ELECTROENCEPHALOGRAPHIC RESPONSE OF E-LEARNING TASKS ON A LEARNING MANAGEMENT SYSTEM: AN EMOTIONAL AND COGNITIVE APPROACH

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Abstract

The recent development of e-learning has allowed ubiquitous learning, becoming the center of the discussion of educational practice [1]. Nowadays, all university centers support their face-to-face courses with the use of digital platforms such as Moodle, WebCT, etc. In this sense, e-learning platforms should not only help the generation of excellent academic results but also involve students in the learning process. Certain studies show that students who are fully involved in learning are behaviorally, intellectually and emotionally implied with teaching tasks [2].

In adult education the study of theory and practice relegates emotions and put rationality first, reducing the role that emotions play in learning as motivators and in some cases as impediments to learning [3]. Because in non-attendance courses the emotional signals of the student are represented only by text on the screen, with the absence of facial expressions or body language, content or tone of the dialogue. A growing interest has emerged in the study of the role of emotions in online learning, in which the design of engaging and meaningful learning experiences must achieve cognitive, affective and social engagement [4].

There is a growing interest in the use of neuroscience in educational research [5]. The present study evaluates the emotional state of the student during autonomous online learning. Specifically, neuroscience devices such as an EEG electrocardiogram (EEG) a Galvanic skin response (GSR) and a Blood Volume Pulse (BVP) were used to measure differences in emotional metrics (emotional impact and valence) and cognitive metrics (attention, engagement, and memorization). Specifically, three types of activities found on a Moodle platform were tested: "Assignments," "Lessons" and a "Quiz test." Besides, self-reported metrics were used to assess the student's attitude towards the subject, previous experience and the relationship the student has with e-learning technologies.

The results obtained make it possible to determine the activation, impact and emotional valence, as well as the attention, engagement, and memorization that takes place before the activities to be carried out in the learning platforms. The results obtained allow us to design better learning and evaluation materials, through emotional control and the cognitive load produced.

Keywords: EEG, LMS, GSR, attention, engagement, memory, cognitive load.

1 INTRODUCTION

The Interactive learning environments respond to the actions that students have on it and are related to a type of active processing and engagement. The designers of these environments expect interaction with them to generate deep and desired cognitive processes that result in the construction of new knowledge. However, unfortunately, the desired results are not usually produced, as the environments end up imposing additional cognitive processing that makes it difficult for students to learn [5]. This study focuses on assessing the cognitive and emotional aspects of e-learning environments concerning traditional teaching and e-learning methods (mainly paper vs computer-based).

The investment of human and financial resources in the design and development of sophisticated online learning environments, aims to achieve efficiency in learning, allowing learning faster and without mental stress. Some authors believe that with a sufficient level of motivation students can learn in any environment, even those that are poorly designed [5].

If we focus on what we know about human cognitive architecture, it is assumed that it possesses several elements whose characteristics help to understand what cognitive processes and performance look like. One of the essential characteristics of our cognitive architecture is based on the ability to have a large amount of information almost unlimitedly. In this sense, the Long Term Memory (LTM) is associated with the knowledge organized in a schematic way, which has the function of not being changed
immediately through a restriction in the range of changes that occur in the information. On the other hand, Work Memory (WM) is a place for the processing of conscious information that keeps the information in the short term. Some authors argue that the WM is an independent component of our cognitive system or is even said to be an active part of the LTM. Specifically, WM has limitations in terms of duration and the ability to store new information, easily overloaded if pieces of new information are processed simultaneously. In this sense, the cognitive load that students experience during their learning may be caused by limitations in processing and may be determinant for learning as determined by the theory of cognitive load [6].

From the perspective of cognitive architecture, the correct design of interactive learning environments should support the acquisition and use of organized knowledge structures that reduce the irrelevant or unnecessary burden of WM. The unnecessary burden could make it difficult to allocate sufficient cognitive resources to processes that are essential for learning.

According to [6], part of the essential (or intrinsic) cognitive burden is caused by the complexity of the learning material or task. This complexity can be measured by the elements of information that must be processed simultaneously and by the degree of interactivity between these elements and the learner's experience with the task. Most approaches and techniques in interactive e-learning environments can generate essential and unnecessary cognitive processes. Contributing to both increasing and decreasing the cognitive load. Thus interactivity and learner control can help to learn but can also hinder it. By using appropriate levels of interactivity and control, together with specific design techniques, learning environments could be adapted to the true nature of human cognition.

Unlike essential load, a strange cognitive load is related to the diversion of cognitive resources to activities that are not relevant to learning and that are caused by poor design. An example of this inefficient design could be the separation in space and time through different web pages with hyperlinks, of elements related to the information to be processed in order to understand a message with instructions. In this situation the mental integration of the elements will require an additional search, matching and retention of information in WM, while some pieces of information will be located, attended or processed.

Most papers that evaluate the effectiveness of Moodle e-learning platforms study their background by using self-reported questions in quiz [7]. However, few use biosensors or neuroscience equipment to test the efficiency of the platforms. Thus, the main objectives of the study were: To bring improvements in affective terms of the learning platform of the university.

The focus of this work consists of evaluates the emotional state and the cognitive load while the student interacts with a Moodle e-learning platform in comparison with the same interaction that these students would do on paper. The instrumentation used a skin conductance sensor and an electroencephalograph (EEG).

2 METHODOLOGY

A total of 30 university students (15 women and 15 men) between the ages of 20 and 25 volunteered to participate in the experiment. The average age of the participants was 21.8 years (SD=1.471). All are students enrolled in a business administration degree from a Spanish university and were informed about the general nature of the experiment and the requirements if they agree to participate. The study protocol was approved through the ethics committee of Human Research of University of the Balearic Islands. For approval, the institution follows the neuroscience and business association.

The participants were part of an experiment with a total duration of 25 minutes. With the structure that can be observed in figure 1, consisting of a phase of habituation where the participant must perform a test of numerical calculations implemented in the software. The function of this block is to check that the participant understands the dynamics in order to carry out the subsequent calibration correctly. Next, a washout phase is carried out with the eyes closed, it is a period of relaxation with the eyes closed for one minute and a calibration, this task is performed in order to obtain the maximum level of stress of the participant and thus evaluate it individually, depending on their physiological response, for the subsequent analysis of their signal with respect to the evaluation material. Finally, four tasks were carried out that were presented randomly according to the subject of study.
The instrumentation used a skin conductance sensor and a 12-channel electroencephalograph (EEG). These high-level electrodes and multiple channels increase the precision and complexity of brain signal decoding; they represent the latest technology in neuroscience. All the instrumentation and stimulus presentations were synchronized with a common amplifier and its related software, such that we could obtain aggregate measures of arousal. Participants sat in comfortable chairs. The stimulus was presented randomly.

### Figure 1. Experimental process

2.1 Materials

The four tasks they carried out can be seen in figure 2 and consisted of two quiz tests, one on paper and the other on a Moodle platform. Both tests consist of three general culture questions (science, mathematics, and language) and four options each. The other two tasks consisted of reading a text and then answering a question about the text. Both texts were of equal length (102 words) and dealt with two simple nursery rhymes. Once the tasks were completed, the subjects answered a questionnaire about their relationship with the Moodle platforms (see table 2).

### Figure 2. Experiment condition at the washout process (left). SensLab Software by bitbrain to collect and experiment (right).
2.2 Metrics

The results obtained in the study show the main differences in terms of mean activation per unit of time. This metric measures the basal level of physiological activation produced by a stimulus, by a situation or task. Activation with values below zero reveals a state of relaxation or calm and values above show a state of excitation of the subject.

The average emotional impact per time unit was also recorded, i.e., the number and intensity of specific changes in the emotional state produced by a stimulation, external event or the performance of a task (something that attracts special attention, produces excitement or stress). Expressed in as many percents, so 100% indicates variations of higher intensity than those generated by the calibration material.

Another metric used was the average number of hits and the average intensity of those hits. This metric show which tasks and when a cognitive load is performed. In the same way, attention metrics were used, i.e., focusing on the task. The engagement or connection or implication with these tasks was also measured.

Finally, a memory metric was used to record the intensity of the cognitive processes related to the formation of future memories during the presentation of the stimulus. This metric allows us to understand the degree of storage, coding, and retention in memory.

3 RESULTS

Table 1 shows the self-reported items related to the relationship to digital platforms and technology. The students analyzed are experienced in learning platforms such as moodle with an average of 6.20 years (SD = 2.2828). In general, the students are satisfied with their academic performance and prefer the use of paper to learn (X=5.96), not preferring the use of digital devices for learning (3.56) (t student = -4.406; p < .005; dif = -2.40). They also consider that it is easy for them to consult information on digital devices and their relationship with technology is good.
Concerning the results of the EEG and the GSR, we observe differences between the tasks performed being more favorable cognitive load metrics for tasks performed on paper versus those performed on the Moodle platform. In particular, no differences were found in the reading task, but there were differences in the performance of the Quiz test.

4 CONCLUSIONS

This study has double value, first, for students and secondly for teachers and designers who must incorporate into their training program courses that promulgate various tools that allow the students to achieve success and less frustration in their academic accomplishments and subsequent professional success.

Among the main conclusions of this study, the highlights are as follows: When designing e-learning platforms, it is essential to assess the cognitive load of the designs — preferring those simpler designs that make less use of the cognitive load that requires greater use of WM. Specifically, it is intended that the attention and engagement generated by the tasks are positive, producing a positive action on memorization and learning.

Among the limitations of the study, we used only one Spanish university. In this sense, it is proposed to extend the sample to different geographical areas. In the same way, it is interesting to measure the performance of the student throughout the use of different moodle design in order to produce a common characteristic that maximizes the outputs in cognitive and learning terms.

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