Preface

Without knowledge of human cognitive processes, instructional design is blind. In the absence of an appropriate framework to suggest instructional techniques, we are likely to have difficulty explaining why instructional procedures do or do not work. Lacking knowledge of human cognition, we would be left with no overarching structure linking disparate instructional processes and guiding procedures. Unless we can appeal to the manner in which human cognitive structures are organised, known as human cognitive architecture, a rational justification for recommending one instructional procedure over another is unlikely to be available. At best, we would be restricted to using narrow, empirical grounds indicating that particular procedures seem to work. We could say instructional procedure *A* seems better than procedure *B* but why it works, the conditions under which it works or how we can make it work even better would be rendered unanswerable and mysterious.

In contrast, knowledge of how we learn, think and solve problems – human cognitive architecture – can provide us with a coherent, unifying base that can be used to generate instructional hypotheses and data. That base can explain why some instructional procedures work while others fail. Seemingly disparate, even contradictory data can be explained and reconciled. Most importantly, human cognitive architecture can be used to generate instructional procedures that we otherwise would have considerable difficulty conceiving. The structures that constitute the framework of human cognitive architecture provide an essential prerequisite to instructional design for both researchers and professional educators. Those structures allow us to make sense of instructional design issues. Further, we can use our knowledge of human cognitive architecture to devise instructional theories.

One such theory is cognitive load theory that was explicitly developed as a theory of instructional design based on our knowledge of human cognitive architecture. Cognitive load theory consists of aspects of human cognitive architecture that are relevant to instruction along with the instructional consequences that flow from the architecture. This book begins by considering categories of knowledge in Part I, human cognitive architecture in Part II, categories of cognitive load in Part III, followed by the instructional effects that flow from these theoretical considerations in Part IV and the conclusions in Part V.

In recent years, the cognitive architecture used by cognitive load theory has been expanded and anchored within a biological evolutionary framework. Evolution by natural selection has a dual role in cognitive load theory. First, as indicated in Chapter 1 of Part I, we can classify information into two categories. The first category, known as biologically primary knowledge, consists of information that we have specifically evolved to acquire while the second category, known as biologically secondary knowledge, is information that we need for cultural reasons but have not specifically evolved to acquire. Educational institutions were devised to facilitate the acquisition of biologically secondary information and cognitive load theory deals almost exclusively with that category of information. Chapter 1, by analysing these distinct categories of knowledge, provides an introduction to the evolutionary base used by cognitive load theory.

Evolution by natural selection has a second, equally important role in cognitive load theory. Evolutionary theory is usually considered as a biological theory explaining how biological structures, including entire species, arose. That function is, of course, the primary purpose of evolutionary theory. Nevertheless, evolutionary theory can be considered from an entirely different perspective, as a natural information processing system. By thinking of evolutionary theory in terms of the manner in which information is processed, we can extend evolutionary concepts to other information processing systems such as human cognition.

Biological evolution is not normally considered in information processing terms but there are advantages to thinking of it in this way. When considered as an information processing system, biological evolution is able to tell us about a particular class of theories, natural information processing theories. These theories tell us how information is processed in nature and evolution by natural selection provides us with the best known and most detailed natural information processing theory. By treating biological evolution as a natural information processing theory, we can throw substantial light on the characteristics of this class of information processing systems because of the large amount of knowledge that we have available to us about biological evolution.

Knowing how natural information processing systems such as biological evolution function is particularly important because human cognition provides another example of a natural information processing system. If we know how biological evolution functions as a natural information processing system, that knowledge can be used to tell us how human cognition functions because human cognition also is a natural information processing system, analogous to evolution by natural selection. Knowing the characteristics of natural information processing systems in general can tell us about some of the central characteristics of human cognition.

Thus, if we know how biological evolution works, it may tell us much about how human cognition works, assuming both are natural information processing systems. If we assume the way we learn, think and solve problems is part of nature because we are part of nature, we need to know how nature learns and solves problems. That aim can be achieved by treating both evolution by natural selection and human cognition as a natural information processing system. Chapters 2–4 of Part II establish and discuss the suggested analogy between evolution by natural selection and human cognition. In the process, those chapters provide the cognitive architecture that lies at the heart of cognitive load theory.

Cognitive load theory's emphasis on human cognitive architecture and its evolution is not an end in itself. The ultimate aim of the theory is to use our knowledge of human cognition to provide instructional design principles. The cognitive architecture discussed in Part II tells us that when processing biologically secondary information, human cognition includes a working memory that is limited in capacity and duration if dealing with novel information but unlimited in capacity and duration if dealing with familiar information previously stored in a very large long-term memory. Instruction needs to consider the limitations of working memory so that information can be stored effectively in long-term memory. Once appropriate information is stored in long-term memory, the capacity and duration limits of working memory are transformed and indeed, humans are transformed. Tasks that previously were impossible or even inconceivable can become trivially simple. Accordingly, the aim of instructional design is to facilitate the acquisition of knowledge in long-term memory via a working memory that is limited in capacity and duration until it is transformed by knowledge held in long-term memory. The characteristics of that memory can provide guidelines relevant to designing instruction. The initial process of specifying instructional design principles begins in Part III of this book.

The cognitive load imposed on working memory by various instructional procedures originates from either the intrinsic nature of the instructional material, resulting in an intrinsic cognitive load, or from the manner in which the material is presented and the activities required of learners, resulting in an extraneous cognitive load. Chapter 5 in Part III introduces the instructional applications of cognitive load theory by outlining the categories of cognitive load, their interactions and their instructional consequences. Chapter 6 discusses techniques that have been used to measure cognitive load.

The chapters of Part IV discuss the range of instructional effects generated by the theory. Over 25 years, researchers from around the globe have used cognitive load theory to generate a variety of instructional procedures. Those procedures characteristically are tested for effectiveness by comparing them to more traditional methods using randomised, controlled experiments. When the results of such comparisons indicate the superiority of a new procedure over a commonly used procedure, a cognitive load effect is demonstrated. Cognitive load effects provide us with novel instructional guidelines that constitute the ultimate aim of cognitive load theory. These guidelines constitute the major justification for devising cognitive load theory and are discussed in Chapters 7–17. Each chapter describes one or more of the cognitive load effects generated by the theory with each effect indicating an instructional procedure, tested for effectiveness, and recommended for use. The conclusions of Chapter 18 tie together the various strands of the preceding sections.

Over the two to three decades that cognitive load theory has been used as an instructional theory, it has undergone considerable development and change. In an example of a feedback loop, the changes to cognitive load theory have been driven largely by the instructional effects generated by the theory. Most commonly, the theory has generated a new instructional procedure at a point in time and that procedure has been demonstrated in a particular curriculum area using a specific set of materials. On occasions, the effect has failed to generalise to a different area and different conditions. Such failures require an explanation and that explanation usually results in both theory development and new instructional effects and procedures. In this manner, the edifice that constitutes cognitive load theory has been constructed.

Ultimately, the theory stands or falls according to its ability to generate novel, useful, instructional procedures, a justification common to all instructional theories. We hope cognitive load theory passes this test. The most recent version of the theory, along with the instructional procedures generated by the theory over many years is presented in this book. We begin, in the next chapter, by using evolutionary theory to categorise knowledge.

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