DIGITALEDUCATIONREVIEW

# Multimedia, emotions, and learning experience

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## ABSTRACT

This paper considers emotions and learning through multimedia learning, mediated message processing, and affective computing. In multimedia learning, the emotional design includes all relevant features from the visual design, so emotional and motivational features are given through visual appeal. The Limited Capacity Model of Motivated Mediated Message Processing describes emotions as a product of motivated cognition. It explains how to create the message that will most likely fulfil its communication purpose. Through affective computing, adaptive and multimodal learning, aim is to reduce the gap between instructional message design, and the learner's cognitive and emotional mental model. The paper aims to outline emotions and learning considering multimedia learning, motivated mediated message processing, and affective computing as three perspectives in creating a learning experience.

KEYWORDS: Emotional design, motivated cognition, mental models, multimedia learning, learner experience, mediated message processing, affective computing.

## 1 INTRODUCTION

In the field of human-computer interaction, design and emotions have been investigated over the last 20 years. Norman (2004) presented the concept of emotional design to emphasize the importance of emotions for user experience (UX). “The concept addresses the task-related view of system usability while expanded through non-instrumental, affective, and experiential aspects” (Hassenzahl & Tractinsky, 2006 as cited in Heidig et al., 2015, p.). Desmet (2012) described the overall emotional responses of a user considering a wide range of positive emotions like pleasure, trust, joy, relaxation, satisfaction, and negative emotions such as fear, anxiety, frustration, annoyance, anger, and confusion. However, by managing cognitive and emotional friction through the design task, it is possible to avoid emotions related to poor usability and negative user experience. Positive emotions, worthwhile for user experience, are addressed in the term “joy of use”. Thus, Hassenzahl et al (2001) stated that the most basic reason for considering this term is the importance of enjoyment for human life. In line with this, the Control Value Theory of Achievement Emotions shows that learning can be made easier through positive achievement emotions (Pekrun, 2006; Guo et al., 2018.). The learning environments must build learner experiences through positive emotions and motivation. Since motivation allows the learner to put more effort into understanding the learning content, the emotional design elements contribute to integrating motivational and cognitive processes (Mayer, 2014a).

Multimedia learning brings about the instructional message that promotes knowledge acquisition by combining words and pictures (Mayer, 2001, 2009, 2020). An emerging trend in human-computer interaction has user experience in mind, so learning designers consider learner experience design. To encourage motivation and positive emotions, researchers within multimedia learning deal with emotional design especially focusing on the visual attractiveness of graphic elements as a very relevant research issue (Um et al., 2012, Mayer and Estrella 2014, Schenider et al., 2018, Li et al., 2020). “The results show clear evidence that emotional design has positive implications for learning outcomes, however, it is a rather complex concept, which gives it some inconsistencies” (Rodrigues & Silva, 2022).

Besides, in the field of media and communication, emotions and motivation have been investigated through motivated cognition and mediated message processing. Describing emotions as a product of motivated cognition, the LC4MP explains how to create a message that will most likely fulfil its communication purpose (Lang, 2017). The model conceptualizes communication as a dynamic, fundamentally human-centered process considering the totality of a mediated message's forms. It has already been used efficiently for understanding different types of messages, such as political or health messages. Despite its potential for human-computer interaction and educational multimedia, the model has not been sufficiently investigated to explore novel questions and incorporate new methodological approaches (Fisher et al., 2018).

The development of multimedia instructional messages copes with both multimedia and instructional design. While multimedia design aims to integrate different forms of media, instructional design deals with learning strategies and specific learning outcomes. On the other hand, multimedia instruction inherits all of the design problems related to human-computer interaction (Hede, 2001), so the concepts of functionality and usability, as well as the experience of a user or learner, are of utmost importance. Learning experience includes learner emotions and motivation. Thus, through the lens of affects and arousal, we look at multimedia learning, motivated mediated message processing, and affective computing as three interconnected perspectives in creating learning experience.

## 2 THEORETICAL FRAMEWORK

In multimedia learning the starting point is the Cognitive Theory of Multimedia Learning (CTML) which explains how to promote learning by using words and pictures. Humans have an auditory channel and a visual channel for receiving information. Also, learning is an active process of filtering, selecting, organizing, and integrating information. In multimedia learning, both channels are combined to prevent information overload and promote information processing (Mayer, 2001, 2009, 2020). Furthermore, the Cognitive Affective Theory of Learning with Multimedia, CATLM (Moreno, 2006) expands the CTML concerning motivational influences on knowledge acquisition. Through interactive learning, simulations, and virtual reality, the CATLM added emotional and motivational aspects and metacognitive strategies into Mayer's multimedia learning principles (Moreno & Mayer, 2007).

Lastly, to highlight that cognitive and affective processes cannot be separated, Plass and Kaplan (2016) developed the Integrated Cognitive Affective Model of Learning with Multimedia, ICALM. The model proposes that successful multimedia learning arouses the learner's interest while not overloading the working memory. The authors emphasize that "to fully understand how we process the world around us, we need to consider our affective responses to the information we perceive. This is especially important for the designers of digital educational materials, as these materials offer many important opportunities to incorporate emotional considerations." (Plass & Kaplan, 2106, p. 131).

This model aims to generate inquiries for future research within this domain, incorporating components from Pekrun's (2000) Control-Value Theory of Achievement Emotions, Picard's (1997) Affective Computing approach, Izard's (2007) Differential Emotions Theory, and Moreno and Mayer's (2007) Cognitive Affective Theory of Multimedia Learning. Their integrative approach to cognition and emotion signifies a significant advancement in aligning multimedia learning designs with the intricate dynamics of how the human mind operates and evolves. Therefore, they explored the implications of this approach for the design and research in digital learning environments, encompassing areas such as simulations, games, and virtual worlds.

Furthermore, in the area of media and communication there are studies on motivated cognition and limited working memory capacity. Studies include orienting responses (OR) of people while processing mediated messages. Former, the Limited Capacity Model of Mediated Message Processing, L3CMP, deals with information overload by analyzing how people process media content (Lang, 2000). The Limited Capacity Model of Motivated Mediated Message Processing (LC4MP) expands the previous model by including emotions through motivated processing and motivated cognition (Lang, 2006a, 2006b).

Ultimately, as a third viewpoint, we contemplate Affective Computing (AC) in its connection to influence on learning. This expanding multidisciplinary domain delves into how technology can contribute to comprehending human affect, the impact of affect on interactions between humans and technologies, the design of systems to harness affect for improved capabilities, and the ways in which sensing and affective strategies can revolutionize interactions between humans and computers (Daily et al., 2017).

Overall, in human-computer interaction and instructional message design, a positive user or learner experience is created through emotion and motivation. To achieve a more personalized experience, reducing the gap between message design and both cognitive and emotional learner's mental model is being carried out through multimodality and adaptivity. A new generation of educational systems named ATSs (Affective Tutoring Systems) possess emotional intelligence (Petrovica et al., 2017, Hasan et al., 2020).

Affective computing (AC), founded by R. Picard (1997), is the field that includes artificial intelligence (AI), cognitive psychology, and physiology, describing the computer's capability to recognize, model, respond, and express emotions and effectively interact with users. The learning experience encompasses the emotions and motivation of the learner, mediated through affects and arousal. Therefore, we view multimedia learning, motivated mediated message processing, and affective computing as three interrelated perspectives in shaping a learning experience.

## 3 EMOTIONAL DESIGN IN MULTIMEDIA LEARNING

User interfaces enable communication through visual elements (i.e. color, size, shape) that are expected to be visually and emotionally appealing (Silvennoinen, 2016). In multimedia learning, relevant features from visual design are included in the emotional design to emphasize motivational and emotional elements through visual appeal (Mayer, 2014a). The initial research on inducing positive emotions through visual appeal was conducted by Um et al. (2012). Using warm colors and round, anthropomorphic, cartoon-like figures as visual design elements, the research showed an increase in learning outcomes regarding motivation, transfer, and comprehension.

Altogether, previous research has shown that visual design elements can induce positive emotions that facilitate cognitive processes and promote learning. Although Plass et al. (2014) did not get results that fully matched the initial research results by Uhm et al. (2012), they also found that particular design of color and shape can enhance learning. With the same materials as in Plass's studies, Park et al. (2015) did not find that anthropomorphic design elements improve learning outcomes. Yet, the results indicated the important role of emotional states before learning and the effects of arousal and attention regarding expressive anthropomorphisms. By exploring the possible advantages of anthropomorphism in decorative pictures, Schneider et al. (2018) confirmed the relevance of anthropomorphized pictures for learning. To replicate findings from Plass's studies, Mayer and Estrella (2014) used animated learning materials. Although there was no effect on learning enjoyment, they found evidence similar to Um et al. (2012). The findings were generally consistent with the Cognitive affective theory of learning with multimedia. Altogether, studies address the importance of incorporating affects into cognitive principles of multimedia learning (Park et al., 2014).

Furthermore, to determine relevant design features, Heidig et al. (2015) adopted concepts from web design. They found that perceived aesthetics and usability positively affected students' emotional states. Objective differences in aesthetics or usability had no impact on learners' emotional states. Students' emotional states had little effect on learning outcomes, but a more significant effect on intrinsic motivation to learn. Münchow et al. (2017) supported that positive influences triggered by specific design features, such as "warm" colors and rounded shapes, can facilitate

learning if initial affective states are considered. Compared to an affectively neutral environment, learners in an affectively positive environment were superior in comprehension and transfer when the initial affect was strong. Accordingly, “a technology designer working with emotions should be able to identify and measure emotional profiles or pre-existing individual or contextual characteristics that can influence the effectiveness of emotion-based technological services.” (Tiberti et al., 2017, p.3). Besides, Stark et al. (2018) showed the benefits of the emotional design considering textual elements of the multimedia instructional message. Plass et al. (2021) summarized research on the effect of emotion-inducing features in multimedia learning, providing empirical evidence for the emotional design principle. Rodrigues & Silva (2022) state: “The results show clear evidence that emotional design has positive implications for learning outcomes, however, it is a rather complex concept, which gives it some inconsistencies”.

Compared to studies that show how emotional design elements can positively influence learning, the analyses of seductive details as design features, to some extent, have shown the opposite. Seductive details are aimed to trigger learners’ interest (Magner et al., 2014). They have been included in multimedia learning through the coherence principle. The principle states that adding learning relevant graphics to words fosters learning while adding irrelevant graphics does not (Mayer, 2009). Yet, Tislar & Steelman (2021) stated that negative influence of interesting but irrelevant material to a lesson needs to be qualified. Thus, when concluding about decorative pictures (DP), Scharinger (2022) emphasized that DP increased learners' interest and enjoyment and recommended DP to spice up learning materials. Besides, Park et al. (2011, 2015) showed that seductive details do not hamper learning when cognitive load is low, and there are enough cognitive resources. Considering the Integrated cognitive-affective model of learning with media (ICALM; Plass & Kaplan, 2016), elements such as decorative pictures can influence motivation and emotions since arouses the learner’s interest (Mikheeva et al., 2021).

Also, arousal is the central dimension in the PAD model where Pleasure, Arousal, and Dominance are three numerical dimensions. It is the psychological model proposed by Mehrabian and Russell (1974) to represent all emotions using the Pleasure - Displeasure, Arousal - Nonarousal, and Dominance - Submissiveness scale (as the ability to assert oneself). Russell (1980, 2003) proposed arranging all emotions in a circle controlled by two independent dimensions, hedonic ranging from ‘pleasant’ to ‘unpleasant’, and arousal ranging from ‘rest’ to ‘activated’. Schneider et al. (2016) showed that emotionally positive pictures increase the perception of pleasure, arousal, and dominance. Also, retention and transfer performance were enhanced. Besides, Magner et al. (2014) showed that decorative illustrations fostered far transfer by enhancing situational interest and supporting the interplay between cognitive and motivational factors. These results have shown early evidence to improve learning through decorative illustrations. Later, by using data on learning performance, cognitive load, motivation, heartbeat frequency, and electro-dermal activity, Schneider et al. (2019) indicated that a learner's state of arousal can moderate the effect of seductive details.

In the area of communication and media, there are models and theories on mediated message processing. Those models deal with arousal, motivation, and cognition (Lang, 2000; Lang, 2006a) emphasizing the important role of motivational activation in information processing (Norris et al., 2010).

## 4 MOTIVATED COGNITION AND MEDIATED MESSAGE PROCESSING

According to dual motivational theory (Cacioppo and Gardner, 1999), humans have appetitive and aversive systems, and their activation elicits positive and negative emotions. The Limited Capacity Model of Motivated Mediated Message is a theoretical framework that combines the dimensional theory of emotion (Rubin & Talarico, 2009) with a dual motivational systems model (Bradley et al., 2001) and a limited capacity information processing. Constitutive to the LC4MP is the concept of motivated cognition, meaning that motivationally relevant content of mediated message activates the appetitive and/or aversive system (Lang, 2006a). The appetitive system responds automatically to positive stimuli supporting approach behavior such as paying attention and gathering information stimuli, while the aversive system responds automatically to negative stimuli (Lang et al., 2013). In LC4MP, motivation is viewed as “the very beginning of a causal chain of responses that leads from a stimulus to an emotional feeling or experience” (Lang, 2006a, p. 245).

Chung et al. (2015) investigated learning performance considering LC4MP and instructional animation. They discussed the effects of calming positive or negative emotions and arousing positive or negative emotions. Before presenting the instructional material, emotions were induced by the preceding video with four different emotional tones regarding valence and arousal. Thus, calm included both positive and negative, and arousing included both positive and negative. Instructional animations were given with different modalities. The results showed that both arousing groups outperformed calm groups on a recall test only in the written-text group regardless of valence. Emotional valence and arousal did not significantly influence learning performance in the spoken-text group. Thus, the results provide partial support for the LC4MP model and imply that the arousing emotional state can enhance multimedia learning. In the later study, by using background images, Chung and Cheon (2020) investigated how valence and arousal of emotional learning content influenced learning. The between-subjects experiment, 2 (valence: positive, negative) × 2 (arousal: moderately low, moderately high), for both recognition and cued-recall test scores, showed significant interaction effects implying the positive effects of using moderately low arousing negative images. Although both scores were significantly lower for moderately high arousing negative images, they did not differ with increasing arousal of positive images. The findings emphasize the importance of investigating optimal levels of valence and arousal in emotional design. Nevertheless, a message will be better processed, stored in memory, and retrieved if there is sufficient cognitive capacity (Lang, 2000). Accordingly, the Cognitive Theory of Multimedia Learning (Mayer, 2001) states that using spoken language and animated graphics can be helpful if the message is difficult to process (Fox et al., 2004).

In general, information processing can occur through automatic and controlled mechanisms. An audience controls message processing regarding specific goals and interests. By managing the content and structural features of the message, such as arousing content, movement, changes of scene, or camera changes, or dealing with different multimedia elements, it is possible to influence the automatic processing of the message. "It has been shown that many structural features of media messages (e.g., camera changes, animations, voice changes, sound effects) and personally salient stimuli (e.g., an individual’s name or information relevant to an ongoing goal) elicit orienting responses (ORs) in media users..." (Lee & Lang 2015, p. 602). Automatic and

controlled processing can influence cognitive capacity. Therefore, it is achievable to create a message that will most likely fulfil its communication purpose, whether learning, persuasion, behavioral change, or entertainment. The prediction that greater motivational activation leads to better message storage is based on the motivated cognition perspective, meaning that motivationally essential things should be remembered (Lang et al., 2013). A more general theory named the Dynamic Human-Centered Communication Systems Theory or DHCCST (Lang, 2014) describes why pictures, when compared to words, elicit more significant emotional responses while explaining it from evolutionary psychology and motivated cognition perspective.

Certainly, all mental processes are somehow motivated. Mental processes construct mental models as frameworks through which human beings interpret the world. From the time of its origin, the mental model concept is continuously used by applied researchers in the fields such as communication, human-computer interaction, and education.

## 5 MENTAL MODELS, ADAPTIVE LEARNING AND AFFECTIVE COMPUTING

"The mental model construct is used to describe the kind of mental representations individuals build when they reason about a certain matter; a mental model is an internal representation of a real or fictional state of affairs, and is usually built on-the-spot to deeply understand and reason about the state of affairs. Mental models that become permanent through cognitive or physical practice are schemas. Learners construct mental models in response to specific learning situations for which no schema is available or the available schema does not fit the situation. In other words, when confronted with new learning tasks, learners have to construct a mental model integrating their pre-existing knowledge and the new information from the learning environment, along with proper inferences that can be drawn from these." (Bucciarelli & Cutica, 2012). However, if a model is not appropriate, it can cause ineffective learning (Jih & Reeves, 1992). Therefore, learning designers consider the learner's mental model to avoid a negative influence on the learning process and promote a positive learning experience. Learner experience design or learning experience design is an emerging approach that uses methods from related design disciplines such as user experience design, moreover, it considers user experience design an integrated part of learning experience design (Kapros et al., 2018).

According to Hede (2002) the mental model of learning, learning activities, and learning orientation are included in a learner's 'learning style'. In the emerging field of neuroeducation, recent literature suggests that there is currently no evidence to support the learning styles theory (Newton et al., 2021). Today, multimodal learning analytics (MMLA) encompasses multimodal teaching and learning, multimodal data, and computer-supported analysis while dealing with data for modelling learning in complex learning environments (Worsley, 2018). Let us consider the example of language learning language learning, Notaro and Diamond (2018) described multimodal data as different data types handling the face, body, and tone of voice or including EEG, eye-tracking, or multimodal data such as images, audio, video, annotated media, as well as behavioral data such as cursor movements and clicks. Handling overall collected data enables system adaptivity and results in personalized information environments. Scheiter et al. (2017) described the multimedia learning environment that monitors the students' learning by registering and analyzing students' eye movements and their knowledge by employing rapid assessment tasks. Moreover, the learning environment offered either assistive or directive adaptivity through instructional prompts or changes in the design of the learning materials and challenges in the design to discuss. As the reason for the lack of consistency in so far studies, Rodrigues and Silva (2020), emphasized the complexity of the emotional design. In their study, 20 eligible documents about emotional design in multimedia learning were searched from the Web of Science and EBSCO databases. Although the emotional design has positive implications for learning outcomes, the results showed some inconsistencies as it is a rather complex concept. Riemer and Schrade (2019) investigated how learning-centered emotions and self-monitoring influence mental model development in multimedia learning. The study showed the joint effects and the relative importance of emotions and self-monitoring for mental model development in multimedia learning.

Nowadays, artificial intelligence strives to improve systems' behavior by considering users' cognition and emotions. On the other side, Goleman (1995) defined human emotional intelligence features, which are of great interest in affective computing. Thus, Intelligent Tutoring Systems (ITS) aim to support the teaching and learning process by simulating human tutors to provide benefits to the individual who is being taught. By exploiting methods of artificial intelligence through a personalized learning environment, such systems offer a learning environment adapted to the characteristics of an individual. Since ideas from affective computing came into the development of ITSs, a new generation of educational systems appeared – ATSs (affective tutoring systems). That way, ITSs evolve towards systems possessing emotional intelligence (Petrovica et al., 2017, Hasan et al., 2020).

## 6 CONCLUDING REMARKS: TOWARD THE LEARNER EXPERIENCE

The paper delves into the three perspectives on seeing emotions in learning: multimedia learning, motivated mediated message processing, and affective computing. The importance of considering emotions, arousal, and motivation in the design of multimedia instructional messages is evident through the research on emotional design in multimedia learning. Also, there is the crucial role of emotional design in the fields of human-computer interaction and instructional message design, particularly in the context of multimedia learning and affective computing.

Theoretical frameworks from multimedia learning, such as the Cognitive Theory of Multimedia Learning (CTML), the Cognitive Affective Theory of Learning with Multimedia (CATLM), and the Integrated Cognitive Affective Model of Learning with Multimedia (ICALM) provide foundations for understanding how cognitive and affective processes interact in multimedia learning. Evidently, the analysis of emotional design in multimedia learning reveals that visual elements and design features can induce positive emotions, ultimately influencing cognitive processes and promoting effective learning. From the perspective of media communication, the Limited Capacity Model of Motivated Mediated Message Processing (LC4MP) and its emphasis on motivated cognition play a central role in understanding how emotions are processed in mediated messages. However, despite its potential, it is shown that the model has been poorly explored in the context of human computer interaction and instructional message design.

Furthermore, the exploration of mental models and adaptive learning underlines the significance of aligning instructional design with learners' mental models to ensure a positive learning experience. The mental model concept is observable through the concept of learner or user experience. Nowadays, by considering people's mental models as cognitive and emotional, artificial intelligence endeavors to predict what users or learners "like and feel". The evolving of Affective Tutoring Systems (ATSs) and the integration of emotional intelligence in Intelligent Tutoring Systems (ITSs) reflect a broader trend toward personalized and emotionally intelligent educational environments. The integration of emotions and motivation into the design process is presented as essential for creating positive user or learner experiences. In essence, the paper underscores the interconnectedness of cognitive and affective processes in human-computer interaction and instructional design. The call for future research signals a commitment to advancing our understanding of how emotions shape the learning experience in the digital age.

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## MULTIMÈDIA, EMOCIONS I EXPERIÈNCIA D'APRENENTATGE

Aquest article considera les emocions i laprenentatge a través de laprenentatge multimèdia, el processament de missatges intervingut i la computació afectiva. A l'aprenentatge multimèdia, el disseny emocional inclou totes les característiques rellevants del disseny visual, per la qual cosa les característiques emocionals i motivadores es donen a través de l'atractiu visual. El model de capacitat limitada de processament de missatges intervingut i motivat descriu les emocions com un producte de la cognició motivada. Explica com crear el missatge que amb més probabilitat complirà el seu propòsit comunicatiu. A través de la computació

afectiva, laprenentatge adaptatiu i multimodal, lobjectiu és reduir la bretxa entre el disseny del missatge instructiu i el model mental cognitiu i emocional de lalumne. L'article té com a objectiu delinear les emocions i l'aprenentatge considerant l'aprenentatge multimèdia, el processament de missatges motivat i la computació afectiva com a tres perspectives en la creació d'una experiència d'aprenentatge.

PARAULES CLAU: Disseny emocional, cognició motivada, models mentals, aprenentatge multimèdia, experiència de l'aprenent, processament de missatges mediat, informàtica afectiva.

## EXPERIENCIA MULTIMEDIA, EMOCIONES Y EXPERIENCIA DE APRENDIZAJE.

Este artículo considera las emociones y el aprendizaje a través del aprendizaje multimedia, el procesamiento de mensajes mediado y la computación afectiva. En el aprendizaje multimedia, el diseño emocional incluye todas las características relevantes del diseño visual, por lo que las características emocionales y motivadoras se dan a través del atractivo visual. El modelo de capacidad limitada de procesamiento de mensajes mediado y motivado describe las emociones como un producto de la cognición motivada. Explica cómo crear el mensaje que con mayor probabilidad cumplirá su propósito comunicativo. A través de la computación afectiva, el aprendizaje adaptativo y multimodal, el objetivo es reducir la brecha entre el diseño del mensaje instructivo y el modelo mental cognitivo y emocional del alumno. El artículo tiene como objetivo delinear las emociones y el aprendizaje considerando el aprendizaje multimedia, el procesamiento de mensajes mediado motivado y la computación afectiva como tres perspectivas en la creación de una experiencia de aprendizaje.

PALABRAS CLAVE Diseño emocional, cognición motivada, modelos mentales, aprendizaje multimedia, experiencia del aprendiz, procesamiento de mensajes mediato, informática afectiva.

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