

Chapter V

Evaluation of Cognitive Load

INTRODUCTION

Availability of valid and usable measures of cognitive load involved in learning is essential for providing support for cognitive load-based explanations of the effects predicted and described in cognitive load theory as well as for general evaluation of learning conditions. Besides, the evaluation of cognitive load may provide another indicator of levels of learner expertise in addition to performance scores. As mentioned before, due to the available schematic knowledge base, more knowledgeable learners are expected to perform their tasks with lower mental effort than novices.

Even though simple subjective rating scales remain the most often used measures of cognitive load imposed by instructional materials, new more sophisticated techniques are being developed, especially in multimodal environments associated with performance of complex cognitive tasks. This chapter provides a brief overview of traditional, as well as some novel methods for measuring and evaluating cognitive load. Some recently developed approaches to using these measures in estimating instructional efficiency of learning environments are also discussed.

APPROACHES TO EVALUATING COGNITIVE LOAD IN LEARNING AND INSTRUCTION

There are analytical (e.g., based on mathematical models) and empirical approaches to evaluation of cognitive load (Xie & Salvendy, 2000). Empirical approaches to

measuring cognitive load could be divided into two major categories associated with direct/indirect and objective/subjective dimensions. Accordingly, there are direct objective measures (e.g., dual-task methodology, eye tracking techniques, or brain activity measures such as fMRI); indirect objective measures (physiological measures such as cardiovascular indicators, EEG, behavioral measures such as linguistic indices or interaction features, and learning outcome measures); direct subjective measures (self-reported stress level); and indirect subjective measures (self-reported mental effort) (Brünken, Plass & Leutner, 2003). Task or performance-based measures (e.g. primary task measures, dual task measures) and self-reports (subjective self-rating scales such as unidimensional Likert-type scales and multi-dimensional scales, e.g., NASA TLX) are mostly posterior indicators of cognitive load. Most of other measures of cognitive load are concurrent measures that are collected during the task performance.

One of the first methods for evaluating cognitive load that was used within a cognitive load framework was based on constructing and studying computational models (Sweller, 1988). It is possible to model cognitive processes in terms of elementary cognitive operations. For example, production rule models can be used that are based on condition-action (or *if-then*) pairs where specific cognitive actions take place when corresponding conditions are in place. By counting the number of active conditions in learner working memory, it is possible to estimate the level of working memory load required for performing specific cognitive tasks. Instruction processing times were also used as indicators of cognitive load (Sweller, Chandler, Tierney, & Cooper, 1990) before more directly related techniques were developed or adopted, and applied to instructional situations. In most of recent research studies within a cognitive load framework, subjective ratings and the dual-task technique have been used.

Subjective measures (e.g., Hill, Laveccchia, Byers, Bittner, Zaklad, & Christ, 1992), psychophysiological measures (Beatty, 1982; Paas, van Merriënboer, & Adam, 1994), and the secondary-task method (Bloem & Damos, 1985) are major empirical methods used for measuring mental workload. Subjective rating scales are capable of providing valid and reliable estimates of perceived mental load in a non-intrusive way (Gopher & Braune, 1984; Nygren, 1991; Paas et al., 1994). In most studies using subjective scales, cognitive load has been assessed retrospectively after learning based on the assumption that learners are capable of reflecting on their cognitive processes and report their mental effort during learning (i.e., there is a direct relation between subjective measures and actual load). An important advantage of this approach is its simplicity and practicality due to non-intrusiveness into actual cognitive processes.

Van Gog and Paas (2007) suggested that process-tracing techniques may allow the tracing of actual cognitive processes that occur during learning and problem

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