Chapter XX
Measuring Cognitive Load

Nanette M. Hogg
University of Nebraska at Kearney, USA

ABSTRACT

Cognitive load theory describes learning, in terms of a processing system, when all too often, working memory is overloaded and learning is impeded. Measuring cognitive load is an important component of research in the area of information processing. The design, delivery, and administration of an instrument, as well as its reliability and validity, are discussed as a solution to the measurement of cognitive load. A nine-point subjective rating scale ranging from very, very low (1) to very, very high (9) measures cognitive load, defined as the mental effort needed to complete a task. It is a replica of the instrument used by Paas (1992) and Paas and van Merriënboer (1994). The measurement instrument can be used both on paper and on the Web.

INTRODUCTION

Cognitive load theory (Sweller, 1988; 1994) is an instructional theory, based on the discipline of cognitive science, that describes learning in terms of a processing system, the working memory, and a storage system, which is long-term memory. Information is stored in long-term memory after working memory processes it. Working memory, however, is extremely limited in both capacity and duration, making it difficult to process complex information. These limitations may be increased due to poorly designed instruction and instructional materials, thereby, obstructing the learning process.

BACKGROUND

Cognitive load is defined as the processing of information that occurs in working memory. For example, while learning the English language, word meanings, word types, (nouns, verbs, adjectives, and adverbs), and word order must be considered. Word meanings, types, and order are all single elements that can be learned individually and processed in short-term memory. As the individual elements are learned, a building block of information forms a schema to categorize information that combines the interaction of the single elements. For example, the building block could include the adjective "green" that describes a noun and the placement of that adjective before

the noun. The term "green tree" is the interaction of two elements, the adjective and noun. When multiple elements that interact are categorized, they can form a schema. In this example, an entire grammatically correct sentence can be constructed with each word interacting correctly with the other words. When each word must be considered as well as the interaction with the other words, a great amount of processing would occur in the working memory. When the schemata for the English language are in place, the sentence is constructed without having to process the individual elements and the interaction of those elements.

Cognitive load theory (CLT) promotes ways to design instructional materials to reduce cognitive load on the working memory. The basis of this theory states that when extra burdens are placed on the working memory, the limited capacity prevents schemata acquisition. When too much information is readily available or the materials are poorly designed, burdensome restraints are placed on the limited space of the working memory and learning is impeded. Learning may fail, not necessarily due to the complexity of the information, but because of the way the instruction is presented, wasting the use of cognitive resources. Sweller (1988) suggested that in order for learning to take place, information must be processed in the working memory and stored in long-term memory, which is unlimited and holds huge numbers of schemata. Instructional materials should be designed in such a way as to minimize the use of working memory resources in order to facilitate an increase in the construction of the schemata.

Cognitive load theory indicates that working memory must organize and process information before schemata are constructed. Then, once schemata are constructed, the individual must use the knowledge. This can be accomplished efficiently through transfer or automation. Transfer occurs when one or more schemata are consciously brought into working memory as a single element and applied to a new or different situation. Automation occurs when the schemata are unconsciously used in a situation. Continuing with the same example, the process of sentence construction is somewhat automatic for most English-speaking people, so the word types and word order do not need to be considered. The cognitive processing of elements can occur anywhere on a spectrum from complete conscious control to full automation. Prior to automation, cognitive processing can take place with conscious control. Sweller (1994) tells us that with time and practice, a specific process can become automated. Once a schema is fully automated, it is stored in long-term memory and can act as a single element in a more complex task. At the fully automated level, the more complex task also can act as an element in yet a more complex task. Cognitive load and the working memory resources are greatly reduced when automation occurs, so more working memory is available to process other information.

Cognitive load can be classified into categories and discussed as levels of processing in the working memory. Intrinsic cognitive load is the processing in working memory that must occur for the task at hand, such as the task of processing the elements to learn the English language. Intrinsic cognitive load cannot be determined by the number of elements. It can only be determined by the interactivity between the elements, no matter if the number of elements is small or large. Learning information that is not based on knowledge of other elements has low intrinsic cognitive load and does not require much processing in the working memory. This type of learning is usually in a serial fashion, or in isolation, such as the colors. The color green is learned and the color red is learned without interaction between the two or without interaction with other elements. A higher level of intrinsic cognitive load is required when the task at hand needs simulation of new information or previous knowledge. The adjectives and nouns are known; now the sentence must be constructed using previously known elements and perhaps new elements, such as order. Intrinsic cognitive load is difficult to measure and unlikely to be controlled,