

Evolution of cognitive load when learning a procedure in a Virtual Environment for Training

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Introduction

Procedural learning is a complex learning situation that may induce a high cognitive load. At the beginning of learning, individuals have to transform declarative knowledge, from instructions being consulted, to procedural knowledge through the development of several levels of mental representations (Kieras & Bovair, 1986; Bovair & Kieras, 1991) in Working Memory. After several repetitions of a procedure, procedural knowledge can be directly retrieved from Long Term Memory. It is then considered as acquired (LeFevre, 1987). This process moves from a conscious to an automated processing, that needs time and cognitive effort. Based on Fitt's (1964) and Anderson's (1983, 1995) models, we can consider three stages: (1) the cognitive stage that requires the systematic use of instructions to perform the procedure (long and cognitively expansive stage); (2) the associative stage, when the learner develops production rules such as “IF... THEN...” and implements a knowledge compilation process (in this stage, errors are gradually detected and corrected); (3) the autonomous stage, when the procedure has been repeated several times (the learner is able to perform the procedure quickly, error-less, and with no need of instructions).

The study presented here is the starting point for a thesis in Cognitive Psychology, whose general aim is to reduce the learner's cognitive load induced by procedural learning in a virtual environment. We intend to implement and test various design of the environment in order to facilitate the first learning stage (cognitive stage). To achieve this, we first conducted a study to observe the process of procedural learning in a Virtual Environment for Training (VET) prototype.

Method

Twelve students in their fourth year of engineering school specialized in computers science (Ecole Nationale d'Ingénieurs de Brest) were involved in this study.

The VET prototype used for this research, *Virtual Analyzer* (Le Corre, Fauvel, Hoareau, Querrec & Buche, 2012), is a virtual environment for blood analysis. The VET is connected

to a touch pad that reproduces the blood test launching interface linked to the VET. The learner acts in a 3-dimensional environment in which he/she has to perform a sequence of actions guided by audio instructions.

The experiment was carried out in two sessions. During the first session, the participants had to perform seven trials of a 125 steps procedure. After a one week delay, the participants came back for the second session, where they had to perform three additional trials of the same procedure.

For each trial, collected measures were: total time for the completion of the procedure, total number of consultations of the instructions and number of irrelevant actions.

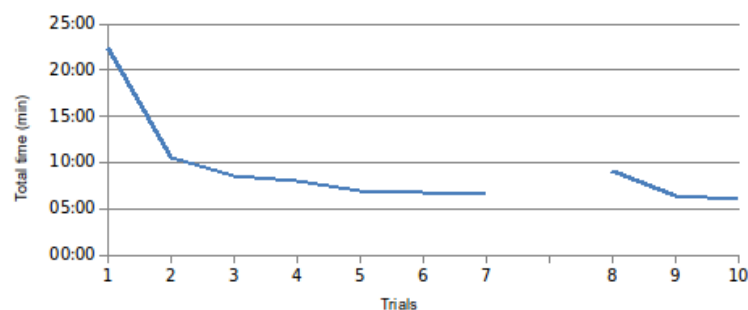
Results

The number of irrelevant actions could not be taken into account to analyze the results due to errors in the log files.

The other results of this experiment show a typical learning curve.

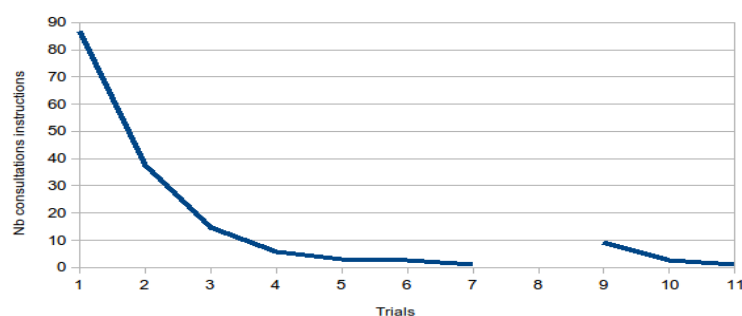
The total time to perform the task decreases with the number of trials (Figure 1). On the second test session, results show a statistically significant difference between trials 7 and 8, and between trials 8 and 9, but not between trials 9 and 10. There is no significant difference in performance between trial 7 and trials 9 and 10.

Figure 1: Total time for the completion of the procedure (in minutes)



The number of consultations of the instructions also decreases with the number of trials (Figure 2). At the beginning of the second session (trial 8), the number of consultations of the instructions increases significantly compared to the end of the first session (trial 7). Comparisons between trial 8 and 9 show a significant difference, and no significant difference between trial 7 and trials 9 and 10.

Figure 2 : Total number of consultations of the instructions



Discussion

The aim of this study was to investigate how learning and related cognitive load evolve when individuals have to learn a procedure in a virtual environment for training. The results are congruent with Fitt's (1964) and Anderson's (1983, 1995) models. Total time to perform the procedure and the number of consultations of the instructions decrease progressively with the repetition of trials. Meanwhile, after a one week delay, the number of consultations of the instructions shows that the procedure is not completely stored in LTM. Our future work will focus on design principles that can be applied to reduce the cognitive load in the first step of procedural learning.

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