

hand, factors such as the number and complexity of the procedures, their importance or their frequency of use may require learners to depend on written instructions each time they perform a task. For example, airplane pilots review printed check-lists each time they fly.

2.3. Learning conditions for application

As argued above, having a skill means knowing when to apply particular procedures. In some cases, the conditions for application are perfectly straightforward. For example, when the procedures come in a strictly ordered sequence, the precondition for any given procedure is the result of correctly executing the previous procedure. The conditions for application may be much more complex, however. In skills such as using a computer, there may be multiple ways to accomplish a goal. Under certain conditions, one procedure might be much more efficient or advantageous than the rest. If novices do not appreciate the conditions under which the procedures are most useful, they might overlook procedures that would be very useful to them. Instead, they might always choose to use some inefficient procedure that they happened to learn first or that may initially be easier to remember.

Card, Moran and Newell's (1983) study of experienced users of text-editing system demonstrated that experts have well-defined rules for selecting between procedures. The text-editor involved offered two basic methods of moving the cursor: searching for a specified string of characters or moving the cursor up or down a line at a time. The subjects had consistent strategies for choosing between these methods (e.g. use the search method if the target location is more than three lines away, use the line-feed method otherwise). Presumably, these computer users developed their strategies themselves, but their early learning was not observed. At least some of the subjects had developed fairly inefficient strategies. For example, one subject never used the string search method; she used some variation of the line-feed method even when the target location was over ten lines away.³

If we wish learners to use a repertoire of procedures appropriately, it may be necessary to *motivate* the use of some procedures by demonstrating the advantages they have in particular situations. Acquiring a repertoire goes beyond the ability to decide between specified procedures on demand. Even if a person can, when queried, consistently judge which of two procedures is more efficient in a given context, he may not always select the most efficient one in *real* situations. The learner may fail to ask (or be unwilling to ask) for each subgoal, 'which procedure is optimal here?' Computing the relative costs

³Card, Moran and Newell successfully modelled how the experts used selection rules, but they were not interested in the relative efficiency of the rules their subjects had come up with nor in how the subjects had acquired their rules.

of procedures can be time consuming and tedious, and not without its share of the costs. Therefore, unless a procedure easily 'comes to mind', it may remain unused. This means that skilled performance involves not only the ability to recognize the situations in which a given procedure is optimal, but the ability to retrieve the best procedure easily and rapidly when necessary.

It is worth noting that learning sophisticated selection strategies is probably unnecessary for skill tasks such as learning to assemble a device or operate a piece of equipment. Since the procedures in these tasks are less multipurpose, they are also less interchangeable. It is more likely that the conditions for application in these tasks grow out of ordering constraints rather than considerations of efficiency.

2.4. The independence of the three components of skill learning

The three components of skill learning that have just been described are fairly independent of one another. A learner may know that a specific procedure exists for solving a problem without knowing or remembering how to apply it. For example, a child knows what shoe-tying is and when it needs to be done, but lacks the ability to carry out the procedure. Similarly, by rote learning, one may learn to perform a series of steps without knowing what the steps are for. Finally, one may understand what a procedure does and how to carry it out, but not know when or why to use it. This situation often arises when novices consult computer manuals: they finish reading a description of a command, understand more or less what it does and how to issue it, but lack the slightest inkling as to when they would ever want to use it or how it relates to other commands they have learned. Since each of the three components is necessary to skill learning, each can constitute a 'bottleneck' for acquiring a skill.

3. THREE TYPES OF ELABORATIONS FOR FACILITATING SKILL LEARNING

The question we address in the remainder of this chapter is how the presentation of information in an instructional text can facilitate learning in the three components just described. We will focus on a particular aspect of instructional texts, namely the degree to which the main points are elaborated.

The effect of elaborations on the acquisition of information from a text has been the topic of considerable speculation and research (Reder, Charney and Morgan, in press; Anderson and Reder, 1979; Reder, 1976, 1979, in press; Weinstein, 1978; Mandl and Ballstaedt, 1981; Mandl, Schnotz and Tergan, 1984; Bransford, 1979; Chiesi, Spilich and Voss, 1979; Craik and Tulving, 1975). In the view of most researchers, there are several reasons why elaborations should help subjects learn and remember the main ideas of a