognise the possibilities that it can offer. Lave (1988), for example, suggests that knowledge gained from experiential learning is "the locus of the most powerful knowledgeability in the lived-in-world" (Lave 1988: 14). The computer affords new instructional opportunities in terms of exploration and learner control (Salomon 1991) which should be considered by the designers of CBT software and exploited through their designs.

Recent research has highlighted a compromise solution to the inherent difficulties associated with the subject of learner control, suggesting that its value may lie in allowing context to be decided by the learner, with the instructional material offering a range of context themes for the user to select from (Ross *et al.* 1989). This can lead to a personalisation of the instruction by the learner which fosters "motivational effects and/or learning advantages" (Ross *et al.* 1989: 37). This approach is an attempt to restrict or limit the *degree* of control that the user of CBT materials should be given. This issue will be developed further through *Principle II.*

A facet of the computer that is of great importance in providing control to the learner is its information accessing capabilities. In order to have control over the sequence and structure of the lesson the learner will need to be able to access any one from a range of possible topics from a single point. Providing ways to support this type of access is a key determinant of the potential of CBT. Development environments to support the instructional designer in this area are available. Most notably, these include hypertext and hypermedia systems which can be used as authoring environments for CBT materials. Such authoring environments have facilities (such as buttons) that can easily be used to provide access to information contingent upon the learner's actions. It is likely that this type of system will assume greater significance in CBT design (Park 1991). Examples of this type of hypertext/hypermedia environment are Apple's HyperCard and Silicon Beach's SuperCard,[1]

[1]Whilst some authors would refer to such systems as a 'hypermedia' or 'multimedia' systems because of their ability to make use of graphics and to co-ordinate interactive video (IV) and interactive compact disc (CD-I) images, this study will follow Megarry (1988), and use hypertext as a general term to cover all of the concepts.

which represent prime examples of how modern technology can provide rich instructional environments, not only through their ability to make use of graphics and sound but also through their structural properties (Relan 1991).[2]

5.4.3 Principle II: Interaction

> *Whilst it is necessary to allow the learner a degree of control, the software should make use of the possibilities of the technology to monitor the information which has already been imparted and to present meaningful, contextually sensitive choices to the learner. In this way the sequence in which information is imparted can be related to the user's current state of knowledge about the system whilst retaining a degree of user control.*

The issues that are raised and addressed by this principle may be classified as follows:

(i) the complexity of the learner control issue;

(ii) providing effective learner control in CBT.

[2]Furthermore, such environments allow the rapid prototyping of CBT materials that has recently been suggested as an important factor in the development of effective CBT (MacKenzie 1987).

(i) the complexity of the learner control issue

The purpose of *Principle II* is to provide the instructional designer with an awareness of the problems of the learner control issue, and to suggest a way that CBT software may be designed to overcome these problems. As shown in table 1, the same pedagogical issues of motivation, sequence, structure, and mode of representation are addressed. Providing the possibility for learner control is likely to intrinsically motivate learners. However, the central issue here is the effect that the provision of learner control will have over the sequence and structure of the CBT lesson and the ways in which the delivery medium can be used to address any potential problem areas.

Learner control is a complex issue. Whilst not suggesting that there are any concrete rules governing the level of control that should be given to learners by CBT programs, interactive technologies can embody a degree of learner control in CBT materials through the provision of limited freedom to the learner. The possibility is that the learner can be provided with control in an environment which imposes an overall structure.

Limiting the degree of control should alleviate two of the main problems that arise from allowing the learner total freedom to direct the instructional process. These are the *disorientation* of the leaner, and the formation of *incorrect associations* during learning. In complex CBT lessons, learners can easily follow complex paths through the instruction and become disoriented (Conklin 1987). Furthermore, during their navigation of a CBT lesson, learners may move from one topic to another believing incorrectly that there is an association between the two.

Both of these phenomena arise when there is a high degree of learner control – for example, when uncontrolled exploration of a complex instructional environment is encouraged. Whilst one remedy is to direct the instruction thus removing control from the learner, this would tend to result in a reduction in (if not loss of) intrinsic motivation. Consequently, the learning experience would be impoverished. Another strategy is to impose some form of overall structure on the CBT lesson (Mace 1989, van der Berg and Watt 1991).[3] Whilst these ideas are important and should be made use of in CBT design, this principle will develop an additional approach based on the actions of the learner.

(ii) providing effective learner control in CBT

One solution, advocated in this principle, is the use of the information handling capacities of the computer to monitor the CBT material that has already been seen by the learner. The information gathered in this way can be used to influence the sequence in which topics are seen by the

[3]Another pragmatic approach to training in a similar vein is Carroll and Carrithers' (1984) "training wheels" for user interfaces. Here much of the applications functionality is made inaccessible to new users, so that they can easily identify and learn about the fundamental facets of the system without being distracted by more complex detail. This also allows the avoidance of situations from which novice users may find it difficult to recover.

learner. Choices that are given to the learner may be altered accordingly, making the alternatives contextually sensitive and instructionally relevant to each individual learner. This depends upon an understanding of the overall structure of the lesson and how the topics in it are linked.

One way to achieve this is through the creation of a 'user profile' which holds details of the topics, or particular pieces of information, that the learner has encountered. Moreover, it could also hold the results of any answers to questions that were used in the CBT materials. In this way a view of the learner's interaction with the software can be built up. The profile provides useful information to guide the CBT lesson and can be seen as imposing the kind of overall structure that Mace (1989) recommends, though the sequence of the CBT lesson will appear more flexible to the learner who may well be unaware that any structure is imposed. The benefits of providing control to the learner can be gained with less risk of its associated drawbacks.

This means that the CBT lesson can be managed so as to effectively structure and sequence its instructional content, an issue that theorists from various schools have seen as of great importance (Bruner 1960, 1966; Gagné 1985; Skinner 1968). This should reduce the likelihood of the formation of incorrect associations by the learner since the instructional options are restricted to those that are of direct relevance at any given time. Here the computer is effectively used as an information handler which organises and represents the content of the CBT lesson. It has been suggested that this may represent the most effective instructional role of the computer (Megarry 1988).

5.4.4 Principle III: Locative Fit

> *The information to be imparted should be structured so as to counter the limitations of short term memory, making use of the computer's 'ability' to re-access information and provide non-linear access to that information. The same information should be available for access from multiple points in the lesson.*

The issues that are raised and addressed by this principle may be classified as follows:

(i) the importance of repetition and reinforcement;

(ii) re-framing repetition and reinforcement.

(i) the importance of repetition and reinforcement

This principle addresses the issues that remain at the heart of CBT: repetition and reinforcement. However, their role and importance is re-framed because of the flexibility of sequence and structure offered by the interactive computer medium through its potential to access information easily in a non-linear manner. The role of this principle is to raise the awareness of CBT designers with respect to this potential and to propose a simple, practical way to make use of the non-linear access of information in support of the issues of repetition, reinforcement, sequence, and structure.

Traditional computer-based instruction material has recognised the possibilities of using the computer to reinforce information as an aid to learning (see, for example, the TICCIT project, discussed in Wilson 1984). In CBT software information has been structured such that learners are forced to consider the same concept again and again in a short space of time. This of course reflects learning theorists' views on repetition, reinforcement, and contiguity used to overcome the limitations of short term memory (see, for example, Gagné and Briggs 1979).

This idea underpins the most established delivery approach used in CBT materials, usually called *drill-and-practice*. Here, learners are given an example of some concept and have to demonstrate their understanding through answering questions to some pre-defined level of competency (i.e. until they correctly answer four questions consecutively). Even in a limited form, this type of learning may be useful for CBT (Steinberg 1991), but the instructional medium affords additional possibilities to support reinforcement that have not been fully exploited. The behavioural connotations associated with reinforcement through its past use in 'programmed instruction' may be supplanted thanks to the technological developments embodied in interactive computers. Because the computer can easily support rich interaction between the two instructional partners the notion of drill-and-practice as the mainstay of CBT software is beginning to change. This change, however, has not yet been fully realised, and "too many computers are still used as page-turning devices, despite their immense capability for more flexible and interactive styles of presentation" (Megarry 1988: 173).

It is important that designers realise the potential of CBT in this area and consider the different ways in which the delivery medium may be used. One of the most pertinent problems arises from our inclination to "apply technology within the constraints of past experiences" (Steinberg 1991: 4). In terms of CBT software this has lead to many programs resembling 'books', because of the direct transfer of task from the old technology to the new, with little or no consideration of the differences between the two. When the possibilities of the computer were more limited, this approach was understandable, but the possibilities that computers afford in terms of presentation style and information access suggest that this paradigm for CBT software is inadequate and should be supplanted.

(ii) re-framing repetition and reinforcement

The key to the change rests in the breaking away from thinking of a computer-screenful of information as a 'page' and from the notion of reading text in a linear fashion (Meggary 1988). Current computers possess the capability to support this through the non-linear access of information on which hypertext environments such as Apple's HyperCard are based. The effective exploitation of these possibilities depends on the ability of the instructional designer to make the break that Meggary advocates. CBT material should be designed with the instructional potential of the medium in mind. This centres on the ability to provide access to information in different orders and from different points in the CBT lesson. In this way information can be repeatedly seen and ideas reinforced at instructionally meaningful times, so as to reinforce correct, and avoid the formation of incorrect, associations.

One mechanism that could be used to achieve these aims is the provision of multiple access points to information from within a single piece of CBT software, perhaps through the use of buttons. Selecting specific buttons allows the learner to revisit information, and this would have a direct bearing on the sequence of information that learners see. Access could easily be given to background topics that had already been covered, to give the potential to reinforce such information that has long been felt to be beneficial in overcoming the restrictions of short-term memory. The overall structure of the CBT lesson could still be dictated by the designer, with only access to contextually relevant information being given, thus avoiding potential disorientation.

In addition to providing basic reinforcement through the repeated presentation of information, it has also been suggested that providing relevant information from multiple access points may afford "different conceptual perspectives [that are] essential for attaining the goals of advanced knowledge acquisition" (Spiro *et al.* 1991: 28).

Just as poorly structured lessons can lead to the formation of incorrect associations between topics, designers providing well thought-out lessons with well-structured choices can give learners perspectives that can increase the effectiveness of the instruction. These alternative perspectives arise from providing meaningful situations to revisit the same material in different contexts and at different times, and bear directly on the mastery of complexity in understanding, and preparation for transfer (Spiro *et al.* 1991) an issue which is of paramount importance in CBT. Such perspectives obviously rely on the skill and expertise of the designer of the CBT lesson, but are supported and indeed made possible by the mechanisms sustained by the medium.

There is an implied link here to the issue of learner control since the learner must decide to revisit information in order for reinforcement to occur and to gain the additional perspectives that Spiro *et al.* see as important. The same considerations over the provision of learner control as were outlined relating to *Principles I* and *II* are therefore applicable. Once more, this suggests that it will fall on the designer of the CBT material to provide well-structured lessons with instructional situations in which choices for re-access are contextually meaningful, since badly designed situations and choices may lead to impaired learning.

5.4.5 Principle IV: Multiple Representations

> *Make use of the technology's ability to provide multiple representations to present information in different forms related to the user's current state of knowledge about the system. This will mean using graphical and textual displays as necessary to facilitate learning. Also make use of the representational possibilities of the technology (animation, auditory, etc.) to convey ideas and information in a meaningful way and as an elaborator and reinforcer.*

The issues that are raised and addressed by this principle may be classified as follows:

(i) the importance of display techniques;

(ii) providing meaningful representations.

(i) the importance of display techniques

As the title of this principle suggests, the instructional factor that is central to this principle is the mode of representation, and the way in which different ways of representing information can affect the learning process. The computer affords many modes of representation, from basic textual to complex animated graphics, which will be applicable in different instructional situations.

Simple and general guidance regarding the display of information to the learner (including for example the grouping of information) is of great importance to designers of CBT materials (Lucas 1991). Faiola and Debloois (1988) for instance, found that dividing large portions of information into smaller units improved visual clarity and led to improved retention of information. Baird *et al.* (1987) have advocated the grouping of information elements around the screen's optical centre to prevent them being ignored. Similarly Lucas (1991) notes the general importance of visuals as elaboration aids that can also help the learner to remember and retrieve descriptions through association.

At a more general level, the different forms that a representation can take are of importance. Learning theorists have long recognised the value of using pictorial representations to convey information to learners inexperienced in a particular concept, for example. Bruner (1966) suggests three modes of representation (enactive, iconic, and symbolic) and outlines their potential instructional value (Bruner 1966). Whilst instructional materials have made use of pictorial representations to convey information, the highly interactive nature of the computer medium allows the CBT designer additional instructional possibilities.

(ii) providing meaningful representations

As was noted in the discussion of *Principle II,* the potential to tailor the presentation of information to the individual learner is one such possibility. Furthermore, it is linked to the notion of provision of multiple access points outlined in *Principle III.* Bruner's classification is useful since it shows the value of modes of representation other than the textual one on which CBT has traditionally relied. This reliance seems to be decreasing, but there are new considerations that must be taken because of the improved graphical and auditory capabilities of the computer.

One is the relation of the mode of representation of information to the learner's position in the tutorial. If some control over the interaction is given to the learner the idea of the user profile will be of use to determine how to present the information. At a general level this may mean the presentation of different detail to the learner depending on the information that has already been seen on the same topic.

Simulations of the working environment perhaps represent the most important example of the way in which providing meaningful representations related to the learner's position and interaction with the CBT lesson can be used. Since the working medium is often complex, the appearance of the simulations can be daunting for learners. Providing the 'correct' level of detail in simulations will determine how meaningful they are. This level of detail relates to *fidelity,* the degree to which a simulation imitates the 'real' working environment.

Although it has been suggested that increasing fidelity in simulations should lead to improved learning and transfer to the working environment (see, *inter alios,* Wolfe 1978, Shneider 1985), more recent research has suggested that this is not necessarily the case (see, *inter alios*, Allen *et al.* 1986, Boreham 1985). There appear to be two primary explanations for this: high fidelity means higher complexity which can tax memory and other cognitive abilities (Miller 1974), and proven instructional techniques that improve initial learning (such as corrective feedback) tend to lower fidelity (Baum *et al.* 1982). The compromise is to adjust the fidelity based on the phase of the instruction for which the simulation is intended (Alessi and Trollip 1985, Alessi 1988). In this way designers can increase the fidelity of the simulations that are used as the learner progresses through the CBT lesson. Low-fidelity simulations could be supported by increased textual support to help the learner, whereas high-fidelity simulations could closely approximate the working environment (as in the case of flight simulators).[4]

It will of course fall to individual designers to make decisions as to what types and levels of representation are appropriate based on a consideration of the target group and the lesson content. The issues involved are, however, extremely important and should be considered by CBT designers.

[4]It is likely that this issue will gain increasing importance as CBT developers consider the possibilities of virtual reality in training.

5.5 Summary

This chapter has presented a set of four interrelated principles of *immersion, interaction, locative fit,* and *multiple representations* that seek to address shortcomings of the systems approach to the design of CBT materials. It has been suggested that their form makes them both flexible and pragmatic: they are general and non-prescriptive, thus making them integratable with current design practice. Furthermore, they address and conjoin salient issues of pedagogy and technology to make effective instructional use of the interactive delivery medium. The principles are complementary, addressing similar instructional issues from different perspectives. They represent a coherent framework for designers of CBT materials that re-interprets and re-frames established, key instructional factors - such as motivation, repetition, reinforcement, sequence, structure, and mode of representation - in terms of the contemporary interactive computer that constitutes the delivery medium for CBT. They draw on current and established research in the field of instructional design, but avoid the level of detail that characterises much of the research in this area and that decreases the applicability of its findings to CBT design in real-world situations. As such, they may have the potential to raise the awareness of designers of CBT materials on these key issues.

Having stressed the importance of the practical applicability of the four principles, chapters 6 and 7 examine the usefulness of the principles through the presentation and discussion of findings from two sources of empirical work. The first is a survey of CBT designers which sought to canvass their opinions on the issues addressed by the principles (chapter

6); the second is a set of user trials carried out on a piece of CBT software developed following the principles (chapter 7). These two studies allow the comparison of responses from designers and users of CBT materials. This may highlight anomalies, such as differing importance attached to different issues, that will contribute to a deeper insight into the relative importance of the issues and of the principles themselves.

Chapter 6

The Design Survey

6.1 Introduction

This chapter presents a survey of designers regarding the four principles developed in chapter 5. The aim of the survey was to assess the practical applicability of the principles. The survey was questionnaire-based, and sought to elicit designers' views of both the importance of the issues addressed by the principles, and the framing of the principles. The questionnaire posed questions about the issues underpinning the principles, presented and assessed the value of sample pieces of guidance, and presented the principles in their complete form so that the designers could comment on their usefulness.

6.2 Methodology

The design survey consisted of a postal survey of ten CBT designers, all of whom had previously agreed to take part. They were presented with a three-part questionnaire (in appendix A). Section A of the questionnaire asked about the designers' current approach to CBT design. Section B concerned issues addressed by the principles and presented sample guidance abstracted from the principles. Section C presented the principles in their complete form and asked for the designers' comments on the principles' value. The questionnaire was pre-tested by two designers. Normal conventions for questionnaire design were followed (Schuman and Presser 1981, Sheatsley 1983).

The primary purpose of the design questionnaire was to assess the value of the principles from the perspective of CBT designers. However, the questionnaire provided the opportunity to obtain other important information. Whilst section B of the questionnaire was concerned with how the designers viewed the abstract issues raised by the principles, their value as *design guidance* was addressed by section C of the questionnaire. This separation of the *issues* in the principles from the way in which they are *framed* allows the assessment of the extent to which there is a discrepancy between how the designers view the *issues* and how they view the guidance *itself*. If, for example, designers seem to agree with the issue, it does not automatically follow that they will see the way in which those issues are expressed as helpful. Furthermore, designers may feel that they already address the important issues raised by the principles, yet fail to provide evidence in support of this through their comments on the principles themselves (Gould and Lewis 1985).

Since section A covers the designers' current approach to CBT design, the relationship between this and the way in which designers view the value of the principles can also be examined.

6.3 Results

Certain results were expected from the design survey. It was expected that CBT designers used some form of model. The degree of prescription of these models was not expected to be uniform, but the general characteristic was expected to be replicability. This would conform to the way in which the systems approach is actually used in CBT design (providing a resource on which CBT designers draw to frame some kind of model or guidance for their design), and was expected to highlight the importance of the role of the designer's past experience.

It was also expected that the designers would generally support the issues raised. Disagreement with the issues was expected where they represented a departure from norms, such as providing personalised instruction through the monitoring of the learner and the use of learner profiles. In these cases, where the designer had no direct experience of addressing the issues, some scepticism was anticipated.

Furthermore, it was assumed that there would be some difference between the responses of the designers to the issues addressed by the principles presented in abstract form and the principles themselves. This might arise from the designers' lack of active experience in employing the guidance in CBT design. For example, the abstract issues and even the sample guidance might seem important to the designers, but the principles might not since the designers had not deeply considered their application.

Detailed results from the design survey are given in appendix B. The following section will present summaries of the results and focus on discussing the points that they raise.

6.4 Section A

6.4.1 Results

This section contained three general questions that assessed the way in which the designers author CBT materials. Table 2 presents a summary of the responses to this section of the questionnaire. The following discussion will raise specific points from the responses of the designers.

	Yes	No
(i) Writing CBT materials	10	0

(ii) Using Authoring System (AS) or More General Language (MGL)	AS	MGL
	5	5

	Yes	No	No answer
(iii) Is the approach to design replicable?	7	1	2

	Yes	No	No answer
(iv) Is the approach to design formal?	2	6	2

Table 2: Summary of the designers responses to part A of the design questionnaire

6.4.2 Discussion

The designers questioned currently design CBT materials. There is a split between those using authoring systems and those using more general languages. Amongst those using authoring systems, four stated that they used Apple's HyperCard (one also used SAS/AF), whilst the other used OWL's Guide. The designers using more general languages tended not to state which language they used. (One, however, stated that the more general language that they used was HyperCard, indicating that it is not always viewed as an authoring system).

Only two of the designers described what could be classed as 'prescriptive' models of the design process. More general approaches were outlined by seven of the designers. These approaches were at a similar level to the way in which the systems approach is used in real-world design situations. Even more general was the approach of the remaining designer, who stated that she used an "interlocking set of useful things". Although it is difficult to assess the replicability of this particular approach, eight of the designers taking part in the survey used approaches which could be classed as being replicable, including various design cycles and methodologies, most of which involved some degree of iteration between different stages in the design.

Four of the designers stressed the involvement of representatives of the potential target group in the design after the initial specification stage. Whilst this may not accurately reflect their approach to design it is possible that lack of user involvement reflects the real-life constraints of time and money that are placed on CBT designers.

6.5 Section B

6.5.1 Introduction

This section of the questionnaire consisted of a series of closed questions to assess designers' attitudes to important issues in the design of CBT material, and their reaction to the sample guidance that was proposed. The reactions of the designers to this section relate to the importance of the underlying issues addressed by each principle.

6.5.2 Part 1: the *immersion* principle

Table 3 shows a summary of the responses given in this section of the questionnaire, which was concerned with the issues addressed by the *immersion* principle. As table 3 shows, the designers' responses generally supported the need for guidance for CBT designers in the area of direct and active involvement of the learner in CBT materials, and suggested that the issues raised in this section were of importance to CBT designers.

(i)(a) The creation of a learning environment that predisposes the learner to learning is an important goal of CBT.	strongly agree	agree	disagree	strongly disagree
	6	4	0	0

(i)(b) One way to create such an environment is to directly and actively involve the learner in the learning.	strongly agree	agree	disagree	strongly disagree
	7	3	0	0

(ii)Do you feel guidance on how to achieve such direct and active involvement would help you to produce more effective CBT materials?	Yes	No	No answer
	10	0	0

(iii)(1)Make the interaction between the learner and the CBT material richer by using the graphical capabilities of the computer to give continuous representation of the learner's action. This will rely on the instancity of response on the part of the CBT material.	very important	important	unimportant	of no importance
	3	7	0	0

(iii)(2)Make use of animation and visual representation in general to isolate concepts in the CBT material.	very important	important	unimportant	of no importance
	1	7	2	0

(iii)(3)Make use of the auditory capabilities of the computer medium to enrich the learning experience.	very important	important	unimportant	of no importance
	1	6	2	0

(iii)(4)Give the learner some kind of control over the learning to make the learning experience richer. This could be achieved through allowing some form of exploration using the computer medium's ability to provide non-linear access to information in the CBT material.	very important	important	unimportant	of no importance
	7	3	0	0

Table 3: Summary of the responses covering the issues addressed by the *immersion* principle (section B part 1 of the design questionnaire)

Difference in expression of the guidance may account for the differing importance placed on the four pieces of guidance given in this section of the questionnaire. Two of these items were detailed and presented an example of how the guidance could be used; these items were well received. In contrast, the second and third items – concerning the use of animation and visualisation, and the auditory capabilities of the medium – were short and concise, and seen as less important. It is possible that the designers were unaware of how to make use of these items, and accordingly rated them as less important. There was also one missing answer, concerning the use of the auditory capabilities of the computer medium. This designer felt that this issue was so environmentally dependent that he could not judge its general importance.

6.5.3 Part 2: the *interaction* principle

Table 4 shows a summary of the responses given in this section of the questionnaire, which was concerned with the issues addressed by the *interaction* principle. Whilst there were fewer positive responses than for the previous section, the general consensus still seemed to be that the topics addressed by the *interaction* principle were relevant to the design of CBT materials, and that the sample guidance was of importance.

(i)(a) Providing learner control is an important goal of instruction generally, and therefore of CBT.	strongly agree	agree	disagree	strongly disagree
	4	6	0	0

(ii) Do you feel that guidance on how to develop CBT materials that provide learner control would help you to produce more effective CBT materials?	Yes	No	No answer
	10	0	0

(iii)(a) Whilst it is beneficial to give learners a degree of control, too high a degree will disrupt learning.	strongly agree	agree	disagree	strongly disagree
	2	3	4	0

(iii)(b) The sequence in which topics in CBT materials are encountered effects how well people learn from them.	strongly agree	agree	disagree	strongly disagree
	0	9	1	0

(iv) Do you fell that guidance on how to provide learner control and effective sequencing in CBT materials would help you to produce more effective CBT?	Yes	No	No answer
	9	0	1

(v)(1) Keep a record of topics that have already been seen by the learner in order to present meaningful, relevant choices about the direction of the instruction to the learner, providing control of sequence with a degree of learner control.	very important	important	unimportant	of no importance
	1	8	0	0

Table 4: Summary of the responses covering the issues addressed by the *interaction* principle (section B part 2 of the design questionnaire)

The question that was given the greatest number of negative responses related to the need to restrict the degree of control given to learners. Despite seeing the issue as unimportant, the guidance presented to address this issue was well received by the designers, indicating the complexity of the learner control issue.

6.5.4 Part 3: the *locative fit* principle

Table 5 shows a summary of the responses given in this section of the questionnaire, which was concerned with the issues addressed by the *locative fit* principle. The responses summarised in table 5 show that the designers see the issues addressed through the *locative fit* principle as pertinent to the design of effective CBT materials, and perceive the sample guidance presented as useful.

(i)(a) Information given to learners through CBT materials should be structured so as to counter the limitations of short-term memory.	strongly agree	agree	disagree	strongly disagree
	1	7	2	0

(ii) Do you feel that guidance on how to develop CBT materials that counter limitations of short -term memory would help you to produce more effective CBT?	Yes	No	No answer
	8	0	2

(iii)(1) Make use of the computer medium's ability to re-access information in CBT materials. Revisiting information can reinforce its content, helping to overcome the limitations of short-term memory.	very important	important	unimportant	of no importance
	3	4	1	0

(iii)(2) Make the same information available from multiple access points in the CBT material. This will help counter the limitations of short-term memory since the possibilities for reinforcement through revisiting will be increased.	very important	important	unimportant	of no importance
	2	5	1	0

Table 5: Summary of the responses covering the issues addressed by the *locative fit* principle (section B part 3 of the design questionnaire)

6.5.5 Part 4: the *multiple representations* principle

Table 6 shows a summary of the responses given in this section of the questionnaire, which was concerned with the issues addressed by the *multiple representations* principle.

Although, as table 6 shows, the designers saw the use of multiple representations in CBT materials as important, the ratings for the guidance on how to make use of different forms of representation can be seen to be the lowest for any in this section of the questionnaire. A likely explanation is that the sample guidance referred to 'assessing the learner's current state of knowledge', a subject that is linked to the AI approach to instruction and that is very difficult to achieve. The sample guidance did not distinguish itself from the AI approach, and this may account for the scepticism of the designers.

(i)(a) Representing information in different ways (for example, through animation, still graphics, text) is an important facet of CBT.	strongly agree	agree	disagree	strongly disagree
	2	7	1	0

(ii) Do you feel that guidance on how to develop CBT materials which make effective use of the different forms of representation would help you produce more effective CBT materials?	Yes	No	No answer
	9	0	0

(iii)(1) Relate the form of the representation to the learner's current state of knowledge. For example, use animation to convey new ideas, and text for information which has been seen by the learner and which the learner understands.	very important	important	unimportant	of no importance
	3	3	3	0

(iii)(2) Assess the learner's state of knowledge with respect to the CBT material in order to find the best form of representation. This could be achieved through some form of active testing during the CBT lesson on which to base the decision.	very important	important	unimportant	of no importance
	1	4	3	0

Table 6: Summary of the responses covering the issues addressed by the *multiple representations* principle (section B part 4 of the design questionnaire)

6.6 Section C

6.6.1 Introduction

Section C of the questionnaire presented the principles in their complete form (as they appear in chapter 5) and asked for comments from the designers as to their value and usefulness in the design of CBT materials. Comments from the designers will be presented for each of the four principles in turn, followed by discussions of the relevant points that they raise.

6.6.2 Principle I: the *immersion* principle

Results

Of the ten designers questioned, nine agreed that the issues raised and expressed in the *immersion* principle represented useful guidance for designers of CBT materials.[1] There were, however, several cautionary comments made. These included reservations about areas in the use of the guidance, as in the case of designer 2 who stated that "for some

[1]The other designer commented only on the problem of using audio in multi-learner settings, and the over-exploitation of features of technology without giving a clear indication of his level of support for the issues addressed by the principle. When answering the associated questions in section B, the designer supported the ideas in all but one case, again when involving audio, citing personal experience of the difficulties that can arise with sound in multi-learner environments.

purposes, exploration need not be limited". The difficulties in providing absolute guidance on the learner control issue re-surfaced in the conflicting comments of designer 4. He stressed that learner control, whilst important, must be restricted since "some items [in a lesson] need to be in order". An obvious example of this would be in lessons with a hierarchical structure, containing topics that hold information that is prerequisite to a deeper level in the lesson. Another comment on this issue came from designer 6 who felt that whilst learner control was important, questions still remained about its employment since "too little [research] has been done on study skills re CBT".

Another area that provoked cautionary comments from the designers was in the over use of particular facets of the technology. Designer 3, for example, noted the need for:

> caution against the over exploitation of the capacities available (animation, sound, etc.) which can complicate and distract from the learning experience.

This view was supported by designer 5 who stated that:

> too much exploitation of 'bells and whistles' features is evident [in some CBT materials] without the designers really knowing whether such features are beneficial.

Discussion

Two issues of importance are raised in these comments. The first concerns the issue of learner control. The conflicting comments of designers on this issue demonstrate its complexity. The degree of control that should be given to learners will depend upon particular design circumstances such as the prospective target group for the instruction.

The second issue raised by the designers relates to the issue of 'enrichment' in CBT lessons. The line between the enrichment and complication of the learning process may well be a fine one. Whilst caution is necessary, the responses of the designers to the questions in the questionnaire also suggest that they recognise that materials which do not engage or involve the learner will be less effective. It rests therefore on the designers themselves to find an appropriate degree of enrichment, or use of the capabilities of the delivery technology, for their CBT materials. It is likely that this level will vary depending upon both the subject matter and the prospective learner group.

This is the difficulty in providing guidance to designers: context cannot be taken into account. The underlying issues addressed by the *immersion* principle were however generally supported by the designers, and well summed up by the comments of designers 10 and 7 who said, respectively, that the "learner has to be involved to learn effectively" and that "simply reading screen after screen of instructions is not enough".

6.6.3 Principle II: the *interaction* principle

Results

In this part of the questionnaire, eight of the ten designers supported the principle of *interaction*. One of the remaining designers (designer 6) actively disagreed, commenting that the subject of monitoring the responses of the learner in an attempt to provide them with contextually sensitive choices in the CBT material was "fraught with difficulty" and that "too many assumptions have to be made about the learner". The other designer who did not support the *interaction* principle did not however actively disagree with the guidance. Instead, he cautioned that care had to be taken since learners do not always take in information that is imparted by CBT lessons.

Of the eight designers supporting the principle, four made comments which are important and should be raised here. As with the *immersion* principle, caution was expressed as to the applicability of the *interaction* principle in different circumstances. Designer 3, for example, expressed agreement with the issues involved, but suggested that the applicability of the *interaction* principle may be "limited to isolated and relatively simple aspects of lessons". The main concern arising from the comments is that whilst the idea of providing learners with contextually relevant choices was widely supported by the designers, the way in which it can be implemented was questioned. Indeed, designer 10 stated that the principle raises "important issues, but [that they are] difficult to address" and that "making learning relate to individuals is a good idea, but [is] difficult in practice". Designer 1 also supported the idea of allowing different choices for different learners, commenting that "different individuals may benefit from different orders" but expressed uncertainty about how such a mechanism would be put into practice.

Discussion

The comments of the designers show that they have reservations with respect to the viability of the use of monitoring and testing to provide personalisable instruction. The first of these is the use of the responses of the user to personalise the instruction through the provision of contextually sensitive choices in the CBT lesson. Whilst this is a difficult area, the responses of the learner are the only source on which CBT designers can draw in an attempt to provide personalisable instruction. Though limited in scope and effectiveness, monitoring and testing of learners within CBT materials provide a potential way of alleviating the problems associated with non-personalisable instruction (such as ineffectiveness for particular types of learner) if the resulting choices given to learners are based on their responses.

The caution that users do not always take in information that is imparted by CBT lessons may also be addressed by embodying some form of testing into CBT materials to try to assess the knowledge of the learner with respect to topics covered by the CBT lesson. However, the suitability of such tests may well depend upon particular circumstances.

Although the issues addressed by the *interaction* principle are complex, they at least represents an attempt to provide personalisable CBT materials, and as designer 4 noted "if CBT can adapt methods based on learners' actions etc., so much the better".

6.6.4 Principle III: the *locative fit* principle

Results

On the whole, this principle was also well received, with seven of the ten designers taking part in the survey making comments in general support of the ideas expressed in this section of the questionnaire. Again, caution was expressed in the comments of several of these seven designers. Designer 2, for example, strongly agreed with the guidance, provided that the "capabilities in item [principle] 2 [i.e. the presentation of meaningful, contextually sensitive choices to the learner and the retention of a degree of learner control] are present to avoid inappropriate repetition". Designer 3 also supported a link between this and the previous principle, noting that the *locative fit* principle was not only "important and doable," but also that the "frequency with which information is accessed could contribute to item [principle] 2 – giving an indication of problem areas".

Of the other designers supporting this principle, designer 4 agreed that reiterating important points is necessary but questioned the degree to which it should be employed saying "but should we [CBT designers] cater too much for short term memory. After all traditional materials don't".

Other difficulties with the issues covered in this section were raised by the designers whose comments do not generally support the principle. Designer 1 stated that it would be better to "fetch a summary back [rather] than deliberately re-introducing topics that the user may not have forgotten". At a more general level, designer 9 questioned the practical difficulties of employing this principle in CBT since different learners will "remember things for different amounts of time, for different reasons and using different methods". As such he did not see how "such a principle can be quantitatively represented in a teaching package". The remaining designer who did not support the principle (designer 5) stated that their "knowledge and experience of this aspect of design [was] limited".

Returning to those designers who did support the guidance presented in this section, three felt strongly about the issue of reinforcement and revisiting of information. Designer 6 stated that learners "must be able to revise quickly," a comment which supports the notion of allowing multiple access points to the same information; designer 10 noted that reinforcement was the "mainstay of learning materials"; and designer 7 stated that the guidance of the *locative fit* principle "is compulsory".

Discussion

The comments of the designers raised several points that will be discussed here. The first is the link between the *locative fit* and *interaction* principles that was noted by two of the designers. This link could be realised through the monitoring of the learner's access to particular items and the provision of choices based on the results of this monitoring: frequent access may indicate a problem area that requires additional information to be given, or at least offered, to the learner.

Comments presented in the results section, notably designer 4's comments about traditional materials, also suggest that some designers may have difficulties in making use of the possibilities of the delivery technology. This may be because of our natural inclination to frame problems in terms of our past experiences, and so to think of solutions in terms of how the problem would be addressed using less interactive delivery media.

The difficulty in accepting the novel possibilities that interactive computers offer to training may also account for the comments of designer 8. Whilst generally supporting the principle and the issue of reinforcement of information, he stated that "it is surely easier for the user to recall linearly structured lessons than an *ad hoc* navigation system created by continually jumping back and forth". This may represent a resistance to change. The sequence of the information that a learner sees may well influence its retention, through the formation of correct and important associations, for example. Providing the correct sequence is therefore an important part of the authoring of linear training materials, but it is this sequence rather than the linearity that aids recall. There seems little reason to think that linear materials *per se* should lead to better recall than non-linear materials, if topics in non-linear training materials are well structured and the learner's control is restricted to avoid the formation of incorrect associations between different topics or items. Indeed, recall may well be enhanced through the improved motivation and learning associated with providing the learner with control over the learning process.

Designer 1's comments in the results section about the re-introduction of topics without the user's intervention seem to miss the point about the *locative fit* principle. The principle does not advocate this, instead it states only that "the same information should be available from multiple access points," and not that it should be forced upon the learner. Providing the learner with the *option* to revisit information is the important point.

The comments of designer 9 in the results section highlight the difficulties in providing guidance that is generally applicable in a range of design situations and for a potentially vast number of different learners. The most that designers of CBT materials can hope to do is to author lessons that attempt to take the differences in learners' abilities and styles of learning into account by building in some degree of personalisability. Such materials will allow individual learners to employ their own style of learning – exploring to a greater or lesser degree, for example – albeit in a somewhat constrained learning environment (as in the case of the restriction of learner control to avoid disorientation).

6.6.5 Principle IV: the *multiple representations* principle

Results

Of the ten designers questioned, eight made comments in support of the guidance. Of the other two designers, one could be seen as being supportive, though his comments were difficult to classify. The reservations of this designer (designer 3) centred on the use of multiple representations related to the learner's state of knowledge, saying that "the criteria necessary to make such decisions about representation may be difficult to embody within CBT materials".

The other designer whose comments were not supportive of the principle (designer 1), focussed on her own work with sound rather than on the wider issues addressed by the principle (showing the impact of individual experience).

Those designers whose comments supported the principle also raised cautionary notes. Amongst these was a feeling, expressed by 3 designers, that care had to be exercised to ensure that the representational possibilities of the medium were not over-used: in the words of designer 2, "the medium shouldn't overcome the message". This was supported by the comments of designers 3 and 8, who commented respectively that authors should "guard against over elaboration" and that "the use of technological possibilities for their own sake may result in overloading the user, thus clouding their memory".

The other wholly supporting comments still raised interesting points. These included those of designer 4, who noted that using the guidance may have "the advantage of (a) relating the user to the [learning] environment and (b) by making repeated stabs at it [a particular topic] will drive the message home". This relation to the issues of reinforcement raised in the previous section (through the *locative fit* principle) was also noted by designer 10, who commented that "using them [multiple representations] to elaborate/reinforce may also work [and that] this is related to reinforcement issues of item [principle] 3".

Discussion

The reservations of designer 3 about the difficulties in relating the representation to the learner's state of knowledge are of importance. The most common alternative however is to rely heavily on textual representations which may not be engaging for the learner. The particular modes of representation that are effective, and therefore the ways in which the *multiple representations* principle should be applied, will be dependent on individual circumstances. Particular training situations may lend themselves well to graphical representations and the use of sound, whereas others may not. This is highlighted by the comments of designer 6 who supported the principle, noting that it was "particularly useful for remedial learning". In general, the role of the principle is to make CBT designers aware of the representational possibilities of the medium so that they are able to make an informed choice when they are authoring training materials.

The same cautions – concerning the over-use of facets of the medium raised when discussing the *immersion* principle – were also noted here. The common factor in the two principles is a reference to the representational possibilities of the medium, such as sound and graphics. The cautionary comments may well arise because many CBT lessons do over-use these facets of the technology, seeking instructional effectiveness through the novelty factor of the medium rather than its considered and informed use. This should not detract from the usefulness of the *multiple representations* principle, rather it shows that designers should be encouraged to consider these issues more deeply when designing CBT lessons.

6.6.6 The 'general comments' section

A space was provided at the end of section C for designers to give their general comments on the value as a whole of the four principles to CBT design. Only three of the designers made any comments in this section. Of these designer 1 was the only one whose comments were critical, questioning the importance and centrality of interactivity, saying that "people get too hooked on 'interactivity'". This may be true in certain circumstances: some instructional materials may be poor despite being interactive, but their ineffectiveness is more likely to be linked to poor design than high interactivity. As with all of the issues raised by the principles, interactivity is not the factor that wholly determines the effectiveness of a CBT lesson. It is however an important issue which, if addressed as part of well designed CBT material, is likely to contribute to its overall effectiveness through the engagement and motivation of the learner.

Of the others, designer 4 noted that "CBT can supply in depth knowledge easily", but questioned whether it should "replace traditional methods". That CBT can supply in depth knowledge "easily" is a contentious issue, and it could be argued that the abundance of poor CBT materials suggests otherwise. On the second point, however, the question of whether or not CBT should replace traditional methods of instruction has to be framed in terms of resources: CBT may be financially beneficial and remove some of the traditional time constraints (see chapter 2). If, as a result of these considerations, CBT is to be used, the materials should at least be effective and exploit the capabilities of the medium.

However, constraints on the design of CBT materials also exist and these issues are realised by designer 8 who notes that "unfortunately, time and money are frequently quoted as the biggest constraints in designing user interfaces for CBT". Furthermore, he goes on to say that:

> although instructional guidance is welcomed, it is frequently ignored. Often this may be because the guidelines are too extensively written.

The designer does not make it clear whether this is a criticism of the guidance presented in section C of the questionnaire or not, but since the principles are short it is more likely to be a general criticism of design guidance, and provide support for the form of the guidance over more prescriptive methods.

6.7 General discussion

The structure of the questionnaire meant that the issues addressed by the four principles developed in chapter 5 could be assessed independently of the way in which they were framed. This also allows a comparison of issues and expression of issues which will be discussed in this section.

There was little overall difference in the importance placed on the issues addressed by the principles and on the principles themselves: those designers who saw the abstract issues as of little importance raised similar points when commenting on the principles themselves.

The only notable exception to this consistency across sections concerned the *multiple representations* principle. Whereas eight of the designers made comments in general support of the principle, the guidance expressed in abstract form was poorly received. As was suggested during the earlier discussions, one reason for the lack of support for the abstract guidance may be their relation to the learner's knowledge. It was noted in the discussion of the *interaction* principle that this is regarded as a complex issue. The abstract guidance suggested that the assessment of the learner's state of knowledge could be achieved through some form of testing, whereas this point was not raised in the principle itself. It could be that this is a reason for the disparity in the support for the issues covered by this principle. The designers may have felt that testing learners was too difficult an area on which to base the choice of style of representation.

The alternative is for the training materials to be non-personalisable and to rely on set styles of representation at set points – a situation which is less likely to involve and motivate the learner. However, the degree to which this is the case will depend on the particular lesson and target group. Perhaps the most important issue is that designers of CBT materials are aware of the representational possibilities of the computer, and make use of them wisely to avoid purely textual lessons which may lead to low levels of involvement on the part of the learner.

More general exceptions to the overall consistency of answers across the different sections may be at least partially explained by the reservations that often accompanied the statements of support given to the principles. This is illustrated by the responses of designer 4 who qualified his support for the *locative fit* principle by questioning whether or not CBT designers should cater for short term memory in light of what he saw as the limited attention paid to the area by traditional training methods.

General, non-prescriptive guidance such as principles stimulate comments from designers that arise through their consideration of the issues that the guidance addresses. At its most basic level, this at least means that designers are more likely to think about the important issues than when given more prescriptive guidance such as models, since principles are more naturally expressed and do not represent a direct challenge to the design practice of the CBT designers.

Whilst the form of principles makes them more easily and generally applicable than other more prescriptive forms of guidance, specific questions of applicability were still raised. The most common reservations outlined were those of ease of applicability and relevance in particular design situations. In terms of the former, the experience of designing a piece of CBT software as part of this study (see chapter 7) represents an attempt to illustrate that the principles can be applied to produce CBT materials. Problems may well arise for designers because of their lack of familiarity with particular facets of the delivery medium that are addressed by the principles, and this is perhaps related to the reservations that designers often had in the over-use of these facets. This was especially evident in the discussion of the *immersion* and *interaction* principles, where designers cautioned against the medium overcoming the message. The optimum level of use of particular aspects of the technology will obviously depend upon the particular training application. Again the point is to raise the awareness of designers on this issue; cautioning against over-use is important, but should not be a reflex response to the unique possibilities that the computer can offer.

Overcoming such a reaction may also be hindered by understandable inertial considerations that lead to a resistance to change from the way in which designers currently approach the design of CBT materials. This may account for the tendency of designers to frame problems in terms of non-linear media for which they may have been traditionally used to designing materials.[2] Even if they have always designed computer-based instruction, the capabilities that now exist are still relatively new. Therefore, CBT designers may not have made much attempt to use them

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[2] This may have been the case for designers 4 and 8 leading to their comments for the *locative fit* principle.

in an informed way, relying instead on the novelty factor and basic use of graphics to make the instruction seem more interesting.

Whilst resistance is difficult to overcome, the fact that the principles are interrelated and provide a framework for design is advantageous. An understanding of the principles and the way that they are related, through addressing common themes and related issues, can inform the design of CBT materials without providing a totally prescriptive approach to which designers would be understandably resistant. Furthermore, the agreement of the majority of the designers questioned with both the abstract issues raised by the principles and the principles themselves suggests that the principles address the correct issues, and represent a useful tool for designers of CBT materials.

One other contributory factor to the acceptance of the principles may be the designers' current design approach. The designers that specified the most formal approaches to design also provided the most consistent negative responses to the questions in section B. It could be suggested that the formality of the current design approach bears on the importance that the designer attaches to the issues addressed by the principles. This link cannot be demonstrated to any real extent, although certain comments did display an amount of resistance to the possibilities of the technology. This was evident in the discussion of the *immersion* principle, when caution was expressed over the degree of use of enriching aspects of the technology, questioning whether such features were beneficial to CBT. Whilst these are interesting points, it would be unwise to stress any link between the designers' current approaches to CBT design and their acceptance of the issues and principles too strongly since the study was only small, and did not examine this area in detail. Furthermore, designers that outlined less formal approaches also raised cautioned about various issues addressed by the principles.

6.8 Summary

The responses of the designers to the principles and the issues that they address suggest that the principles were well received by the designers. This indicates that the principles address important issues that are pertinent to the design of CBT materials. The designers' responses suggests that the guidance would be of use in the design of CBT materials.

Much of the questionnaire specifically relates to the relation of basic instructional factors to the capabilities of the computer medium. This relation between the instructional factors and the way that the medium can be used to effectively support them is central to the principles. Therefore, the designers' support of the principles and the issues that they address highlights the general importance of the paradigm of conjoining pedagogy and technology in framing guidance for CBT design.

Chapter 7

Applying the Principles

7.1 Introduction

This chapter will draw on other empirical support to assess the applicability and effectiveness of the principles. The first part of this chapter discusses the authoring of a CBT lesson developed following the principles proposed in chapter 5, the second reports the findings from subsequent user trials.

The sample CBT lesson allowed the ways in which the principles could be interpreted and applied to be explored. Different data collection methods were used: video-tapes of users, a series of simple tasks, and interviews. The data from these different methods were integrated and drawn upon to assess the overall importance of the issues addressed by the principles.

7.2 The application of the principles

The software that was developed in this study was a small introductory tutorial for part of a document production system called Nisus, which offers a high degree of functionality and combines text and graphics. The lesson was produced at the University of Hull between the months of June and September 1992. The software was authored using Apple's HyperCard (Apple Computer 1988), a programming environment which allows rapid prototyping. The lesson was implemented on Macintosh II and Macintosh LC machines.

7.2.1 Principle I: *immersion*

The central issue addressed by *Principle I* is the immersion of the learner which occurs as a result of the lesson's level of interactivity. The richness of any interaction is dependent upon the degree of direct and active involvement of learner. Such involvement is fundamental if effective, highly interactive instructional software is to be produced.

The tutorial was designed to be highly interactive in an attempt to ensure direct and active involvement on the part of the user. This was achieved through the embodiment in the tutorial of specific examples of interactivity, resting on the concepts of continuous representation, 'physical' action, and apparent 'instaneity' of response which were identified as being of importance for immersion. The most obvious method of interaction used throughout the tutorial is the use of buttons that invoke changes in the lesson: through 'physically' pressing various buttons the user of the tutorial actively, and instantly, directs their learning. Since there are many occasions when more than one option is open to the learner, her decisions over which course of action to take also personalise the instruction. One instance of this can be seen on the tutorial's opening screen (figure 11) when different choices are given to the learner corresponding to different topics in the tutorial, and the learner is left to make her own decision over which course to take. The possibilities for non-linear access, and re-access of information, that are afforded by HyperCard are exploited throughout the tutorial to allow the learner to access information in many different orders. The provision of choices to the learner can be seen to encourage exploration within the tutorial, since the general linear constraints associated with much traditional CBT software are removed.

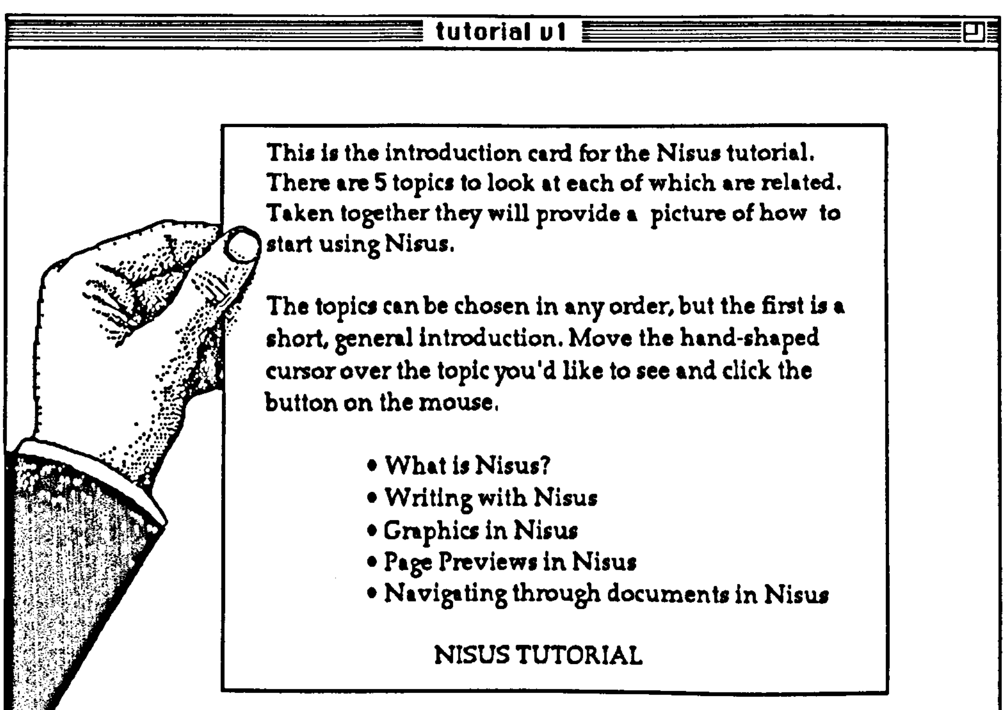


Figure 11: The opening screen of the Nisus tutorial

The *immersion* principle is also used to isolate and teach concepts associated with the icons used in the Nisus application through the use of buttons and associated graphics. This approach is used throughout the tutorial, though the specific detail that is seen depends on the learner's performance, and varies as the tutorial goes on. For example, in the introductory part of the tutorial a simulation of the Nisus screen is used, and buttons are associated with each of the icons. Pressing each icon (button) gives the learner a brief description of its function in Nisus (figure 12).

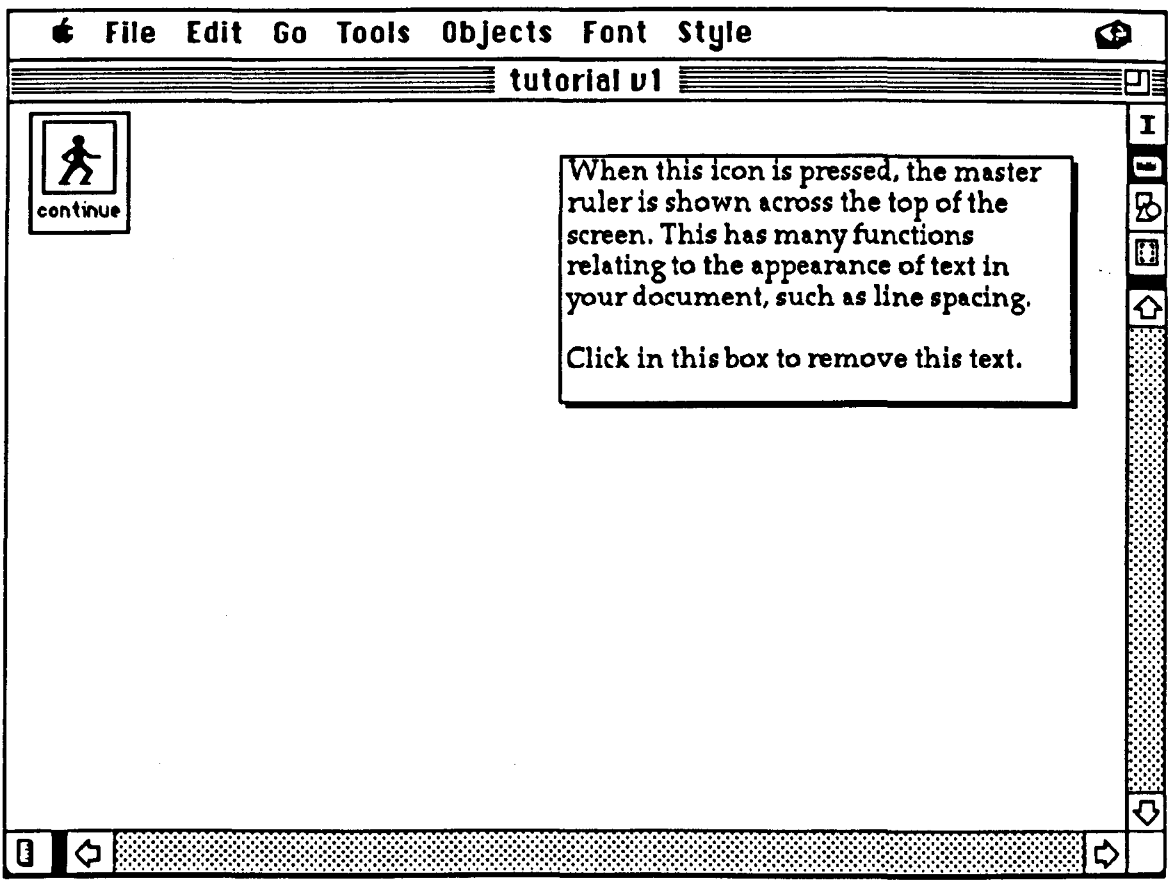


Figure 12: Introductory information about the 'Master Ruler' in Nisus. The 'Master Ruler' icon is highlighted (right hand edge of figure) and explanatory text is presented

When the learner has seen the introductory material, the simulation technique is again used, but the key buttons invoke the actions that they would within Nisus itself, accompanied by some explanatory text (figure 13). The graphical capabilities of the computer are used to give a real-time indication of the position of the cursor in the Nisus document.

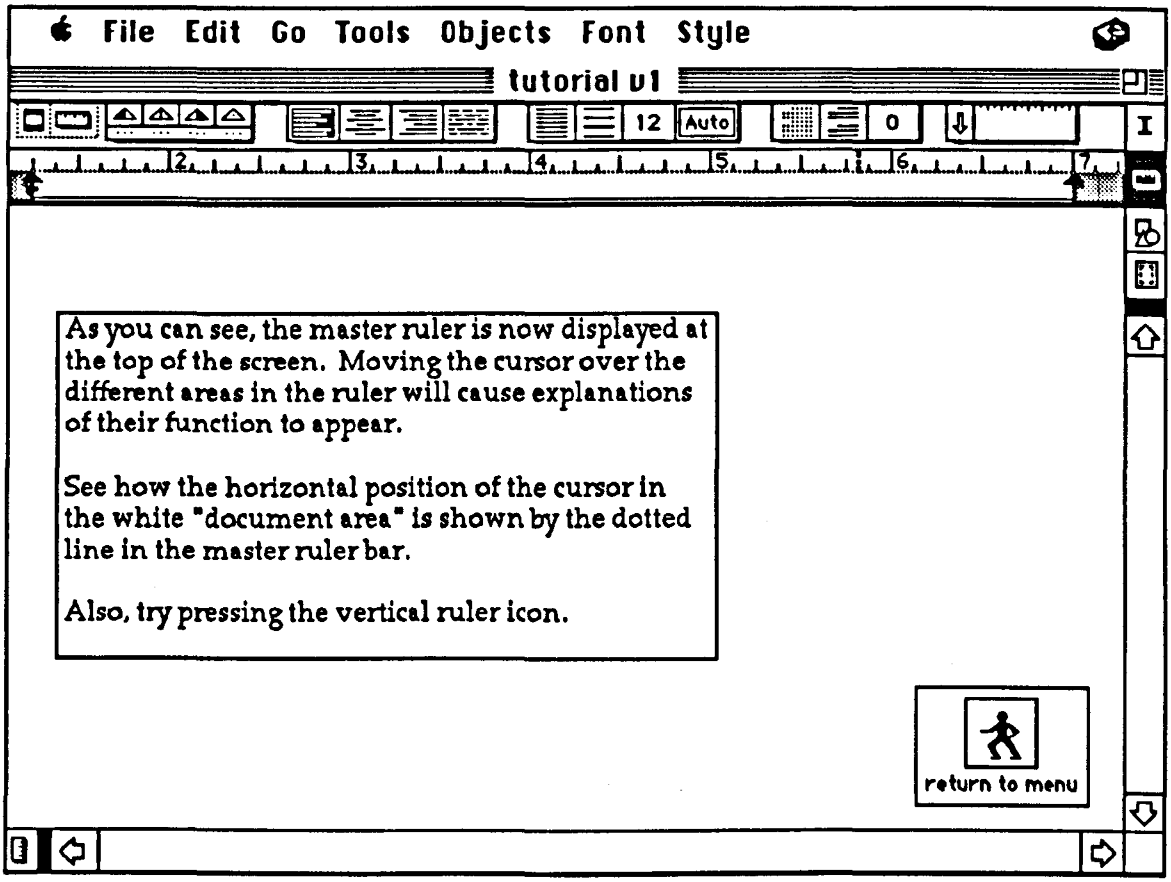


Figure 13: Detailed simulation of the 'Master Ruler' in Nisus. The 'Master Ruler' icon is highlighted (right hand edge of figure) and explanatory text is presented. The position of the cursor is indicated by the vertical dotted line in the ruler (top of the figure)

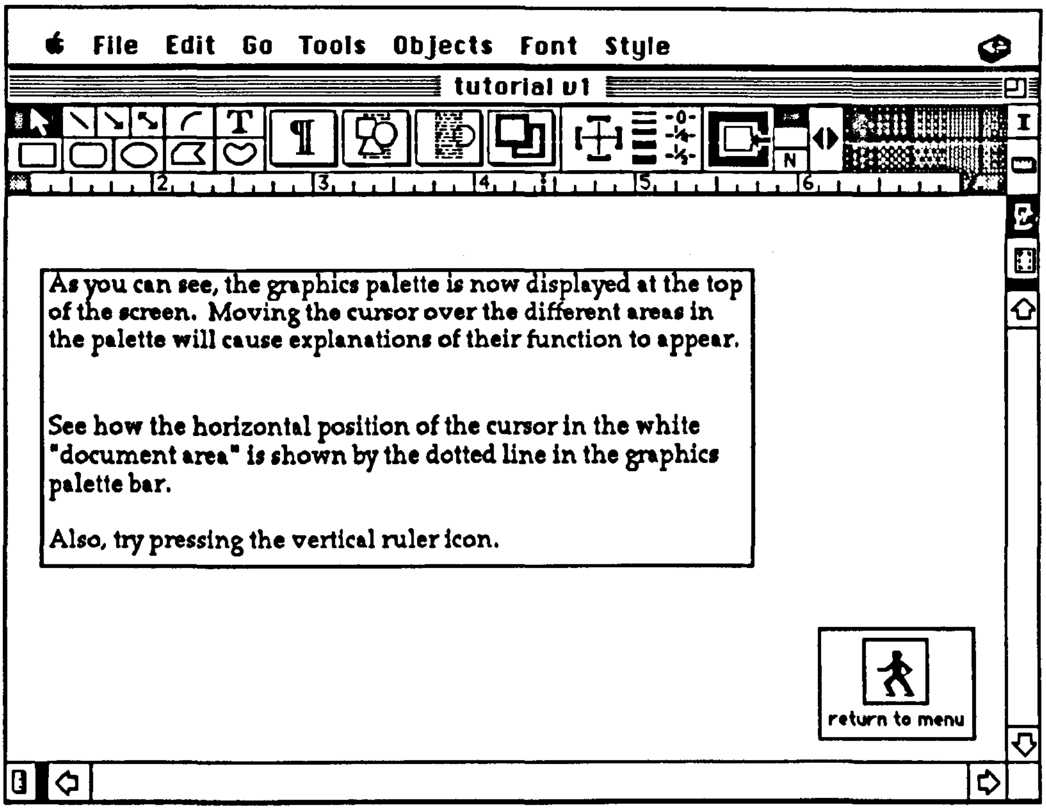
7.2.2 Principle II: *interaction*

One of the key issues addressed by *Principle II* is the way in which designers of CBT lessons can effectively limit the degree of control given to learners without it being detrimental to their motivation, or how to oversee the instructional interaction. The way in which the *interaction* principle advocates achieving this goal is through the monitoring of the information that the learner sees, and the presentation of instructional choices in the lesson based on the results of the monitoring. In this way the choices can be made to relate to the learner's current position within the lesson; choices which direct the learning through their contextuality whilst retaining a degree of learner control.

The monitoring that underpins this principle is used in different ways in the tutorial, one of which is to help determine the control of the lesson. On the opening screen (figure 11) the choices for viewing different topics about Nisus that are given to the learner appear straightforward. The first of these - "What is Nisus?" - provides a general introduction to the workings of the Nisus system. If the learner chooses this option, she will encounter general information and learn about important icons and their functions. The tutorial monitors the learner's choices and acts accordingly. If, for example, the learner does not choose the general introduction, but instead chooses one of the other topics, the tutorial will present information at a more general level than if the same choice were made after having seen the general introduction. Figure 14 shows two alternative screens containing information on the 'Graphics Palette' icon. The learner will see the bottom screen, representing more basic information, if she has not already chosen the general information topic on the opening screen. The particular information imparted to the learner can thus be seen to be dependent on their past interaction with the lesson. This represents an attempt to pitch the details of the information at the correct level whilst leaving the control of the lesson to the learner, and retaining her direct and active involvement.

The monitoring and storing of relevant information regarding the learner's action is also made use of in other areas of the tutorial. Within the general introduction, the learner is encouraged to explore. After having seen all of the icons and information relating to their function, the learner is tested on the information she has just encountered. The performance of the learner in the test is recorded and further information at a more detailed level is provided on areas in which the learner gave incorrect answers. Whilst it is impossible to know whether the learner's answers accurately reflect her knowledge and understanding of the information, the testing and monitoring is used as the basis on which to build an attempt to tailor the instruction to the individual learner. Here, the responses of the learner represent the only source of information on which to base any attempt to contextualise the structure and sequence of the lesson.

The information that is collected during the use of the tutorial by an individual learner can be seen to correspond to the 'user profile' introduced in the discussion of this principle in chapter 5. The profile's importance is in its role in providing meaningful and contextually sensitive choices to individual learners. The control governing this had to be built into the tutorial at a lower level, so that 'decisions' could be made, contingent upon particular areas of the profile.



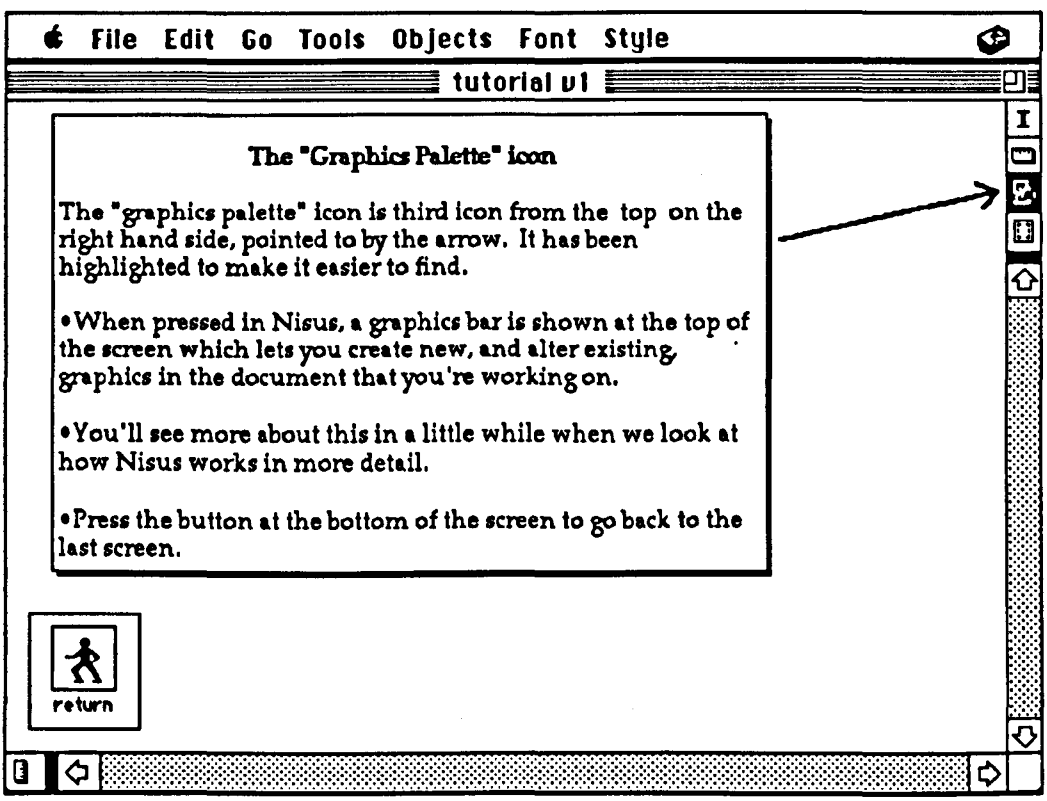


Figure 14: Two different levels of information on the 'Graphics Palette' icon (highlighted on right hand side of the figure)

7.2.3 Principle III: *locative fit*

The key issue addressed by *Principle III* is that of information access: how different parts of the CBT lesson can be visited by the learner. The technological attribute that sets the computer apart from other technologies is its ability to re-access information and remove the linearity associated with other less interactive media.

This type of access to information provides the basic mechanism for any degree of control to be given to the learner. In the Nisus tutorial there is an abundance of cases where the access to information, or parts of the lesson, are non-linear. The opening screen (figure 11) gives the learner options as to which topic she wishes to learn about, with the choice of the learner directing the tutorial. This demonstrates the non-linear structure of the tutorial and allows the instruction to be personalised by the learner's choice of path through the CBT material.

Non-linear access also allows a mechanism for re-access of information to be easily built into CBT lessons. This can be used to overcome the limitations of the learner's short term memory by providing options for the learner to see information on the same topic from different points in the lesson. The usefulness of such multiple access points is likely to depend on the complexity of the CBT material, since the limitations of short term memory become more acute as the complexity and time of the lesson increase. Since the Nisus tutorial is only a short introductory lesson there is little need for extensive recap of topics and the revisiting of information is limited. However, learners who perform poorly in the tests may see information on the same topic (although not necessarily in the same form) on up to four occasions. Providing this mechanism to access information on the same topic from different points within the tutorial – in different contexts and at different times – offers the learner the alternative perspectives within the tutorial that were suggested as being of importance within the discussion of this principle in chapter 5.

The multiple access points in the Nisus tutorial also support the personalisation of the lesson: the learner may take different paths through the tutorial, defined by their actions. Within the tutorial the learner can see information on the function of the different icons from more than one access point within the lesson, though the number of access points depends upon their particular interaction with the material.

7.2.4 Principle IV: *multiple representations*

The key issue addressed in *Principle IV* is that of the representation and display of information. Within the tutorial, this principle is employed through the representation of information to learners in different forms depending upon the learner's position in the tutorial. The nature of this tutorial – providing an introduction to a document preparation system – is such that the use of non-textual representations centres on the representations used within the Nisus application itself. This can be thought of at two levels: the general level of simulating the Nisus environment, and the specific level of making use of the icons used in Nisus to perform actions.

These levels are interrelated since the icons form an integral part of the simulations. The simulations are made use of in the same way as was advocated in the discussion of this principle in chapter 5 (figure 14). The fidelity of the simulations in the tutorial varies dependent upon the learner's position in the tutorial and their past experience. The first simulation that the learner is likely to encounter is low in fidelity, offering a representation of the Nisus environment and textual descriptions of the relevant icons. As the learner continues through the lesson the fidelity of the simulations increases, and the textual support becomes more focussed and attached to particular actions. These simulations also mimic the functions of Nisus, providing relevant screen changes when icons are 'pressed', and make use of the graphical capabilities of the medium to provide these high-fidelity simulations.

The tutorial also makes use of the representational possibilities of the computer in other instances. Relevant icons are highlighted and flash on and off for a short time in an attempt to gain the learner's attention. This can also help in the formation of associations between the icon, its function, and its screen position in Nisus since this information is given within the context of a simulation of the main Nisus screen. The grouping of the information within the tutorial is also of importance. Instead of large blocks of text, there is a general attempt to ensure that only small amounts are on the screen at any one time. This is especially true when specific points are being made – such as the description of the function of a particular icon. Although at certain points, general descriptions of the functions of all of the icons on the main Nisus screen are accessible to the learner, there are limits that prevent the learner from being overloaded.

In order to avoid missed or incorrect associations, textual descriptions in the tutorial are often associated with actions such as moving the cursor over a particular screen position, and are only shown when the cursor is over (or within) a particular area. When the cursor is moved outside this area, the information is hidden. This effectively limits the amount of information that can be seen by the learner at any instant, and should help eliminate the difficulties if each description is relatively short (i.e. does not take up the whole screen). Even if the descriptions are long, there is less chance of incorrect associations being made by the learner since the cursor position - over a particular icon - is related to the specific information being seen.

Other display techniques are also used in the tutorial, including the placement of important information at the optical centre of the screen. This is of less importance when the learner's actions cause information to be presented (as in the case of the information being linked to the cursor being placed within a set area on the screen) and is therefore used when the information is more general. One example of this is when the learner has chosen to move to a particular topic, and general information is presented for the learner to absorb before proceeding. In cases like this, the information is presented at the centre of the screen to attract the learner's attention immediately.

Other forms of information representation are also used in limited amounts within the tutorial. Sound, for example, is used mainly as a reinforcer, to ensure the learner that an action has been taken; and as a intrinsic motivator, to provide feedback on the learner's performance (such as playing applause when answers in tests are correct).

7.2.5 Summary

Demonstrating that the principles can be applied is not sufficient: the effectiveness of software designed in this way should also be explored to provide a guide to their value. Accordingly, the following section presents findings from a set of user trials.

7.3 The user trials: assessment of the tutorial software

7.3.1 Methodology

Various methods of data collection were used within the user trials. These included the video-taping of a small sample of learners using the Nisus software and performing a limited set of tasks in the Nisus application itself. This was followed by video-taped interviews. Qualitative data from these methods gives an additional perspective that broadens the evidence on which to draw in assessing the value of the principles, and is an attempt to gain a deeper understanding of the issues involved.[1]

The user trials, held in November 1992, involved four participants (brief profiles of the subjects are presented in appendix C). Two of the subjects had no previous experience of computer use, and two had basic competence. The user trials consisted of three parts: the use of the Nisus tutorial software, simple tasks in the Nisus application, and debriefing. All of these parts were video-taped, and the interviewer was present throughout and could discuss with the subject.

The participants were encouraged to "think aloud" (Ericsson and Simon 1980) during their use of the tutorial to provide an indication of what they were thinking at any given time and the interviewer prompted when necessary. The interviewer also responded to questions from the participants, although these responses were generally in a form that encouraged the participants to explore the problem.

The results that the learner trials provide are intended to raise issues of importance to the design of CBT materials. With respect to this study, the issues that are of most importance are those raised by the principles that were applied in the design of the tutorial software.

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[1]The adherence to rigid experimental frameworks, reliance on statistical evidence, and the detachment of the researcher, are increasingly seen as problematic in some quarters (see, *inter alios* Chalmers 1982, Woolgar 1988, Casti, 1991, Appleyard 1992). Within education generally, and to a lesser extent in the evaluation of computer-based lessons, the kind of qualitative approach that is used in this study is gaining popularity (Fetterman 1984, Burgess 1985, Hammersley 1992).

7.3.2 Introduction to the results

Past experience in the use of the computer was expected to play a part in the results from the user trials. At the most general level, it was thought that those with previous experience would be more confident and less nervous than the others. Furthermore, this difference in experience was also expected to have some bearing on the appraisal of the Nisus tutorial. It was thought, for example, that different parts of the tutorial would appeal to the different groups, with the more experienced users spending less time on the basic parts of the tutorial and proceeding more quickly. Although the performance of the two groups was expected to differ, they were still expected to support the issues addressed by the principles through their comments in the interviews. It was also expected that the interactive nature of the tutorial would draw supportive comments from the users, along with reference to the control given to them, and the graphical and auditory representations used.

The findings from the user trials are presented in three sections. The first covers the tasks undertaken in the Nisus application after using the tutorial, and acts as an indicator to what the subjects had learned. This can be related to the way in which items were presented in the tutorial to show the importance of the issues involved and the ways that they were employed in the design of the tutorial. This is followed by the general comments of the users given in the interviews. A more detailed discussion framed in terms of the individual principles and the specific issues that they raise then follows.

7.4 Tasks undertaken in the Nisus application

This section of the user trials involved the users attempting ten tasks in the Nisus application itself. Of the ten tasks set, the tutorial had only covered subjects relating to some of them and the subjects should, therefore, have only been able to complete seven of the tasks. This was done to illustrate the degree to which past computer experience played a part. The performance of the subjects in each of the tasks, along with brief accompanying notes, are presented in table 7. This shows that of the seven tasks that had been introduced in the tutorial, all four subjects completed the tasks successfully – although with varying ease and speed.

The use of meaningful icons within Nisus may well have helped the subjects to perform the tasks, as well as any recollection of information from the tutorial. As expected, both of the subjects who had no previous experience (subjects C and D) took more time to complete the tasks and seemed less sure of their actions than subjects A and B. This was demonstrated through their continual use of questions to the interviewer, and can be seen through the notes on their completion of some of the tasks, shown in table 7. Some of the hesitation by subjects C and D – such as when drawing (task 7) and filling (task 8) the rectangle – arose because of the content of the tutorial. Although the subjects were told of the function of the icons when using the tutorial, they were not specifically told how to use them. This may account for the experimentation of subject C, for example, who found the drawing tool immediately but had to find out how to make use of it.

	Subject A	Subject B	Subject C	Subject D
Task 1	Performed task easily.	Performed task easily.	Bit of difficulty grasping what to do. When explained, subject did it quickly.	Performed task easily.
Task 2	Not covered in the tutorial, but used objects in Nisus menubar to perform task.	Realised tutorial did not cover this topic, but could have done task from experience	Realised she could not perform this task	Realised she could not perform this task
Task 3	Not covered in the tutorial, but used objects in Nisus menubar to perform task	Realised tutorial did not cover this topic, but could have done task from experience	Realised she could not perform this task	Realised she could not perform this task
Task 4	Not covered in the tutorial, but used objects in Nisus menubar to perform task	Realised tutorial did not cover this topic, but could have done task from experience	Realised she could not perform this task	Realised she could not perform this task
Task 5	Performed task easily	Performed task easily	Some hesitation, but completed task	Performed task easily
Task 6	Peformed task after a mix-up between 'master-ruler' and 'graphics ruler'	Performed task easily	Some hesitation, but completed task	Performed task easily
Task 7	Performed task easily, probably because of past experience	Performed task easily	Moved to drawing rectangle function straight away. Completed task after some thought	Moved to drawing rectangle function straight away. Completed task after some thought
Task 8	Performed task easily, probably because of past experience	Performed task easily	Performed task after some experimentation	Performed task easily
Task 9	Performed task easily. Commented on this function throughout use of the tutorial	Performed task easily	Some hesitation. Thought for a few seconds then chose correct icon	Performed task easily
Task 10	Performed task easily	Performed task easily	Performed task after some experimentation	Performed task easily

Table 7: Notes on the performance of tasks in the Nisus application by the 4 particpants in the user trials

Overall, and as expected, the subjects with past experience (subjects A and B) performed better. Subject A attempted, and completed, all ten of the tasks, commenting that his previous experience using the Macintosh computer had helped him. Subject B realised that three of the tasks related to topics not covered in the tutorial, but pointed out that he could probably complete them because of his previous use of the Macintosh computer.

7.5 The interviews

7.5.1 General discussion

As expected, there was an obvious difference between the general approach to the use of the tutorial software of those users who had some previous experience of computer use, and those who did not. The latter group were notably less confident and made more use of the interviewer throughout their interaction with the tutorial in an attempt to provide support for their actions. This tentativeness was noticeable throughout their use of the tutorial and, as detailed in the previous section, when performing the ten tasks in the Nisus application itself.

All four of the participants provided at least some general comments on the Nisus tutorial software. Subject A displayed a tendency to refer to the Nisus application rather than the tutorial software even though the interviewer continually stressed that the discussion was to focus on the instructional material rather than on the application itself.[2] This tendency may have arisen because the subject found it difficult to make a separation between the tutorial and the application, although every opportunity was taken by the interviewer to stress the difference and to remind him that the tutorial software was the focus of the study and, therefore, of the questions in the interview. He provided no comments when asked what he thought were the worst features of the tutorial, and noted only "familiarity through use" when discussing its best features. Again, only one issue was raised by the subject when asked which parts of the tutorial he particularly recalled, that of the use of icons.

Subject B provided the most feedback within the general part of the interview. Within the discussion of what he felt were the best parts of the tutorial software, he made two comments, noting that it was beneficial both that "every individual thing [icon, function, etc.] had a description with it" and that the user of the tutorial "could always go back and review anything at any stage". His comments with regard to the worst features of the tutorial were much more specific, and referred to the particular language used in the descriptions of the functions of the icons controlling navigation through a document in Nisus. He complained that the different levels of description for the same icons "virtually repeated itself, just in a bit more flowery language". Whilst this may be a valid comment, none of the other participants in the user trials pointed to these similarities. When asked about the effectiveness of the tutorial, subject B stated that he "got into the hang straight away of

[2]This tendency is of less consequence within the more specific part of the interview (documented in the following sections) because the questions referred specifically to interactions that took place with the tutorial software. As such the scope for misinterpretation, and erroneous reference to the Nisus application itself, was greatly reduced.

how the tutorial worked". When asked by the interviewer why he thought that this was the case, subject B replied that the tutorial's structure was an important factor, noting that "it was all set out in the same pattern; each topic was taught in the same manner". Furthermore, he listed a series of features within Nisus that he felt that he had learned about through using the tutorial software.

Subject C could not isolate any features that she considered to be the best in the tutorial software, although she did highlight a "worst" feature. This was very specific and referred to the amount of time allocated to the user for each answer within the icon recognition test. She commented that she "didn't have enough time to read the first couple [of descriptions of icons on the test]". Again, this is a valid criticism, although its real value lies in highlighting the difficulties that face designers of CBT materials that are to be used by groups of differing expertise and experience. Subject C's comments may partially be explained by her lack of experience and her feelings of trepidation and nervousness in using the tutorial. Indeed, after the first few icons, she performed well in the test.

A compromise solution may be to increase the allowed response time for the first two or three items in the test, until the user becomes accustomed to the format. A more general criticism again shows the difficulty in designing instructional software for use by a range of people. She suggested that the tutorial was not basic enough for her, adding that if she had been more experienced in computer use the tutorial would "probably have made more sense". This difficulty in designing materials for use by people of varying abilities and experience is a central problem in the design of CBT, and highlights the importance of ensuring that as much is known about the target user group as possible. Despite the difficulties that subject C felt that she had encountered, she was still able to list several ideas that were covered by the tutorial and that she felt that she had learned about through the tutorial's use.

The final participant (subject D) provided few general comments about the tutorial. Again, this may be because of her lack of experience in the use of computers and her resulting nervousness, since she was able to provide answers when asked more specific questions in the later parts of the interview. However, she did note that she felt that the best feature in the tutorial was its interactive nature, centring on "the fact that you [the user] have to do things [...] it makes you remember [...] rather than just reading".

These general comments highlight positive points about the tutorial's design. Some of these are issues that arise directly from the principles such as the provision for non-linear access, the importance of structure in the design of instructional materials (both noted by subject B), and the importance of the involvement of the user in the tutorial (noted by subject D). This suggests the importance to CBT design of some of the issues raised by the principles. Whilst noteworthy, the criticisms tend to be more specific and context sensitive (such as the lack of detail in certain descriptions of icons and concern over the amount of time allowed for responses in the test) and do not arise because of inadequacies in the principles. The following sections will discuss the perceived importance of the issues underpinning each of the principles in more detail through the presentation of specific comments from the interviews.

7.5.2 Principle I: *immersion*

Effective design based on the *immersion* principle depends critically upon the richness of the interaction between the learner and the instructional software. Within the tutorial this richness relies upon the use of buttons providing 'instaneity' of response and allowing the learner to make choices to direct and personalise their learning, and through the use of graphics and simulations to isolate concepts. The responses to the questions that are related to these issues are presented in this section (also see appendix D).

All four of the participants in the user trials noted their involvement in the tutorial. There were several comments indicating the centrality of the user in the use of the tutorial, including subject A who stated that "the tutorial was based around you and what you did," and that the user of the tutorial was "bound to be involved". Subject B also supported this view through his responses, noting that he was "totally in control of what was going on". The importance of this active involvement of the user was demonstrated succinctly by subject D who commented that she thought it "better that the user doesn't switch off, rather than if there's just a lot of reading".

Eliciting what the subjects regarded as the important factors for the direct and active involvement of the user proved difficult. When questioned on their views about the richness of the interaction between themselves and the tutorial, only one of the participants (subject C) offered any real comments. She defined the interaction as being "quite rich, because I had control over what I was doing and, basically, it [the tutorial] wasn't going to do anything that I didn't tell it to do". The comments from the other subjects were less detailed, probably arising from the difficulty in separating features which affected the richness of the interaction.

These comments took the form of suggestions for improvement (in the case of subject D who said that the tutorial would have been better had it been in colour), or the isolation of features in the tutorial which appealed to particular participants (such as the use of visual effects between separate screens, noted by subject B). The difficulties encountered in obtaining responses from the subjects led to questions being asked about individual features in the tutorial that support the direct and active involvement of the user - such as the use of buttons to provide choices to the user, the resulting scope for the personalisation of the instruction, and the use of graphics and simulations within the tutorial.

Whilst the individual subjects provided different thoughts on the specific value of buttons within the tutorial, there was a general agreement that they were useful and contributed to the involvement of the user. The more specific comments ranged from those concerning the perceived role of buttons - subject D noted that buttons were there to "guide you" and to stop the user feeling that she was lost; and she also noted that their association with an action "makes you feel as though you're not alone" - to very particular observations - subject B commenting on the visual appearance of particular buttons stated that the "very fact that they symbolised what they were going to do got [him] involved". Since one of the main uses of buttons within the tutorial was to allow the learner to determine their own path through the tutorial, the issue of personalisation of instruction was also raised at this point in the interviews.[3]

When using the tutorial software, the participants in the trials generally followed the options presented in a linear order. Indeed the only exception to this was subject D, who missed out one of the topics by accident and returned to it when she realised that she had not seen the information. Of the four subjects, three (subjects A, B, and D) stated that they had chosen the options sequentially because of a lack of confidence, or because they assumed some advantage in visiting the topics in the order that they occurred on the menu. Subject D indicated her lack of confidence in the use of computers by saying that she thought that choosing a different path would be beneficial for more experienced users. Subject A also advocated a linear approach to seeing the general topics:

> Subject A: Anybody who [was] a little bit frightened would have to do the same [...] or I think they'd be silly not to.

Both subjects A and B, who had some previous computer experience, assumed some advantage in going through the topics in order, as can be seen from their comments:

> Subject A: There's obviously a list and it seems sensible to follow it through.

[3]The subject of control of the instruction is also covered in the following section, when discussing the issues related to *Principle II*.

Subject B: I did it in order because although it said that there was no preference for which order you did it in, I assume that the people programming the package would have found it maybe beneficial – just somehow the way you learn, or whatever – to go through it in that kind of manner.

However, these comments refer only to the approach to visiting the general topics presented on the main menu in the tutorial. Within each of these topics the subjects had great scope to see information and perform actions in different orders. Whereas the subjects generally approached the visiting of the main topics in the order in which they appeared on the opening menu, they saw a benefit in being able to approach the information covered within these main topics in a more exploratory way, and demonstrated this through the different ways in which they visited material within these main topics. Subject A, for example, saw the ability of the learner to control the direction of their learning in this way as a positive feature:

Subject A: You can suit it to yourself. It depends on how confident you are, whether it's with learning or with your confidence in your ability to use the system. It's good that it's up to you.

This was also echoed by subject C, who commented that this kind of personalisation of instruction was important since it allowed different learners to approach topics in different ways, focussing for example on topics of most interest to them. Furthermore, subject C saw personalisation of the instruction through control being given to the learner as a potentially motivating factor, and stated that it "makes [the learner] feel more confident". Subject B, whilst generally supporting the provision of learner control in this way, also sounded a cautionary note:

> Subject B: [Allowing the learner to control the instruction is] good in the sense that people learn in different ways; comprehend things in different ways. It's quite acceptable that people do it [the tutorial] in a different order, but it's got to be set out so that people don't get lost in it [...] There's got to be some basic structure, or framework, behind it that you can refer to.

In this tutorial, the basic structure (or framework) to which subject B refers could be seen to be the list of general topics covered by the tutorial. This is important in interactive instructional environments since without it learners may easily become disoriented, which in turn will be detrimental to learning. The provision of a basic framework, such as ensuring that the learner has to work through a list of basic topics within which they can explore information concerning that topic, is an important starting point, although the issue of providing the learner with contextually sensitive choices – raised by the *interaction* principle and covered in the following section – may also be relevant.

The final issue covered by the *immersion* principle concerned the use of the graphical capabilities of the computer. Within the tutorial simulations of the Nisus screens (making use of these capabilities) were widely used. The four participants agreed that these simulations were useful in, for example, isolating concepts: Subject D said that the usefulness was in their ability to provide the learner with "a feel of what was to come" in Nisus itself. The visual effects that were used within the tutorial were also commented upon. These effects, used during transitions between different screens were seen by subject B as motivational and were also useful because they "made a clear cut difference between all the different screens that appeared" during the tutorial.

7.5.3 Principle II: *interaction*

The issues that are addressed by the *interaction* principle link in with those raised by the *immersion* principle, notably through the provision of control to the learner. This principle is concerned with the restriction of this control to avoid the problems of disorientation, for example, that are commonly associated with allowing unlimited exploration to learners. The principle suggests that it may be possible to achieve this through the monitoring of the responses of the learner, and the provision of choices based on these responses. In this way the choices may be made to relate to the learner's needs, so making it less likely that the learner will become confused and disoriented by visiting information that has no bearing on the topics about which they are currently learning. The responses to the questions that are related to these issues are presented in this section.

Many of the responses regarding the provision of learner control were given in the preceding section. Within this part of the interview, subject B again reiterated the need for some form of limitation of the control given to learners; he agreed that there was value in allowing the learner to explore within the tutorial but added caution:

> Subject B: [the learner should not be allowed to] lose sight of the framework or guidance or whatever. You shouldn't be allowed to learn without being given guidelines.

This suggests that some form of structure should be imposed on the learner in an attempt to restrict, for example, the formation of incorrect associations by the learners. Other participants in the user trials did not mention the potential problems with providing the learner with unlimited control. Instead they reiterated the advantages of being allowed to direct their learning. Subject C stated that a positive feature of the tutorial was that the learner could "do as much as [they] want to do at [their] own speed instead of being rushed by it [the tutorial]". Perhaps little mention was made of the difficulties that can arise through the provision of learner control for the very reason that the tutorial restricted the degree of control.

This suggestion is to some extent borne out by the comments of the subjects when asked whether or not they thought that the tutorial monitored their actions and responses in any way, and tailored the instruction accordingly. None of the four subjects thought that they were monitored and the instruction tailored to suit them. When questioned more deeply, two of the subjects realised that parts of the tutorial provided them with choices based on their responses. The most obvious area was after the testing where the subjects were provided with options based on their performance:

Subject B: It monitored me there [in the test]. It showed me which ones I got wrong [...] and it realised I probably needed a refresher.

Subject C: [The tutorial] realised things you [the learner] need more help on and more explanation.

The four subjects were generally in favour of testing and thought that it was useful. Subject A did, however, feel that the degree of usefulness might depend on the learner's experience saying that while testing is "something that's going to help" the learner it would probably be more helpful for learners that are "not happy about using computers". Subject D was less discriminating, saying that testing was both "good in general" and within the context of the tutorial because it provided "a kind of doubling up of what you'd [the learner] learned".

The only comment that was less supportive of the idea of testing came from subject C, who felt that the testing in the tutorial was "thrown at" the learner. She did, however, feel that it was "not too bad" because the learner could "see how much [they had] taken in and the things [the learner] gets wrong [and one could] obviously go back and find out", and added that the tutorial did explain the testing. The reservations expressed by subject C may well be because of her lack of computer experience and the fact that the test was encountered fairly early on in the tutorial. As the tutorial progressed, subject C became visibly more comfortable using the tutorial and encountered fewer difficulties.

7.5.4 Principle III: *locative fit*

The *locative fit* principle is concerned with structuring the instruction in the CBT lesson so as to counter the limitations of the learner's short term memory. Within the tutorial this is achieved by allowing the learner to access, or re-access, information through the provision of mechanisms for non-linear access so that the learner can visit, or re-visit, relevant topics as they wish. The ability to access topics, and information within the topics, in a non-linear order was well received by the participants in the user trials. This was not surprising given the enthusiasm displayed for the provision of learner control within the tutorial that was reported in the previous sections. The subjects were asked how they thought the instruction given by the tutorial compared to a more linear medium, such as a book, in which re-access of information was more difficult.

Subject A thought that the tutorial was "better in a practical sense". When asked to explain this he said that the tutorial was "a more flexible idea" than a book, and that learners "don't always need [the] structure" that is associated with books. Subject B agreed that the tutorial's advantage lay in the ease with which it could support non-linear access to information. Subjects C and D focussed on the increased motivation when using the tutorial as opposed to a book:

> Subject C: In a book you can just switch off can't you? [The tutorial] does get you [the learner] more actively involved in it [and, as a result] you obviously take a lot more in than with a book which is just there.

> Subject D: [The tutorial is better than learning from a book] because you get more involved; it's not as boring.

Furthermore, all four of the subjects agreed that allowing learners to re-access information was important. When using the tutorial all of the subjects re-visited information within topics to remind themselves of it, and one of the subjects (subject B) re-visited a whole topic as he felt that he may have not learned about some parts of it. There were also many comments from the interviews that demonstrated the subjects' support of the re-access of information. Subject C, for example, stated that re-accessing information was "obviously [...] a good idea if you [the learner] haven't understood something", but raised an important point, saying that "it's better to give [the learner] the choice to see it [information] than it being forced [upon them]". The success of this approach, however, depends upon being able to motivate the learner to want to see the information.

7.5.5 Principle IV: *multiple representations*

The issues raised by the *multiple representations* principle relate to the effective use of the different forms of representation supported by interactive computers. The four subjects agreed that different forms of representation should be used, with the form depending on the position of the learner within the tutorial. Subject D, for example noted that this was a good idea when instructing the learner on the function of the icons in Nisus:

> Subject D: I think it's a good idea to start off with just saying what will happen, and then moving on to what actually does happen.

This reference to the level of detail and the use of simulations with increasing fidelity as the learner proceeds through the tutorial was also seen as beneficial by subject A, who thought that it was the kind of structure that learners would need "especially when you think that if you [the learner] weren't happy that you knew you could always go back and do it [see simpler representations] again [...] It's, again, letting things go as they suit you".

More generally, the use of graphics was also raised in this part of the interview by subject C who, commenting on the use of graphics in the simulations, said that it was "definitely a good idea. It just makes it look a bit different: more attractive, not as intense [as purely text-based instruction]".

The importance of the layout of information within the tutorial also formed part of this section of the interviews. The association between the way that information was presented to the learner – for example, its position on the screen and the way that information was grouped – drew comments from the participants. Subject B stated that, when displayed, general information was "nice and central" and subject C noted that general information was always presented "in a box". Subject B also commented on the grouping of information near to its associated icon:

> Subject B: Information appeared close to the [related] icon which was a good point. Boxes never overlapped. There was only ever one box on the screen at a certain time [...] but I could very easily go back and look at another one.

This grouping was used when linking the display of information to the position of the cursor, so that information appeared dependant on where the learner moved the cursor. This was seen as important by the four subjects, and was summed up by subject B who said that it was a:

> Subject B: good idea [to link the display of information to the position of the cursor] because if things just appear centrally on the screen you think they're just general points - not that I remembered the information by where it appeared on the screen, but by the very fact that it appeared near the icon.

In addition to the techniques for displaying information, this part of the interviews also covered the participants' reaction to other graphical techniques used within the tutorial. This included, most notably, the use of flashing icons to draw the learner's attention to icons about which they were learning at particular times. This was thought, according to subject C, to be a "very good idea" although she questioned the duration of the flashing, commenting that it should perhaps have gone on for longer.

Whilst only limited use was made of sound in the tutorial, all four of the subjects thought it important. Subject A, for example, thought it a "good idea because [...] it's a different medium through which to get a point across"; subject D agreed saying that sound was "something else to grab your notice rather than getting bored or whatever. It stimulated you [the learner]". Subject C also found the use of sound in the context of the tutorial reassuring:

> Subject C: I liked it [...] you felt like it [the tutorial] was sort of responding to you, and that you were more like working together. Also, it just made it not seem as severe: more light-hearted, more enjoyable.

The final question in the interview asked the participants if they felt that they had been inundated with information at any one time during their use of the tutorial. Of the participants, two stated that they felt most inundated with information at the beginning of the tutorial:

> Subject A: I felt it more when I started the tutorial.

> Subject D: Perhaps a little bit [inundated] at the beginning.

This may well be because of their apprehension at using the tutorial, especially since the greater volume of information was given to the learner later on in the tutorial and yet no reference to inundation of the learner with information was made then.

7.6 Conclusions

As expected, past experience in the use of computers and applications software played a part in the performance of the subjects in the trials. Subjects A and B were visibly more confident and sure of their actions, both in using the tutorial and in performing the tasks, than the inexperienced subjects C and D. This also seemed to have a bearing on their appraisal of the tutorial. Subjects C and D supported the use of sound more vigorously, and subjects A and B made reference to other software they had used.

Despite the specific differences, all four of the participants supported the issues raised by the principles through their comments on the facets of the tutorial through which they were implemented. Perhaps the most important of these issues were the involvement of the learners and the control that they were given over their learning. All of the subjects commented on their engagement in the tutorial, and said that it made the CBT lesson better than other more passive forms of instruction, such as books. Furthermore, their engagement was increased by the provision of control to them through the exploitation of the information accessing capabilities of the medium. From their use of the tutorial, it seems that the use of non-linear access to support exploration is most useful with a generally imposed framework. In the tutorial software, for example, all of the subjects explored within the topics and encountered information in different orders, yet followed the general topics sequentially. Perhaps the subjects, especially when inexperienced, attach some form of security to approaching the lesson in this way. This suggests that an effective way of overcoming the difficulties of the learner control problem may be to allow exploration through control within a general framework imposed by the designer, representing the overall structure of the lesson. The level at which this structure is imposed will depend on the scope of the lesson and the particular target group, but may well be an effective general strategy.

7.7 Comparing the findings of the user trials and the design survey

The findings from both studies suggest the general importance of the issues that the principles address. This was shown through the direct responses of the CBT designers questioned in the design survey, and through the positive comments of the subjects in the user trials about parts of the tutorial that embodied these issues.

The two groups that took part in these studies (designers and users) obviously have different perspectives on CBT. The designers raised many cautionary points, whilst accepting the general importance of the issues addressed by the principles. The users tended to focus on very specific criticisms of the tutorial software, that was mostly unrelated to the principles themselves (such as poor wording). These contrasting orientations are to be expected, but still raise important points.

The development of the tutorial software, along with the supporting comments from the user trials, address some of the reservations of the designers. One example of this is the mechanism for personalising the instruction through the building up of user profiles by monitoring and testing. Several designers agreed that personalisable materials would be useful, but questioned the ease with which they could be produced. The approach used in the tutorial was very simple, but the users still commented on the resulting control that was given to them, and the way in which they were allowed to personalise their instruction. All of the subjects in the user trials saw this as a positive point.

Another reservation aired by the designers was the mechanism for restricting control. Although the user trials were only small scale, they did suggest that the provision of an overall structural framework inside which learners could be provided with control represents a compromise on the issue. The motivational aspect can be retained, whilst avoiding the major problems of disorientation and the formation of incorrect associations that are related to unlimited learner control. However, it should be noted that the degree to which this type of approach is effective will always depend upon the way in which individual CBT lessons are designed.

This is a general issue that applies to all of the principles. Individually, their application to CBT design will not lead to effective materials. When viewed together designers will gain a more complete view of the ways in which the important issues are related, but this will still not guarantee the effectiveness of their lessons. The ultimate responsibility lies with individual CBT designers, who must assess the importance of the issues to their particular design circumstances and form strategies for their application as they see fit. In certain cases designers may wish to provide more, or less, control to the learner. The important issue is that their decision is informed: it is informed design practice that will ultimately lead to more effective CBT materials.

The studies that have been presented in this and the previous chapter suggest that the principles that were developed address issues that must be considered by CBT designers, and that can help inform design practice.

Chapter 8

Conclusions

8.1 Introduction

This thesis has been concerned with the provision of guidance for CBT designers based on a conjoining of pedagogy and technology to re-frame fundamental instructional issues in terms of the scope of the computer medium.

A number of factors contribute to the increasing importance of CBT: the complexity of widely used interactive-technology based artefacts is likely to lead to a large market for training materials; the fall in cost and rise in performance that has underpinned the rising use of technology in the workplace also provides justifications for using computers as the training medium; using computers as the training medium should ease knowledge and skills transfer to the working environment through the familiarity gained by the user. CBT also offers financial benefits over other training media, through the potential for re-use of the training software and the removal of temporal constraints associated, for example, with human instruction.

A key issue is the instructional potential of the computer medium and the ways in which it can be realised. The capabilities of the interactive computer to provide complex graphics and audio, non-linear access to information, and its inherent interactivity all represent important factors that are instructionally relevant, and can bear on the effectiveness of CBT.

8.2 Current approaches to CBT design

The most common approach to CBT design (the instructional models of the systems approach) pays little, if any attention, to the possibilities of the medium. This is primarily the case since the systems approach pre-dates the development of modern interactive technologies. It has also been suggested that developers of instructional models for CBT design tend to distance themselves from the delivery technology, perhaps in an attempt to make their models more widely applicable. Different types of design guidance that fall under the systems approach are abstracted from different instructional theories and underpinned by some basic instructional factors. The difference lies in the form that guidance takes which ranges from highly prescriptive models of the design process to less prescriptive guidance from which the CBT designer can "mix and match".

However, another view is that the models constitute a resource on which the designer can draw, abstracting important points and incorporating them with their past experiences to build an overall approach to CBT design.

Two contemporary approaches attempt to overcome the shortcomings of the systems approach: the evolutionary approach and the Second Generation instructional design (ID_2) approach. Although the evolutionary approach allows some flexibility to incorporate strategies for using modern technologies through its lower degree of prescription than many of the models of the systems approach, it still does not provide active guidance on which CBT designers could draw. Moreover, the flexibility afforded by the evolutionary approach is of little benefit when the way in which the systems approach is used in real design situations is considered. Since few designers are likely to follow the prescriptive models of the systems approach, and instead interpret them and apply them to their individual design circumstances, the evolutionary approach may well just represent the way in which the systems approach is actually used.

ID_2 draws on AI techniques to provide computer-based tools for CBT design. The limitations of the approach are likely to stem from several quarters. The use of AI techniques is likely to cause problems of scope and applicability, and the complexity of the ID_2 system may well be detrimental. However, the most important shortcoming in terms of this study is that ID_2 fails to address the primary shortcoming of the systems approach: there is no consideration of the ways in which the capabilities of the delivery medium will be exploited to provide effective CBT software.

8.3 Design principles for CBT

The shortcomings of the systems approach to CBT design, and the failure of contemporary approaches to adequately address them, highlight the need for additional guidance. This study has proposed a set of four principles for CBT design covering issues related to *immersion, interaction, locative fit,* and *multiple representations.* The discussion of existing approaches highlighted the areas that were seen as fundamental to the effectiveness of the principles: their applicability in real-world design situations; and their active consideration of the instructional possibilities of the modern computer.

8.3.1 The structure of the guidance

The issue of applicability bears on the structure of the guidance. In order to be usable across a range of design situations, guidance must be flexible and not impose itself on the designer. Furthermore, since designers are likely to have an established methodology for CBT design, highly prescriptive guidance – even if potentially effective in particular design situations – would be less likely to be adopted. This is because it would probably require an unworkable shift in design practice, especially in light of the role that experience plays in design. All of these reasons suggest a more general approach to framing design guidance. This study developed principles on which CBT designers could draw as they saw fit. By pitching the guidance at this general level it was hoped that the designers would at least be made aware of the salient issues in CBT design.

8.3.2 The content of the guidance

The production of effective CBT materials depends critically on making use of the instructional possibilities of the computer medium. Furthermore, any guidance for CBT designers should be grounded in established, basic instructional factors. The critical point is that these factors are considered in light of the potential of the delivery medium; that they are re-interpreted and re-framed so as to make effective use of the computer medium. This was the goal when framing the four principles in this study; moreover, the principles are interrelated and constitute a coherent framework for CBT designers. When viewed together, the principles address the salient instructional and pedagogical factors and the relationships between them.

The nature of the empirical studies undertaken as part of this work means that their results offer suggestions only. This is as much a reflection on the complexity of design as it is on the nature of the studies.

The diverse situations that constitute CBT (with different variations of medium, subjects, and target groups) when coupled with the limited scope of the studies makes any conclusions necessarily tentative. The responses do however indicate that the issues addressed by the principles are of importance in the design of CBT materials. Furthermore, their use in the design of a piece of CBT software for the user trials demonstrates that they can be applied successfully, and their generality suggests that this should be the case in a wide range of design situations.

8.4 The significance of the principles to CBT design practice

8.4.1 Applicability

The study as a whole raises more general issues. The first of these concerns again the form that guidance for the design of CBT should take, and the implications that it has for CBT design practice. This study has suggested that the effectiveness of guidance in the design of CBT software depends on its generality; making guidance applicable over a wide range of design situations. Support for this view is available from the area of HCI where research in the area of software design practice has suggested that general, simple, and informal guidance is of great importance to the design of effective software, and that basic principles represent a vital resource for design (Gould and Lewis 1985, Mulligan *et al.* 1991, Bellottti 1988).

The importance of providing general, informal guidance can also be seen by examining the impact that highly prescriptive guidance has on the design process. This type of guidance is likely to be restrictive, since allowance cannot simply be made for context. This means that the model for the design process is specified at the outset, and that it is applied to produce the finished piece of software. One of the fundamental points about design, however, is that it is an on-going process. The specification and use of prescriptive design guidance removes this evolutionary dimension of design, and can only impoverish the process. Furthermore, it stifles creativity and reduces the scope for drawing on past experience to inform the design. Although iteration in the design process may help to overcome some of these problems, it represents a poor compromise forced by the nature of formal and prescriptive guidance.

The basis for the iteration is usually the results from some form of user involvement, typically through testing the software. All too often, prescriptive guidance dictates that this occurs towards the end of the design process when a working version of the software has been written. To gain a better insight into the potential effectiveness of a CBT lesson, the involvement of the users should begin at an earlier stage in the design process. This represents a move towards user-participatory design. As more sophisticated authoring environments that facilitate rapid prototyping for CBT emerge, this kind of participatory design may be adopted more widely. If this is to be the case, the guidance that is used by CBT designers must be flexible and avoid prescription. The role of such guidance will be to raise the awareness of designers on the important issues so that they can make informed choices and decisions during the design of the CBT lesson.

8.4.2 Effectiveness

The second general issue raised by this study concerns the content of the guidance, and the general 'paradigm' that it represents. This study has suggested that it is crucial that designers make effective instructional use of the possibilities of the delivery medium. The discussion of the systems approach showed that several fundamental instructional factors can be isolated, and it is the ways in which these factors are implemented that will determine the effectiveness of CBT lessons. The issue of importance is that these basic instructional factors are considered in light of the possibilities of the delivery medium: it is the paradigm of conjoining pedagogy and technology that underpins the principles developed in this study that is of greatest importance. For example, it may be that particular design situations favour certain interpretations of the principles and the instructional factors; the important issue is that designers make informed design decisions based on an understanding of the salient pedagogical and technological issues. As new facets of technologies emerge, such as those that support the expanding field of Virtual Reality (VR), the specific ways in which the basic instructional factors are employed in the design of CBT materials will change. However, the underlying importance of ensuring that they are interpreted and used effectively in light of the capabilities of the technology will not.

8.5 A critical re-evaluation

This chapter has reviewed and evaluated the central concerns of this thesis and the potential of the principles to inform the design of CBT materials. This final section will consider points arising from this study and will suggest alternative ways in which parts of this study could have been approached. Possibilities for future work arising from this thesis will also be introduced and discussed.

8.5.1 Empirical work

The data collection techniques used in the empirical studies undertaken as part of this work (chapters 6 and 7) were appropriate to the kinds of findings that were required: general pointers to the usefulness of the principles, both in terms of the abstract issues that they addressed and their potential to inform CBT design. The characteristics of these techniques play a part in the kind of results that they give. Other techniques exist that could have been used had an alternative perspective, and different types of findings, been required.

The design survey

The design survey relied on remote data collection through a design questionnaire answered by ten practising CBT designers. Data from the design survey was difficult to collect, because of the problems of securing participants; and difficult to analyse, because of the open questions used and the capricious nature of the answers. These are well known limitations of surveys *per se* and are not peculiar to the design survey reported in chapter 6. Although open questions, for example, present classification problems, the information contained in their answers provides depth that cannot be gained from closed questions. Questionnaire design represents a trade-off between classification and complexity: closed questions provide one-dimensional answers that can be easily categorised, open questions lead to complex comments that are open to interpretation.

Although the design survey only used a small sample size of ten designers, other surveys tend to involve a higher number of respondents. Practical limitations usually play a part in the number of respondents that are used, and the design survey was no exception. As Steinberg (1991) found, getting designers to participate in surveys is a difficult task. Over 100 designers were approached, directly or indirectly, and asked if they would be prepared to take part in the design survey, but of these only ten agreed. This shows the difficulty in securing large sample sizes for surveys of this type. Reasons for the reluctance of designers to participate may range from constraints on their time to an unwillingness to discuss their approach to CBT design for commercial reasons.

Whilst a survey was the most practical and suitable form of data collection for this study there are other forms of data collection that may be suitable in different circumstances. Design exercises may be useful, with designers being observed designing CBT software. If this approach was used, the degree to which CBT designers already employ ideas expressed in the principles could be seen. The designers could then be introduced to the principles and the impact that they had on design could be assessed. The closeness to the design process and the direct interaction between the designer and the interviewer, along with the obvious benefits of actually getting designers to use the principles in real-world design, could well lead to findings that are more representative of the usefulness of the principles than a survey. Within practical constraints this would be a good idea but there would again be difficulties in securing a large sample size.

A more detached form of data collection that would overcome the problem of securing participants for design exercises would be a review of existing CBT packages. The packages could be assessed and features corresponding to the issues addressed by the principles could be noted. This would provide an overall view of the importance that designers currently attach to the issues. Such an exercise could also be used as a foundation to identify areas that CBT design did not seem to address satisfactorily. This could underpin - and even provide a focus for - further empirical work into the value of these areas, perhaps through the kind of survey that this thesis presented in chapter 6. The inherent difficulty with this type of review would be its subjectivity. To overcome this, the review could be used as part of a wider range of data collection methods.

The user trials

A characteristic of the user trials presented in chapter 7 was their small sample size. It may be that a larger sample size would provide a more accurate representation of the thoughts of users of CBT software. If such a study were to be undertaken its value would be likely to depend on the involvement of the users themselves. A strength of the user trials reported in chapter 7 was the qualitative methods used to gather data and the interaction between the interviewer and the user. These methods would still be important even with a larger sample size.

Whilst the user trials were suited to the type of findings required, and practical constraints imposed, by this study other forms of data collection exist that may be effective in different circumstances. For example, many evaluation studies in the field of computer-based instruction rely heavily on quantitative data such as the logging of key-strokes. The key-strokes may then be analysed to re-create the user's actions from which evaluators draw inferences about the user's underlying rationale. The user trials presented in this thesis avoided this type of empirical method. Such quantitative methods are more often used when clear hypotheses are to be tested. Within the scope of this thesis, such a reliance would not have been appropriate since an understanding of the issues addressed by the principles was the central concern. Such an understanding would be difficult, if not impossible, to build up from the statistical data that quantitative methods offer. If the empirical work had focussed on testing the principles themselves the key-stroke kind of approach may have been more applicable. Subsequent work could move in this direction to test the principles in detail.

The value of quantitative methods here is that they provide another view of the data. Quantitative data may well prove useful when combined with qualitative methods to provide support for certain points. It is in this role that quantitative methods could have played a part in the user trials. However, there are a great number of different approaches to data collection both qualitative and quantitative, and it would be impractical to make use of all of them in a single study.

8.5.2 Further work

The principles proposed in this study are built on established and accepted theories of the learning process and draw on contemporary research findings concerning the relevant delivery technologies. The principles were framed by considering the interaction between these two areas and conjoining associated pedagogical and technological issues. This gives them a sound underpinning. The empirical work that was carried out in this thesis also suggests that they address the keys issues for CBT design from the perspectives of both designers and users.

Although this thesis used established literature from the fields of learning and technology it is possible that similar principles could have been reached in different ways. Perhaps the most obvious of these would have been to observe and assess the design and use of CBT materials. This would provide a source of information on which to draw in isolating factors of value in CBT design. Consultation with designers and users would have been likely to highlight areas seen as central to the effectiveness of CBT lessons. Such an approach may well have pointed towards similar areas as those identified by the four principles presented in this thesis. Undertaking work to this extent could reinforce the importance of the principles and the issues that they address.

There are also other areas of future use and development of the principles. A central difficulty in specifying design guidance is the possibility that the guidance will be inapplicable as design circumstances change. Perhaps the most obvious change in terms of CBT design will be in the technologies that are used to deliver the materials. The solid foundation of the principles in learning and instructional theory is useful here. Even as the delivery technologies advance, the instructional foundations of the principles are likely to remain highly applicable to CBT design. The generality of the principles and the lack of reference to specific delivery technologies are also points that will tend to make the principles applicable even as technologies evolve.

Other future uses of the principles could focus on the way in which they are used. Although the primary role of the principles is as design guidance for CBT materials, it is possible that they could be used to inform the design process in different ways. Central to this is the distinction between passive and active use of the principles. As they were proposed in this thesis, the role of the principles is passive - raising the awareness of CBT designers on salient CBT design issues. More active use of the principles in the design process would rest on an operationalisation of the principles. In this sense the principles could be used as a methodology for design. To achieve this, several pieces of CBT software would have to be designed following the principles. This software could then be assessed and key points could be extracted to serve as more directly applicable guidance covering the design process. This kind of guidance could be integrated with existing design practise covering, for example, needs analysis for the lesson and evaluation of prototype software, to provide an overall design methodology. Although the methodology may be limited in scope - with distinct methodologies developed for different design situations (such as different target groups) - it would provide more directly applicable guidance, and is one area of future work in which the principles could be used.

Appendices

Appendix A: The Design Questionnaire

Appendix B: Results from the Design Survey

Appendix C: Outlines of the Participants in the User Trials

Appendix D: Outline of Questions for User Interviews

Appendix A

The Design Questionnaire

This appendix contains a copy of the design questionnaire that was used in the postal survey of CBT designers reported in chapter 6.

Design Questionnaire

This questionnaire is concerned with the way that you, as a designer, think about computer-based training (CBT). It is split up into three sections which cover the following topics:

Section A: the way in which you currently approach the design of CBT materials.

Section B: important issues in designing CBT materials; issues in which designers need additional guidance.

Section C: the provision and usefulness of additional guidance.

Section A

This section will ask about the way in which you currently approach the design of CBT materials.

(i) Do you currently write (or author) CBT materials? (Please circle the appropriate response).

Yes **No**

(ii) If the answer to (i) is 'yes' do you use an authoring system (i.e. a piece of software that is specifically for CBT design), or a more general programming language (i.e. Pascal)? (Please circle the appropriate response).

Authoring system **More general language**

(iii) Please give a brief description of how you approach the design of CBT materials, including for example the name of the authoring system or general purpose language that you use, and the stages in design that you follow. If you use a specific model of instruction or other well-known approach, please include details, along with any information that you feel is important to the design (i.e. you may produce non-computer-based versions first then convert them when you are satisfied with the lesson).

Section B

This section will ask about important issues in the design of CBT materials, and areas in which design guidance is needed. The section is split into four parts. In each case, please circle the appropriate response.

Part 1:

(i) To what extent do you agree with the following statements?

(a) The creation of a learning environment that predisposes the learner to learning is an important goal of CBT.

strongly agree　agree　disagree　strongly disagree

(b) One way to create such an environment is to directly and actively involve the learner in the learning.

strongly agree　agree　disagree　strongly disagree

(ii) If you agree or strongly agree with (b), do you feel that guidance on how to achieve such direct and active involvement would help you to produce more effective CBT materials.

yes　no　no opinion

(iii) If the answer to (ii) is 'yes' please consider the following:

Below are four statements representing guidance on how to achieve 'direct and active involvement' of the learner in CBT. How do you rate them in terms of importance.

(1) Make the interaction between the learner and the CBT material richer by using the graphical capabilities of the computer to give continuous representation of the learner's action. For example, make use of input devices like the mouse to allow the learner to choose options, and show the choice being made on the screen. This will rely on instaneity of response on the part of the CBT material.

very important important unimportant of no importance

(2) Make use of animation and visual representation in general to isolate concepts in the CBT material.

very important important unimportant of no importance

(3) Make use of the auditory capabilities of the computer medium (speech and other sounds) to enrich the learning experience.

very important important unimportant of no importance

(4) Give the learner some kind of control over the learning to make the learning experience richer. This could be achieved through allowing some form of exploration using the computer medium's ability to provide non-linear access to information (i.e. information does not have to be seen in a set order) in the CBT material.

very important important unimportant of no importance

Part 2:

One of the topics covered in this part of the questionnaire is 'learner control'. Learner control in CBT means letting the learner direct the instruction themselves, rather than imposing a set direction which the learner must follow. Providing learner control can have many effects, from allowing the learner to set their own pace, to choosing the overall direction or flow of the lesson.

(i) To what extent do you agree with the following statement.

(a) Providing learner control is an important goal of instruction generally, and therefore of CBT.

strongly agree　　agree　　disagree　　strongly disagree

(ii) If you agree or strongly agree with (a), do you feel that guidance on how to develop CBT materials which provide learner control would help you to produce more effective CBT materials.

yes　　no　　no opinion

(iii) To what extent do you agree with the following statements.

(a) Whilst it is beneficial to give learners a degree of control, too high a degree (for example, through unlimited exploration) will disrupt learning.

strongly agree　　agree　　disagree　　strongly disagree

(b) The sequence in which topics in CBT materials are encountered effects how well people learn from them.

strongly agree   agree   disagree   strongly disagree

(iv) If you agree or strongly agree with either (a) or (b), do you feel that guidance on how to provide learner control and effective sequencing in CBT materials would help you to produce more effective CBT materials.

yes   no   no opinion

(v) If the answer to (iv) is 'yes' please consider the following:

Below is a statement representing guidance on how to achieve learner control and effective sequencing in CBT. How do you rate this statement in terms of importance.

(1) Keep a record of topics that have already been seen by the learner in order to present meaningful, relevant choices about the direction of the instruction to the learner, providing control of sequence with a degree of learner control.

very important   important   unimportant   of no importance

Part 3:

In this section, please circle the appropriate response to the following questions.

(i) To what extent do you agree with the following statement.

(a) Information given to learners through CBT materials should be structured so as to counter the limitations of short-term memory.

strongly agree   agree   disagree   strongly disagree

(ii) If you agree or strongly agree with (a), do you feel that guidance on how to develop CBT materials which counter the limitations of short-term memory would help you to produce more effective CBT materials.

yes   no   no opinion

(iii) If the answer to (ii) is 'yes' please consider the following:

Below are two statements representing guidance on how to develop CBT materials that counters the limitations of short-term memory. How do you rate these statements in terms of importance.

(1) Make use of the computer medium's ability to re-access information in CBT materials. Revisiting information can reinforce its content, helping to overcome the limitations of short-term memory.

very important   important   unimportant   of no importance

(2) Make the same information available from multiple access points in the CBT material. This will help to counter the limitations of short-term memory since the possibilities for reinforcement through revisiting will be increased.

very important important unimportant of no importance

Part 4:

(i) To what extent do you agree with the following statement?

(a) Representing information in different ways (for example, though animation, still graphics, text) is an important facet of CBT.

strongly agree agree disagree strongly disagree

(ii) If you agree or strongly agree with (a), do you feel that guidance on how to develop CBT materials which make effective use of the different forms of representation would help you to produce more effective CBT materials.

yes no no opinion

(iii) If the answer to (ii) is 'yes' please consider the following:

Below are two statements representing guidance on how to develop CBT materials that make effective use of the different forms of representation supported by the computer medium. How do you rate these statements in terms of importance?

(1) Relate the form of the representation to the learner's current state of knowledge. For example, use animation to convey new ideas, and text for information which has been seen by the learner and which the learner understands.

very important important unimportant of no importance

(2) Assess the learner's state of knowledge with respect to the CBT material in order to find the best form of representation. This could be achieved by some form of active testing during the CBT lesson on which to base the decision.

very important important unimportant of no importance

Section C

The purpose of this section is to obtain your views on the provision and usefulness of additional guidance for designers of CBT materials. Listed below are four items which address the issues introduced in Section B.

Please could you provide some comment on what you feel to be the usefulness of each of the items to CBT designers, and finally provide any general comment on their value as a whole to CBT design. The comments can be as brief or as detailed as you like.

Item 1

- Create an environment that predisposes the user to learning through the provision of a *learning environment in which the learner is directly and actively involved.* This can be achieved through the use of the *graphical* and *auditory capabilities of the computer,* the encouragement of *limited exploration* (through the exploitation of the abilities of the computer to provide non-linear access) to give the learner a *degree of control.*

Please write your comments on *Item 1* here:

Item 2

- The software should make use of the possibilities of the technology to monitor the *information which has already been imparted* and to present *meaningful, contextually sensitive* choices to the learner. In this way the *sequence in which information is imparted* can be related to the user's current state of knowledge about the system whilst *retaining a degree of user control.*

Please write your comments on *Item* 2 here:

Item 3

- The information to be imparted should be structured so as to *counter the limitations of short term memory,* making use of the computer's 'ability' to *re-access* information and provide *non-linear access* to that information. The same information should be available for access from multiple points in the lesson.

Please write your comments on *Item* 3 here:

Item 4

- Make use of the technology's ability to provide *multiple representations* to present information in different forms related to the user's current state of knowledge about the system. This will mean using *graphical* and *textual* displays as necessary to facilitate learning. Also make use of the representational possibilities of the technology (animation, auditory, etc.) to convey ideas and information in a meaningful way and as an *elaborator* and *reinforcer*.

Please write your comments on *Item 4* here:

Please write your general comments here:

Thank you for completing this questionnaire and for your help in this survey.

Appendix B

Results from the Design Survey

This appendix contains the detailed results from sections A and B of the design survey, described in chapter 6. Table 1 refers to section A of the design questionnaire, and tables 2 to 5 refer to section B.

	Section A: Questions				
Designer Number	(i) Writing CBT materials (Yes/No)	(ii) Using Authoring System or More General Language (AS/MGL)	(iii) Replicable (Yes/No)	(iii) Formal or Informal approach (F/I)	(iii) Comments
1	Yes	AS	No	I	Interlocking set of useful things No model of instruction outlined
2	Yes	AS	No answer	No answer	No comments made by designer in response to this question
3	Yes	AS	Yes	I	Specifies a design cycle: iterative at all stages, user feedback
4	Yes	MGL	No answer	No answer	Answer only specified AS used. No comment on other issues
5	Yes	AS	Yes	F	Development methodology and model outlined
6	Yes	AS	Yes	I	Outlines methodology for design. Iterative. User input
7	Yes	MGL	Yes	I	Designer specified an iterative design cycle
8	Yes	MGL	Yes	F	Modularised design cycle. Iterative. User involvement
9	Yes	MGL	Yes	I	Iterative approach to design
10	Yes	MGL	Yes	I	Design cycle specified.Allows for iteration and user involvement

Table 1: Answers and comments from section 1 of the design questionnaire

Designer Number	Section B Part 1: Question Numbers						
	part (i)		part (ii)	part (iii)			
	(a)	(b)		(1)	(2)	(3)	(4)
1	strongly agree	agree	yes	important	important	very important	very important
2	strongly agree	agree	yes	important	unimportant	unimportant	very important
3	agree	strongly agree	yes	important	important	important	very important
4	strongly agree	strongly agree	yes	very important	important	important	important
5	strongly agree	strongly agree	yes	important	important		very important
6	strongly agree	strongly agree	yes	important	very important	important	important
7	agree	strongly agree	yes	important	important	important	very important
8	agree	strongly agree	yes	very important	unimportant	unimportant	very important
9	agree	agree	yes	important	important	important	important
10	strongly agree	strongly agree	yes	very important	important	important	very important

Table 2: Answers from section B, Part 1 of the design questionnaire

Designer Number	Section B Part 2: Question Numbers					
	part (i)	part (ii)	part (iii)		part (iv)	part (v)
	(a)		(a)	(b)		(1)
1	agree	yes	disagree	agree	yes	important/ unimportant
2	strongly agree	yes	disagree	agree	yes	important
3	agree	yes	agree	agree	yes	important
4	strongly agree	yes	disagree	agree	yes	important
5	agree	yes		disagree		important
6	agree	yes	strongly agree	agree	yes	important
7	strongly agree	yes	disagree	agree	yes	important
8	strongly agree	yes	agree	agree	yes	very important
9	agree	yes	agree	agree	yes	important
10	agree	yes	strongly agree	agree	yes	important

Table 3: Answers from section B, Part 2 of the design questionnaire

	Section B Part 3: Question Numbers			
	part (i)	part (ii)	part (iii)	
Designer Number	(a)		(1)	(2)
1	agree	yes	important	important
2	agree	yes	important	important
3	agree	yes	very important	very important
4	disagree			
5	agree	yes	unimportant	(probably) important
6	agree	yes	important	important
7	strongly agree	yes	very important	very important
8	agree	yes	very important	unimportant
9	disagree			
10	agree	yes	important	important

Table 4: Answers from section B, Part 3 of the design questionnaire

Designer Number	Section B Part 4: Question Numbers			
	part (i)	part (ii)	part (iii)	
	(a)		(1)	(2)
1	strongly agree	yes	unimportant	unimportant
2	agree	yes	unimportant	unimportant
3	agree	yes	important	important/ unimportant
4	agree	yes	very important	important
5	agree	yes	unimportant	(probably) important
6	agree	yes	important	important
7	strongly agree	yes	very important	very important
8	agree	yes	very important	unimportant
9	disagree			
10	agree	yes	important	important

Table 5: Answers from section B, Part 4 of the design questionnaire

Appendix C

Outline of the Participants in the User Trials

This appendix presents brief descriptions of the four participants in the user trials reported in chapter 7.

Subject A: Male, late teens. Background in physical and social sciences. Previous limited use of general packages for the Apple Macintosh range of computers, such as simple drawing packages and word-processors.

Subject B: Male, late teens. As with subject A, had a background in physical and social sciences, and had previous limited use of general packages for the Apple Macintosh range of computers.

Subject C: Female, late teens. Background in social sciences. No previous computing experience whatsoever.

Subject D: Female, late teens. Background in physical and social sciences. As with subject C, had no previous computing experience whatsoever.

Appendix D

Outline of Questions for User Interviews

This section presents an outline of the questions that were asked in the interviews discussed in chapter 7. The interview consisted of two types of questions: general and specific. Both of these sections covered the same areas, although the specific questions were obviously focussed on the issues raised by the principles, whereas the general questions allowed the learner scope to talk about anything they wanted to.

(i) general: discussion

- What do you feel were the best features of the tutorial and why?
- What do you feel were the worst features of the tutorial and why?
- Do you think that you learned anything? - What in particular sticks in your mind?

(ii) specific: questions related to the issues raised by the principles

immersion: questions about:

- the direct and active involvement of the learner
- the richness of the interaction - can the learner provide examples?
- the use of buttons in the tutorial
- the personalisation of the instruction
- the use of graphics and simulations

interaction: questions about:

- the control of the instruction by the learner
- the use of testing within the tutorial
- exploration in the tutorial
- the use of monitoring, and the provision of choices related to the learner's performance

locative fit: questions about:

- non-linear access of material
- the relation of the instruction to other media, for example a book
- the re-access of information
- seeing information on the same topic in different forms

multiple representations: questions about:

- the display of information:

  simulations (different levels of detail in different simulations)

  layout of text (e.g. grouping, optical centre)

  other graphical effects (e.g. flashing on/off)

- displays linked to cursor position
- the use of sound in the tutorial
- inundation of the learner with information

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