SUMMARY OF SECTION II

This part of the book reviewed empirical findings related to managing cognitive load in verbal and pictorial representations, interactive multimedia, dynamic visual representations, and instructional simulations and games. Empirically established interactions between levels of learner expertise and different formats of multimedia presentations (expertise reversal effect) were described.

The expertise reversal effect has been consistently replicated with a large range of instructional materials and participants either as a full reversal (with significant differences for both novices and experts) or, more often, as a partial reversal (with a non-significant effect for either novices or experts, but with a significant interaction). The estimates of effect size differences for novices and experts ranged from 0.45 to 2.99, with the overall mid-range value of 1.72. This number could be interpreted in a simplified way as indicating that if there were effects of a similar magnitude on both sides (for novices and experts), the effect size for each side would be around 0.86, a large-size effect by accepted standards. If the effect is of relatively lower magnitude on one side (the case in most studies), then it would be accordingly stronger on the other side.

In cognitive load theory, the expertise reversal effect is associated with imbalances between learner organized knowledge base and provided instructional guidance. Two major types of such imbalances are described. One could be caused by an insufficient learner knowledge base that is not complemented by appropriate instructional guidance, especially at the initial stages of novice learning. Another type of imbalance could be caused by overlaps between available knowledge of more advanced learners and provided instructional guidance. The need for higher knowledge learners to integrate and cross-reference redundant instructional guidance with available knowledge structures that relate to the same situations may consume additional cognitive resources. A minimal instructional guidance would allow these learners to take advantage of their knowledge base in the most efficient way.

The expertise reversal effect is a logical extension of the aptitude-treatment interaction studies. Although the need to consider levels of learner prior knowledge was recognized early within that approach, few research studies and instructional design recommendations demonstrated explicitly how to use the aptitude-treatment interaction approach in practice. Aptitudes and instructional treatments were investigated without taking into account associated cognitive processes. Applied psychometric rather than cognitive diagnostic measurement instruments were not suitable for real-time use in adaptive instructional systems.

Cognitive load theoretical framework creates conditions for effectively handling these shortcomings. However, a limited number of studies in optimal instructional methods that could be used for balancing executive guidance at different levels
of learner expertise is a major limitation of the research in this area. Identifying broader range of instructional methods and procedures that are optimal for learners with different levels of expertise remains an essential direction for future research. Extending findings from mostly well-defined technical domains to relatively poorly defined tasks and domains represents another important research direction.

General guidelines for managing cognitive load in multimedia learning could be briefly summarised in three separate directions. Managing intrinsic cognitive load could be achieved by, for example, appropriately sequencing learning tasks from simple to complex or by presenting isolated elements first followed by the presentation of all interactions between them. Decreasing extraneous cognitive load could be accomplished by presenting verbal explanations that accompany pictorial material contiguously in time or space, preferably as narrations, adapting the pacing of presentations to learner cognitive characteristics, properly segmenting presentations, presenting cues to prevent unnecessary visual search, etc. Finally, increasing germane cognitive load could be done, for example, by presenting problems that vary in relevant features, prompting learners to predict the next step in a process or imagine procedures and concepts.

Online or computer-based multimedia environments allow plenty of opportunities for implementing cognitively-based design principles and techniques for managing cognitive load. For example, dynamic onscreen presentations could display only relations and links corresponding to selected elements of the text or diagrams when needed by individual learners. Also, on-screen diagrams could be combined with auditory explanations instead of conventional visual-only formats. For more experienced learners, however, elimination of redundant audio and visual sources of information could be beneficial for learning by turning off the auditory mode.

According to the expertise reversal effect, in order to balance the executive function and optimize cognitive load, direct guidance should be provided to low-prior knowledge learners at the appropriate time; unnecessary redundant support should be timely removed as a learners becomes more experienced with the task domain; the rates of information presentations could be regulated to ensure that the learner cognitive capacity is not exceeded. Information presentation formats should also be dynamically tailored to changing levels of learner task-specific expertise.

Eventually, adaptive applications that allow dynamic tailoring of instructional multimedia presentations to changing cognitive characteristics of individual learners have the best potential for optimizing cognitive load and working in harmony with human cognitive architecture. The recent studies in rapid diagnostic assessment methods may offer appropriate real-time tools for the dynamic optimization of instruction. Such assessment methods may provide adequate fine-grained measures of levels of task-specific expertise with a sufficient diagnostic power for
learner-tailored instructional procedures. These issues and specific examples will be considered in the following part of the book.