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Use of animated text to improve the learning of basic mathematics

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ABSTRACT

A small detail can have large consequences. Current technological systems have opened up a huge world of possibilities for teachers at all levels and in every field. This research study concerns the role that can be played by technological resources to improve or promote the cognitive processes that make understanding and learning possible. More specifically it is meant to examine, within the framework of the Cognitive Theory of Multimedia Learning and of the Cognitive Load Theory, put forward by Mayer and Sweller respectively, the benefits that the introduction of slight changes in multimedia materials – in this case, the application of an animation effect to a handwritten text of a mathematical nature – can have over learning quantity and quality. The study involved 255 students in the 2nd and 3rd years of the Spanish secondary education (Educación Secundaria Obligatoria, ESO), who received a computer-based lesson in video podcast format about elementary event probability. Results suggest that suitable inclusion of an animation effect in the materials can facilitate the cognitive processes that specialise in selecting information, building representation models, and making sense, thus promoting students' learning ability.

1. Introduction

Current computer tools make it possible for teachers to create attractive and versatile teaching electronic materials providing information in the form of text and images, moving graphic elements as well as synchronised verbal information. These multimedia materials are finally "packaged" in computer files so that they can be distributed online and reproduced on any fixed or mobile digital device when needed.

However, the main interest of this study does not lie in the medium or specific type of technology used in education (which corresponds to the classic view of educational technology and its applications; cf., among others, Clark, 1994; Kozma, 1994), but in how, when, and what characteristics of instructional materials (in this case electronic and multimedia materials) enhance the cognitive processes that lead to understanding, and thus to meaningful learning.

The specialised research performed within the field of Cognitive Psychology over the last two decades has contributed endless empirical studies in which specific characteristics of the instructional materials seem to facilitate knowledge acquisition (Mayer, 2009), as well as the development of learning strategies and effective tools of intellectual work (Heilesen, 2010; Jarvis & Dickie, 2009; Leijen, Lam, Wildschut, Robert-Jan Simons, & Admiraal, 2009; McCombs & Liu, 2007). The Cognitive Load Theory put forward by Paas and Sweller (2014) and Sweller (1999), and the Cognitive Theory of Multimedia Learning proposed by Mayer (2009, 2014) are the result of the research performed and constitute the theoretical framework of this work.

2. The animation effect in video podcast materials

2.1. Video podcast materials

Digital materials of diverse nature and condition (text, diagrams, pictures…), accompanied by a synchronised (verbal) narrative, which are "saved" in a computer video file which can be distributed online and played on a computer, tablet, smartphone, etc. are known as video

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podcasts (McGarr, 2009), although the terms *podcast*, *vodcast*, *webcast*, and sometimes even *video streaming* are used. As for its modes of use and within the field of education, video podcasts are used in lessons directly taught by a teacher; ad hoc lectures given by experts; speeches and brief demonstrations about specific problem-solving processes; etc. (Crippen & Earl, 2004; Griffin, Mitchell, & Thompson, 2009; Kay, 2012; Loomes, Shafarenko, & Loomes, 2002; Vajoczki, Watt, Marquis, & Holshausen, 2010; Wang, Mattick, & Dunne, 2010).

As regards the use of materials in video podcast format, researchers have given a series of reasons that strongly support their presence in the field of education (see the review performed by Kay, 2012), and five of them explain the choice of this format to produce the learning materials (the number of selected studies that support them is given in brackets): improvement of learning (23 studies); generation of positive emotional attitudes towards learning (14 studies); generation of efficient cognitive attitudes (15) studies; promotion of behavioural changes that promote learning (17 studies); improvement of academic performance (learning outcome) (11 studies).

2.2. Object animation

(Computer) animation is based on the generation and sequential presentation of a number of independent frameworks in which the object(s) represented are gradually modified to simulate movement, which makes it possible to view many different types of processes and dynamic phenomena.

From a physical or simply a perceptual point of view, the notion of animation is understood as the capacity of a material, or portion, to recreate movement (Baek & Layne, 1988). However, from a psychological point of view and as regards the theory of information processing, the notion of "movement" is enriched by targeting the effects that an animated element can have on the cognitive processes leading to the building of the mental representation model in order to facilitate them (Gonzalez, 1996).

In sum, what is shown by both points of view, and the assumption underlying this piece of research, is: (1) the technical effectiveness required to simulate the movement of real or represented objects; (2) the link between a physical feature of the learning materials, such as the animated presentation of part of their materials, and the way in which the human cognitive system processes information in its search for understanding (Mayer, 2009).

Presentation of animated objects has many features and can be applied in many fields, and its use in a learning environment is based on its ability to represent dynamic processes and moving devices (e.g. machines, natural phenomena, chemical reactions, etc.) which could not be provided in a slow, safe, simplified, or repeated manner for reasons of size, cost, speed, risk, or complexity (cf.: Mayer & Anderson, 1992; Mayer & Moreno, 1998, 2002, 2003; Moreno & Mayer, 1999, 2000a, 2000b; Paik & Schraw, 2013).

2.3. Animated symbolic text in video podcast

The animation effect examined in this study has been applied to the writing of mathematical formulae in learning materials in a video podcast format, with a twofold goal in accordance with the Cognitive Theory of Multimedia Learning (Mayer, 2009, 2014):

1. Establishing a working or action framework whose interest lies in learning, not in the use of technology in the field of educations (technology-focused view).
2. Facilitating information processing and thus the cognitive processes that make it possible to understand and learn: (1) maximising the learner's attentional resources, avoiding costly visual search processes; (2) optimising the working memory's processing capacity through the synchronised presentation of visual and aural information; (3) avoiding working memory overload by reducing the processing of irrelevant and even inappropriate information.

According to the basic premises of the Cognitive Theory of Multimedia Learning, information is received through the sight and hearing, and is immediately transferred to the sensory memory, where it is stored for a few seconds before fading. The second step, already controlled by the individual's attention processes, requires the ***selection*** of relevant information from the sensory memory and its transfer to the working memory. The third step lies in the ***organisation*** of information in such a way that the mental model of meaning representation can be created. And the fourth and final step consists in the creation of a new mental model as a result of the ***integration*** of the newly-built model with the existing knowledge model retrieved from the long-term memory. The ***active processing*** performed by the learner in his effort to understand finally leads to the emergence of meaningful learning.

Thus, if the cognitive processes that lead the understanding progress depend on the attentional resources devoted to the task, then the inclusion of elements or characteristics in learning materials that promote these aspects may have beneficial effects on their processing and learning outcomes. Research shows than animated elements not only lead attention towards relevant matters in the materials (Mayer & Johnson, 2008), but when they are also offered in coordination with the verbal narrative, learning is doubly facilitated by the temporal and spatial closeness of their presentation: cognitive temporal and spatial contiguity effects (Mayer & Anderson, 1991, 1992; Mayer & Sims, 1994), and cognitive split-attention effect (Ayres & Sweller, 2014). In this way, the synchronisation is done through the fact that the symbolic text is been written by hand while the explanation is narrated. So this will make the attentional resources focus on leading and managing the active cognitive processes of selection, organisation, and integration.

Another key aspect of the Cognitive Theory of Multimedia Learning is related to the existence of two subsystems for the processing of information according to Paivio's dual-coding theory (1986, 1991) and Baddeley's model of working memory (Baddeley, 1986, 2000, 2003). Thus, the type of information received determines the channel through which it is processed in the working memory. If the information is of a visual nature, it will be perceived by the eyes and processed through the visual channel of the working memory. However, if the information is aural, it will be perceived by the ears and its cognitive processing will take place in the aural channel of the working memory. In this way, pictures, graphic elements and symbolic information (for example, mathematics formulae texts) in multimedia materials will be presented to the eyes and processed through the visual channel of the working memory (with the exception of written text appears to be processed in the auditory channel), unlike spoken texts and other aural information, presented to the ears, which will be processed through the auditory channel.