A systematic review of emotional design research in multimedia learning

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Abstract

This study provides a current systematic review of emotional design research in the multimedia learning domain and explores how emotional design is studied in multimedia learning. All studies on emotional design in multimedia learning published until 2023 were examined thoroughly. In this study, 51 journal articles were identified based on PRISMA guidelines and reviewed regarding emotional state parameters, emotional design techniques, emotional and other measurements, learning materials, research methodologies, and learning outcomes. The analysis provided several salient findings. Firstly, there has been growing interest in emotional design. Secondly, the impact of emotional design on learning outcomes, emotional states, motivation, and cognitive load was explored. Thirdly, most studies preferred subjective measurements or indirect objective measurements. Fourthly, there was a tendency to examine the effects of shape and color elements in the emotional design techniques. Lastly, the studies reported contradictory results on learning outcomes but agreed that emotional design had a positive impact on motivation and emotional state. This review highlights research gaps and provides recommendations for future studies in the field of emotional design in multimedia learning.

Keywords Emotional design · Multimedia learning · Emotion · Systematic review

1 Introduction

Cognitive theories such as the Cognitive Theory of Multimedia Learning, Cognitive-Affective Theory of Learning with Media (CATLM), and Cognitive-Affective Model of e-learning (CAME) have largely formed the basis of studies on multimedia learning

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since the early 1980s. These studies, especially those conducted within the framework of the Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2002), investigate which multimedia designs are more effective for enhancing learning. CTML is based on three cognitive assumptions: dual channels, limited capacity, and active processing. It is known that the sensory system, attention, working memory, and long-term memory are involved in the learning process when learners interact with multimedia material (Mayer, 2019). Emotional design has come to the forefront with the increase in studies showing that the emotional features of the environment, people, objects and context in which learners interact affect the cognitive processes of learners (Clark & Mayer, 2016; Moreno & Mayer, 2007). It is believed that a more holistic learning structure can be achieved by preparing multimedia materials that consider both the affective and cognitive characteristics of learners.

Based on Mayer's Cognitive Theory of Multimedia Learning (2002), the Cognitive-Affective Theory of Learning with Multimedia (CATLM), proposed by Moreno (2006), seeks to elucidate the relationship between emotions and cognitive processes. The theory details the relationship between cognition, affect, and metacognition to consider motivation and affective elements. Affective mediation, metacognitive mediation, and individual differences factors have been integrated into CTML. Researchers tried to improve multimedia learning by taking advantage of emotional-motivational factors. The motivation that influences learners' cognitive processes plays a mediating role in the learning process (Pintrich, 2003). Learning is also mediated by metacognitive strategies that regulate cognitive and affective processes (Moreno & Mayer, 2007). Research based on these approaches pointed to studies of emotional design. The emotional design hypothesis assumes that design techniques that aim to influence emotions will affect learning outcomes (Park et al., 2015). The use of visually appealing multimedia design elements in educational materials has been shown to enhance student motivation and engagement. Therefore, it is important to ensure that the visual design of multimedia materials is aesthetically pleasing and motivating. Emotional design has been tested by many different studies on this hypothesis. Emotional design of multimedia learning involves making graphics more appealing with features such as color, shape, or human-like appearance (Mayer & Estrella, 2014; Um et al., 2012a).

In a similar vein, emotions include interrelated psychological processes consisting of cognitive, psychological, emotional and motivational components (Pekrun et al., 2002). Barrett et al. (2007) stated that emotions emerge after a cognitive event. The concepts of emotion, sentiment, valence, mood, arousal, and affect were used in the research. Attempts have been made to explain these concepts, which were sometimes used interchangeably, through the use of different definitions and measurements. Russell (2003) emphasizes that emotional events are experienced in two dimensions as positive and negative valence dimension, energetic and weak arousal dimension. Emotions that can change according to events and situations are divided into two as positive and negative. Positive emotions are those that contribute positively to happiness and are experienced as pleasant, such as enjoyment, hope, pride, relief. Negative emotions are those that contribute negatively to happiness and are experienced as unpleasant, such as anger, anxiety, hopelessness, shame, and boredom. Positive and negative emotions have different effects on motivation and learning (Kim & Pekrun, 2014). The results

show that there is a positive relationship between intrinsic motivation and positive emotions (Liew & Tan, 2016).

Many different emotional state parameters have been defined in research. Despite being a challenging and somewhat fuzzy concept to define, emotion has garnered various interpretations within the literature. According to Gross (2014), emotions represent our diverse responses to different situations. Affect is the collective term for describing feeling states like emotions and moods. Affective states may vary in several ways, including their duration, intensity, pleasantness (Plass et al., 2014a). Valence is a fundamental component of emotional response (facial expressions, tone of voice, neural activation, expressive behavior) as well as forming the most basic part of emotional experience (Barrett et al., 2007). Valence is considered as an invariant structure in emotional life. Valence occurs at the end of a person's valuation process (for example, judging a situation as beneficial or harmful, good or bad, rewarding or punishing). It characterizes the person's relationship to their environment at a particular moment in time (Roseman, 2011). Roseman (2011) states that arousal is related to the intensity of emotions (and non-emotional processes). It can affect the level of cognitive, affective, and behavioral resources to be allocated for a particular stimulus or situation. Other emotional processes such as mood and emotion are also considered as a function of basic affect. In other words, the basic affect is a more basic feeling found in mood and emotion. Mood was used as an independent variable in 5 studies and its effect on learning was investigated.

Studies on emotions show that positive emotions improve cognition in different ways. Positive emotions significantly affect processes such as information processing, decision making, and problem solving (Erez & Isen, 2002). Caruso and Salovey (2004) stated that emotions guide thinking and motivation. Likewise, Fu (2015) stated that emotions act as a motivating force for learners to achieve their goals. Emotions also facilitate encoding and making decisions, and helps retrieval of information efficiently. Therefore, it can be said that emotions are an important factor in learning. Based on this, Pekrun (1992) stated that the effects of emotions on learning and achievement are formed through some cognitive and motivational processes. In this context, he introduced the cognitive-motivational model. In the model, it is assumed that learning strategies, self-regulation, cognitive resources, academic achievement and motivation are of primary importance among the cognitive and motivational processes that mediate the effects of emotions on learning and achievement (Pekrun et al., 2002).

The interaction of emotions and design first emerged in the field of sales and marketing. Researchers have posited that the role of emotions in the design process is significant, as products that elicit positive emotions are likely to be purchased and utilized more frequently. This connection between design and emotions plays a pivotal role in shaping user experiences (Batra & Ray, 1986; Petty & Cacioppo, 1986). While research on emotions continues, giving human-like features to product designs is the first emotional design in the field of engineering (Norman, 2004). Studies conducted to investigate the contributions that emotional design can provide to learning in the field of education have attracted the attention of many researchers (Plass et al., 2014b; Um et al., 2012a). The question of how emotions affect cognitive processes has formed the basis of these studies. Both positive and negative emotions have different roles in the cognitive process. According to Efklides et al. (2006) positive emotions increase moti-

vation, therefore better cognitive processing and learning are expected. On the other hand, Seibert and Ellis (1991) stated that a positive mood can negatively affect learning by triggering irrelevant thoughts. Norman (2004) argues that positive emotions bring out curiosity and creativity and make the brain an effective learning entity, while he stated that negative emotions protect us from dangers, enable us to focus and help us pay attention to details. Considering the different effects of emotions on the learning process, various studies have been conducted to determine the effects of emotions on cognitive activity and learning in the multimedia learning process.

Moreno and Mayer (2007) emphasize motivation, metacognitive activities and affective elements in the cognitive-affective model they developed as an extension of the cognitive theory of multimedia learning. The fact that emotions are a feature that should not be separated from cognitive processes also makes them important in terms of learning processes. Plass and Kaplan (2016) emphasize that certain features in learning and multimedia design may affect some combinations of cognition and emotion, which in turn, may determine the quality of the learner's interaction with the learning material.

Emotional design focuses on how changes made to design elements affect emotions. The effects of designing multimedia materials with emotional design elements on learning outcomes have been tested by many studies. In a study by Mayer and Estrella (2014), it was found that the emotional design group performed better with regards to their learning outcomes. Plass et al. (2014a) examined design techniques that may evoke positive emotions in learners and evaluate the effects on learning. The results showed that emotional design materials facilitated comprehension, though transfer was not affected. Uzun and Yıldırım (2018)'s research results showed that colorful emotional design in the multimedia learning environment had a significant effect on recall performance, but had no effect on transfer. Wang et al. (2021) found that the internal colorful design promoted positive emotions, retention, and transfer performances of learners.

Emotional design studies aim to examine how visual, verbal, and interaction design elements affect learners' emotional states, motivations and learning outcomes (Brom et al., 2018). There is no clear evidence based on the positive effects of emotional design techniques. Research has been conducted on this method with different variables and design elements, and there are some differences in the results (Wong & Adesope, 2021).

Previous systematic reviews and meta-analyses have examined emotional design with gaps in the literature. A meta-analysis was conducted to examine 33 studies that examined approaches that added anthropomorphic faces and/or pleasant colors to multimedia learning. According to the research results, positive effects were found for intrinsic motivation, positive affect, and enjoyment. In terms of cognitive processes, the positive meta-analytic effects of retention, comprehension, and transfer have been revealed. Preliminary evidence suggested that age affects the impact of manipulations on intrinsic motivation, with greater effects observed in younger learners compared to older ones (Brom et al., 2018).

The purpose of the review conducted by Rodrigues and Silva (2022) was to examine 20 articles investigating the importance of emotional design in multimedia learning from 2016 to 2021. The study examined the use of multimedia supports in

presenting learning content, the emotional design features most commonly used in the development of multimedia learning materials, and the effects of emotional design on the learning process. The findings demonstrate a clear positive impact of emotional design on learning outcomes. However, due to its complexity, emotional design also has some inconsistencies.

The other meta-analysis that has been published on emotional design replicates and extends the findings of Brom et al. (2018)'s meta-analysis (Wong & Adesope, 2021). The analysis of 28 articles revealed that the incorporation of emotional elements in the learning process led to improved learning outcomes, a positive change in affect, increased intrinsic motivation, heightened mental effort, greater enjoyment, and a decrease in perceived difficulty.

Different emotional state parameters have been preferred in emotional design studies. Additionally, emotions have been analyzed using various emotional measurements in these studies. Unlike other review studies, this study examined and analyzed emotional state parameters, emotional measurement, and emotional design techniques collectively with other variables discussed in the studies. Emotional design is widely acknowledged to have a significant impact on cognitive processes. However, relatively little attention has been paid to the influence of emotional states and design techniques. This review aims to further explore the examination of emotional states through the utilization of emotional design techniques as well as methods for measuring emotional states. In order to analyze the distinctive features and shortcomings of the studies under review, the data were examined in accordance with the following research questions.

RQ1. What were the characteristics of all emotional design studies in multimedia learning published until 2023?

The evaluation of emotion in studies exploring the relationship between emotion and cognition in multimedia learning is a topic of significance. Emotions are immediate and reflective responses to stimuli, encompassing changes in multiple components (Lange et al., 2022). The intensity of an emotion is typically denoted as arousal, while the positive or negative nature of the emotion is referred to as valence (Ozel et al., 2021). In light of this, the following research question was formulated to investigate the degree to which emotion is considered in studies that examine the emotion-cognition relationship in multimedia learning.

RQ2. Which emotional state parameter was considered in the emotional design research in multimedia learning?

The emotional design approach represents a novel approach in multimedia design that diverges from conventional studies by incorporating design elements that are both engaging and directly relevant to learning outcomes. In this methodology, the fundamental design elements are manipulated to establish a correlation with the content, and extraneous design elements are not added to the materials (Bai et al., 2022). As such, it is crucial to investigate the various emotional design techniques in order to advance the body of knowledge in this area. In this investigation, the objective is to offer recommendations regarding emotional design approaches through the examination of the following research question.

RQ3. How were emotional design techniques used in the emotional design research in multimedia learning?

Many different variables have been discussed in studies examining the effects of emotional design. The effects on learning outcomes, mood and motivation have been investigated in many studies (Peng et al., 2021; Wang et al., 2023). Different data collection tools and methods were used to collect data on these variables. For research questions 4 and 5, the aim is to examine the data collection tools in detail.

RQ4. How was the emotional state measured in the emotional design research in multimedia learning?

RQ5. Which data collection tools were used to measure various variables in the emotional design research in multimedia learning?

2 Method

A literature review investigates a particular research topic based on existing research by identifying, selecting, and synthesizing the selected research studies to summarize the research topic (Oakley, 2012). The systematic review is to provide new insights, increase understanding of a field of study, and define the subject in a broader way (Gough et al., 2017). In this study a systematic review was performed to define the concept of emotional design in multimedia learning. Five research questions were determined for the review of the studies. To answer the RQs three stages were performed: (1) planning, (2) execution, and (3) reporting. In the planning stage, indexes were selected and the inclusion and exclusion criteria were determined. In the second stage, studies were selected and examined according to the criteria. In the reporting stage, findings related to the studies reviewed are reported and discussed.

The variables in the reviewed studies are organized according to the following categories: (a) Study Characteristics, (b) Participant Characteristics, (c) Multimedia Learning Material, (d) Learning Domain, (e) Research Methods, (f) Emotional State Parameter, (g) Emotional Design Techniques, (h) Emotional Measurements, (i) Data Collection Tools.

2.1 Search sources

The literature search was conducted in databases containing the most important studies on emotional design in multimedia learning. In order to find existing publications a search was initiated in four databases: Web of Science, ERIC, PsycINFO, and Scopus. All emotional design in multimedia learning studies published in the identified databases until 2023 were thoroughly examined. Overall, these databases are valuable resources for accessing scholarly literature and conducting research in diverse academic fields and they are general reference tools most commonly used to identify primary sources by researchers (Frankel et al., 2012). The selection of Web of Science, ERIC, PsycINFO, and Scopus for systematic reviews can be justified by their comprehensive coverage, high-quality content, advanced search capabilities, interdisciplinary nature, and reputation within the academic community. The systematic review's scope was limited to high-quality databases due to the constraints of time and the difficulty of reviewing all studies conducted up to 2023.

The keywords were determined based on a literature review of emotional design in multimedia learning ("emotional design*" AND "multimedia learning*" OR "multimedia*" OR "anthropomorphism*"). The search strategy was based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). The PRISMA method is a widely used guideline for conducting and reporting systematic reviews and meta-analyses in research. It provides a structured framework for researchers to follow when conducting systematic reviews, ensuring transparency, completeness, and reliability in reporting the review process and its findings. Researchers screen the identified records based on predetermined inclusion and exclusion criteria to determine their eligibility for inclusion in the review. Inclusion and exclusion criteria were presented in Table 1. This selection process followed the inclusion and exclusion criteria established for the study. Articles appropriate for the keywords identified in the specified databases were downloaded. Based on the inclusion and exclusion criteria, research in the field of multimedia learning, but not about emotional design, was excluded. Among these studies, original and empirical studies with full-text access were included, and conference papers, dissertations/theses, book chapters, reviews, meta-analyses, or commentary articles were excluded.

2.2 Study selection process

At first, the literature search detected 155 articles from all the aforementioned databases (Fig. 1). Next, 43 duplicate articles were detected in the initial literature search. The remaining 112 articles were reviewed again, depending on the exclusion and inclusion criteria (see Table 2). Of the 112 articles, 49 were removed as they were not empirical and emotional design research articles. Lastly, the remaining 63 articles were rigorously checked, considering the inclusion and exclusion criteria. After elaborative evaluation, 12 articles were removed; 8 articles did not conduct studies in multimedia materials; 4 additional articles were review article or meta-analysis. Finally, not to miss any relevant articles, backward, and forward searching techniques were employed, but no articles found as a result of this search. At the final stage, 51 articles were specified for the analysis process (Fig. 1).

Table 1 Inclusion and exclusion criteria

| Inclusion criteria	Exclusion criteria
The studies must be conducted on emotional design in multimedia learning	The research work is not be related to the emotional design in multimedia learning
The studies must be original and empirical	The studies must not be conference papers, dissertations/thesis, book chapters, review, meta-analysis, or commentary article
The research area of the articles should focus on education.	The research area of the articles should not be outside of education, such as engineering or marketing.
The articles must be full-text	The full version of the publication is not available
The articles should have been published in journals which were indexed by WOS, ERIC, Scopus, EBSCO databases	The study is listed in another database
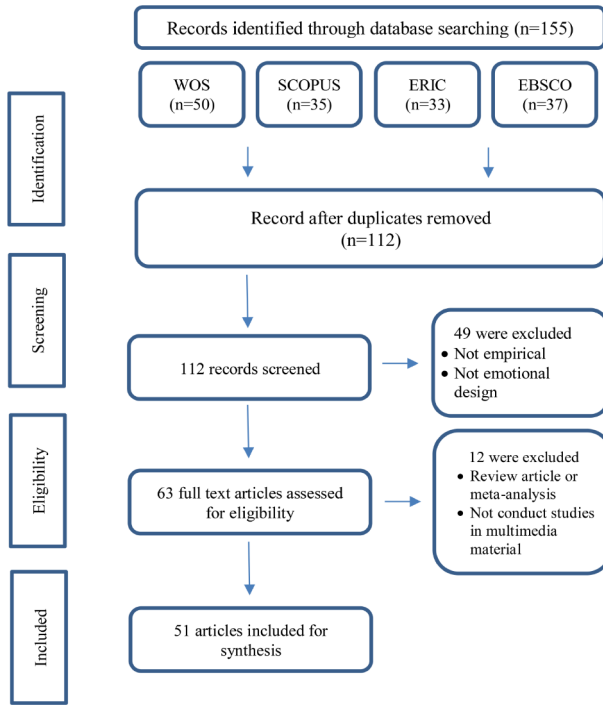
Fig. 1 PRISMA flow diagram (Moher et al., 2009)

Table 2 The countries where research articles on multimedia learning are conducted

Continent	Country	N
Europe 41,17%	Germany	15
	Turkey	2
	Czech Republic	2
	Kosovo	1
	Switzerland	1
Asia 35,29%	Malaysia	9
	China	8
	Taiwan	1
America 21,56%	USA	10
	Argentina	1
Africa 1,96%	South Africa	1

3 Results

3.1 Study characteristics

In the findings related to the first research question, the characteristics of the studies on emotional design in multimedia learning were analyzed. Findings related to year, country, participant characteristics, multimedia learning materials type, learning domain, research method are presented.

3.1.1 Year

Emotional design in multimedia learning studies started in 2012. Most of the studies ($n=40$) were published in the last five years. The most significant number of publications were reported in the years 2018, 2020, and 2021 (See Fig. 2).

3.1.2 Country

Most reviewed studies about emotional design in multimedia learning were conducted in Europe (46%), followed by Asia (34%), America (22%), and Africa (2%) (See Fig. 3; Table 2). Although the first studies have been conducted in the USA, similar to the previous systematic reviews on multimedia learning, the most studies about emotional design were conducted in Germany (Alemdag & Cagiltay, 2018; Coskun & Cagiltay, 2022; Mutlu-Bayraktar et al., 2019).

3.1.3 Participant characteristics

In the reviewed articles, the number of participants was at the least 33 and at the most 334. In the majority of the studies, the participants were university students ($n=32$; 62,7%) whereas the other 7 studies were conducted with college students (13,7%), 6 with middle school students (11,8%), 4 with Amazon Mturk workers as older adults (7,8%), and 2 with primary schools (3,9%; Fig. 4). In the emotional design studies, it was seen that the education levels of the participants were mostly university.

3.1.4 Multimedia learning material

In the emotional design in multimedia learning studies, computer-based materials were mostly employed ($n=30$; 58,82%). It was followed by video ($n=10$; 19,6%),
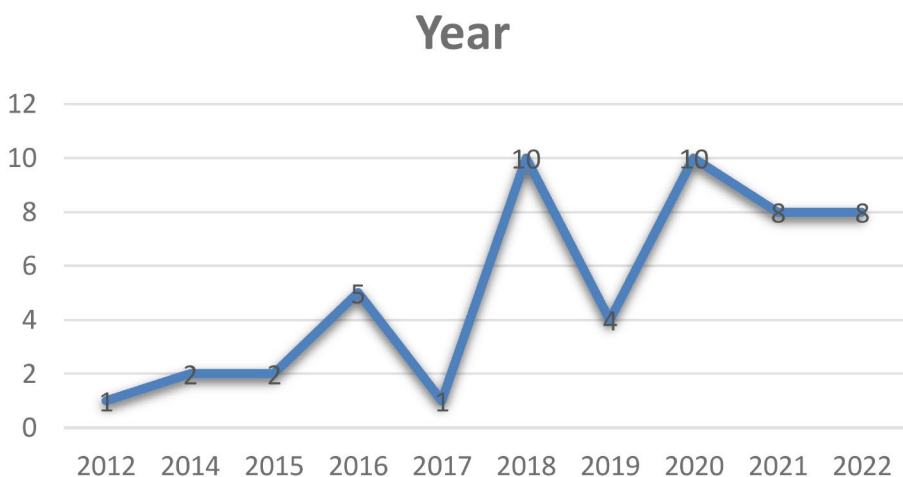

Fig. 2 The distribution of emotional design research in multimedia learning by year

COUNTRIES

EUROPE		ASIA		AMERICA		AFRICA	
Germany	15	Malaysia	9	USA	10	South Africa	1
Turkey	2	China	8	Argentina	1		
Czech Republic	2	Taiwan	1				
Kosovo	1						
Switzerland	1						

N=21   N=18   N=11   N=1

Fig. 3 The countries where research articles on multimedia learning are conducted

Older Adult 7.8%
Primary School 3.9%
Middle School 11.8%
College 13.7%
University 62.7%
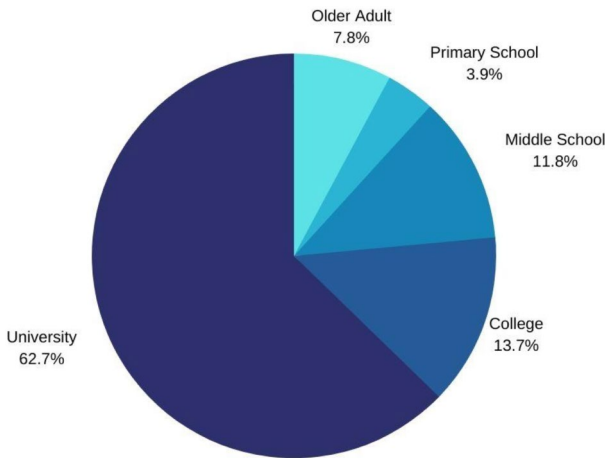
Fig. 4 The education level of participants in the reviewed studies

animation ($n=4$; 7,84%), web-based ($n=4$; 7,84%), and game-based ($n=3$; 5,88%) materials (Fig. 5).

3.1.5 Learning domain

Most emotional design studies in multimedia learning environments conducted thus far have utilized STEM subjects (84%). STEM was used to encompass any sciences such as basic computer programming, immunization, functional neuroanatomy, and
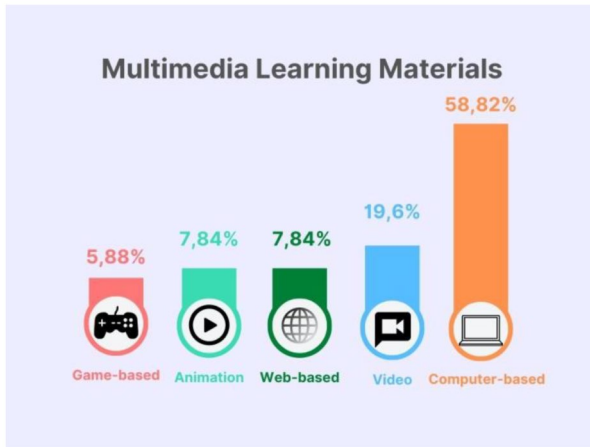
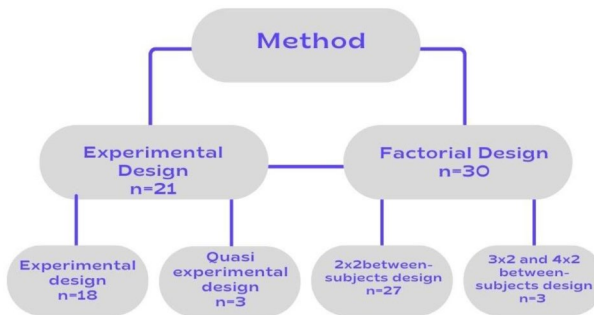**Fig. 5** Multimedia learning environments in the reviewed studies

Fig. 6 Study methods in the reviewed studies

blood cells (etc. Li et al., 2020; Münchow et al., 2017; Um et al., 2012a). Other studies (16%) were carried out on social science subjects (etc. Wang et al., 2021).

3.1.6 Research methods

Different experimental design models related to emotional design elements and emotional states were used in the studies. Experimental design was used in 21 studies and factorial design was used in 30 studies. The most used factorial pattern is 2×2 between-subjects design ($n=27$). Other factorial designs, such as 3×2 and 4×2 between-subject designs, were preferred in a small number of studies (Fig. 6).

3.2 Emotional state parameter

In emotional design studies, the emotional state parameter has been considered as both a dependent and independent variable. The second research question aimed to analyze the emotional state in the reviewed studies. Emotion, affect, valance,

and mood are the emotional state parameters addressed in the studies. In 18 of the reviewed articles tried to explain the effect of emotional design by measuring on affect. PANAS (Positive and Negative Affect Schedule), PANAVA KS (Positive Affect, Negative Affect and Valence Short-Scales) and PAS (Positive Affect Scale) scales were used as positive affect scales. These scales were used to measure emotion in studies. In 7 articles valence was used to explain the effect of emotional design. In these articles the Positive Affect, Negative Affect and Valence Short-Scales (Schallberger, 2005) was used. In 5 reviewed articles, arousal was used to explain the effect of emotional design. Arousal, which is usually considered together with valence, was rated as more excited/activated. Other emotional processes such as mood and emotion are also considered as a function of basic affect. In other words, the basic affect is a more basic feeling found in mood and emotion. Mood was used as an independent variable in 5 studies and its effect on learning was investigated.

3.3 Emotional design techniques

Within the scope of the third research question, findings on emotional design techniques are presented in this section.

In the reviewed studies, "positive vs neutral emotional design" was mostly used ($n = 16$) as the emotional design technique. In the positive emotional design, human-like features such as eyes, mouth, hands, arms, and other human qualities (baby-face bias and cartoon-like characters) were added to non-human objects, rounded lines were used instead of sharp lines, and warm colors were used for the basic objects on the screen. In neutral emotional design, the objects were designed without adding human-like features. Sharp lines and grayscale were used.

The "positive vs negative emotional design" was used in 11 articles. In this technique, the effect of designing based on the representations of negative emotions such as sadness and anger on emotions, as opposed to positive design, was tested. Positive emotions are designed with happy photos, the opposite negative emotions are designed with sad photos (Chung & Cheon, 2020). There are studies investigating the effects of an instructor's positive and negative emotions on learning, motivation and emotional states (Liew et al., 2022).

Color is one of the most used principles of emotional design. Emotional design was tested with the color variable in 11 of the reviewed studies. In positive emotional design high-energy warm or bright colors (yellow, orange and brown) are preferred. In negative design gray tones, low brightness and dull colors (dark green, dull blue) are preferred (Kumar et al., 2019).

The anthropomorphic design elements are mostly used together with color in positive emotional design. Six emotional design studies examined the effects of using anthropomorphic elements on learning. The technique involves incorporating humanoid features into objects (Clark & Mayer, 2016). Anthropomorphism refers to attributing human characteristics to inanimate objects. It is seen as a simple pedagogical strategy that can be used to help teachers explain abstract concepts in accordance with students' understanding of the concrete physical world (Kallery & Psillos, 2004).

The Baby-Face Bias and Cartoon-Similar Characters design approach refers to the tendency for objects with added baby-face features to be perceived as cuter than

other objects without baby-faced attributes. The cuteness of objects includes physical qualities such as having rounded lines with big eyes and a small nose. Objects designed according to such features receive more positive attention and perception. This technique, which is generally used with anthropomorphic design, was used in two studies (Navratil et al., 2018; Um et al., 2012a).

In emotional design, it is aimed to affect the emotions of the learners without changing the learning content. For this purpose, decorative pictures can be added to multimedia material. These illustrations can increase positive emotion and motivation. In addition, decorative pictures can cause seductive detail effect (Schneider et al., 2018a). The effects of this technique on learning, emotion, motivation, and attention in emotional design were examined in six studies (Irrazabal & Burin, 2021; Schneider et al., 2016, 2018a).

Results revealed that positive emotions generally increased as the amount of emotional design features increased. It has come to attention that sound and music are increasingly being acknowledged as crucial elements in the field of emotional design research in multimedia, as factors that influence emotions. Students invested less mental effort in designs that used sound effects along with anthropomorphism and color techniques (Uzun & Yıldırım, 2018). The research conducted by Bülbül and Kuzu (2021) demonstrated that animations incorporating introduction music and emotionally complementary sound effects were highly effective in evoking emotional responses. Results of a study to investigate the effect of texts used in emotional design indicate that the emotional state of learners was not impacted by the positive emotional design of the text, however, participants in the group that was presented with the negative emotional text design exhibited a more worse emotional state after the learning process (Stark et al., 2018).

3.4 Emotional measurements

The learners' emotional states were measured in various tests in reviewed emotional design studies. The emotion scales used in the studies are presented in Fig. 7. The PANAVA-KS was the most widely used in reviewed studies about emotional design in multimedia learning ($n=7$, Schallberger, 2005). This scale was based on the PANAS (Watson et al., 1988). The PANAS was used in 4 emotional design studies. It consists of 10 items each to assess positive and negative affect. The items represent the individual's level of different emotionally charged states. Another scale is the Positive Affect Scale (PAS) from the PANAS was used in 7 articles (Liew & Tan, 2016; Park et al., 2015). Participants indicate the degree to which they experience 10 different feelings related to positive affect (interested, excited, strong, enthusiastic, proud, alert, inspired, determined, attentive, active), using a five-point Likert scale ranging from 1 (very slightly or not at all) to 5 (very much).

In three articles a positive emotion self-report inventory (Gross & Levenson, 1995) were used. In this inventory the participants choose these six positive emotions (happy, excited, content, active, interested, and relaxed) using a 9-point rating scale ranging from 1 (not at all) to 9 (very much). The total score is calculated from the six responses.
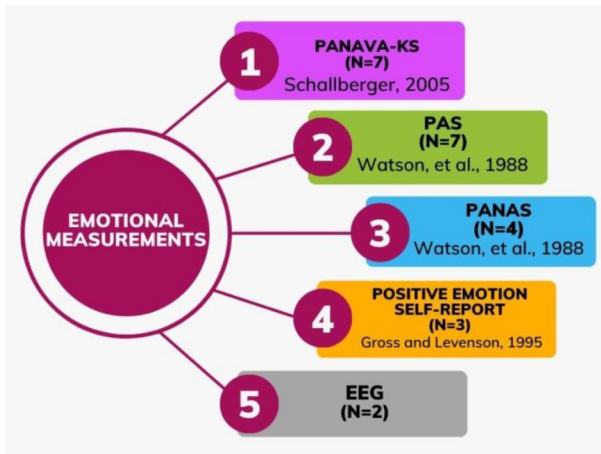
Fig. 7 Emotional measurements in the reviewed studies

In reviewed articles, emotion measurements were mostly made with indirect measurements using a scale. In two articles, direct measurements were made using EEG as an objective measurement and the analysis results were reported. Brain imaging technologies allow us to observe electrical, chemical, or blood flow changes in the brain during information processing or response to stimuli (Mutlu Bayraktar et al., 2023).

3.5 Data collection tools

Of the 51 studies reviewed in this study, 33 of them investigated the learning outcomes with retention or recall tests. Specific instruments used to assess learning were tests for transfer ($n=29$), learning achievement ($n=6$), comprehension ($n=9$), prior knowledge ($n=27$). It was concluded that almost all of the studies investigated the effect of emotional design on learning. In results of 16 studies showed that positively valanced design fosters learning (retention or transfer) performance. In 10 studies no effect was found in terms of learning outcomes.

Various scales were used to measure motivation in 22 studies. The motivation scale developed by Isen and Reeve (2005) was mostly used ($n=12$). The Intrinsic Motivation Inventory (IMI) (Deci & Ryan, 2013) scale was used in four studies. In other studies, motivation self-report instruments or perception study motivation rating tools were used. Results of 18 studies measuring motivation showed that positive emotional design contributes to motivation in the learning process. The results of four studies showed that it did not make any positive contribution to motivation.

Cognitive load was examined in reviewed 20 articles. In studies examining emotional design in multimedia learning, cognitive load was mostly measured using the Cognitive Load Subjective Experience Questionnaire developed by Paas, 1992 ($n=9$). Participants were asked how much mental effort they had spent. In five studies, cognitive load was measured using a six-item 9-point Likert scale (Leppink et al., 2013).

In five of the reviewed studies eye-tracking method was used to examine attention, cognitive activity, fixation, and duration variables (Stárková et al., 2019). Eye-tracking metrics contribute to emotional design studies in terms of providing objective data beyond the data collected as self-reports with scales and tests. In some studies, a longer fixation showed that learners exert more mental effort (Kruger & Doherty, 2016), while in some studies they were interpreted as focusing more on the content (Mutlu-Bayraktar, 2019; Mutlu-Bayraktar et al., 2022). EEG, one of the neuroimaging techniques that are among objective measurements such as eye tracking technique, is also among the data collection tools (See Fig. 8).

Learning outcomes in multimedia emotional design research have been examined through various means. These include assessments of retention or recall tests, tests for transfer of knowledge, evaluations of learning achievement, comprehension assessments, and examinations of prior knowledge. These measures help researchers understand the effectiveness of emotional design techniques in enhancing learning outcomes such as knowledge retention, transferability of learned material, comprehension levels, and overall learning achievement. Reviewed research has mainly focused on retention among the learning outcomes. In 21 of the studies, there was a difference in favor of positive emotional design in terms of retention, while 12 studies reported no difference. While 19 of the studies that utilized transfer tests found a significant difference in favor of positive design groups, 11 studies indicated no significant difference.

4 Discussion and conclusion

In recent years, in the field multimedia learning studies, there has been greater interest, there is an interest in emotional design research. Along with this interest, there are many studies that have obtained different results with the use of similar emotional design techniques (Liew et al., 2022b; Peng et al., 2021; Stárková et al., 2019).
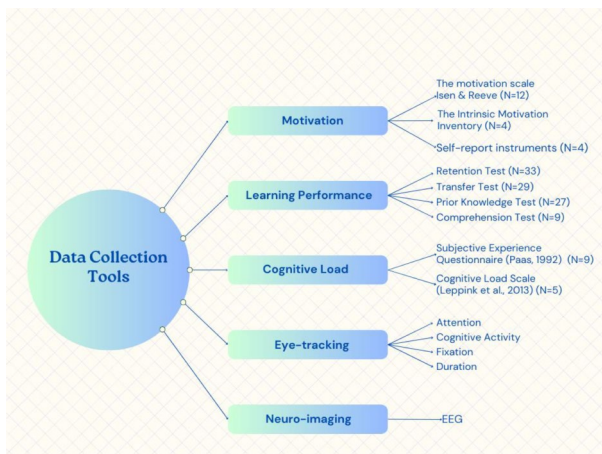
Fig. 8 Data collection tools in the reviewed studies

The effects of emotional design in multimedia learning vary according to emotional design elements, dependent variables, cognitive and affective characteristics, subjective and objective measurements (Liew et al., 2022a, b; Wong & Adesope, 2021). It enables us to interpret different findings in this area. Emotional design is the use of visual, verbal, and interaction design elements that affect the emotional states of learners and encourage learning in multimedia materials (Tan et al., 2021). The current study presents findings from studies examining emotional design in multimedia learning. It surveyed 51 articles published in educational indexes.

In the first research question, a general perspective was presented by reporting the characteristics of the studies examined. The study characteristics were examined in terms of the published year, continent and country, participants, research method, material, and learning domain. The highest number of publications was reported in 2018, 2020, and 2021. The analysis of study characteristics reveals a growing interest in emotional design in multimedia learning, particularly in recent years. The increase in publications since 2018 suggests a burgeoning research area with potential implications for educational practice and theory. Most reviewed studies about emotional design in multimedia learning were conducted in Europe, followed by Asia and America. While initial studies have been conducted in the USA, this trend aligns with previous systematic reviews on multimedia learning (Alemdag & Cagiltay, 2018; Coskun & Cagiltay, 2022). Park, Plass, and Schneider addressed the issue of emotional design in a number of articles from Germany (Park et al., 2015; Plass et al., 2020; Schneider et al., 2018a). The prevalence of studies in Europe, followed by Asia and America, underscores the global nature of emotional design research. However, the concentration of research in certain regions, particularly Germany, raises questions about the generalizability of findings across cultural contexts and highlights the need for more diverse representation in future studies. The fact that research has been conducted mostly in certain regions causes limitations in terms of cross-cultural comparison or interpretation of the results. Research studies in various regions and cultural settings are of utmost importance in broadening the scope of future investigations.

The predominance of university students as participants and computer-based materials in emotional design studies suggests a focus on higher education contexts and technology-mediated learning environments. However, the inclusion of studies involving middle school and primary school students indicates a broader scope of research encompassing diverse learner populations. In almost all of the reviewed studies, materials designed on STEM were preferred. It is noteworthy that there are few studies on social sciences. The overwhelming emphasis on STEM subjects in emotional design studies reflects a common trend in educational research, where science, technology, engineering, and mathematics receive significant attention. Future studies could explore emotional design in other domains, such as social sciences, to provide a more comprehensive understanding of its effects across disciplines.

The most widely used experimental model in emotional design studies is the factorial design model. Positive, neutral and negative emotional design and design elements were determined as factors. The prevalence of experimental and factorial design models underscores the rigor and systematic approach adopted in emotional design research. However, the diversity in experimental designs and factors consid-

ered suggests a need for standardization and clearer methodological guidelines to facilitate comparison and replication of findings.

In the second research question of this study, the emotional state parameters were analyzed. It is noteworthy that the concepts of affect, mood, valence, arousal, and feeling are expressed as emotion in the literature, and these expressions are used interchangeably in some studies. However, it is known that these concepts differ from each other in terms of structure, scope, duration, and boundaries (Imbir et al., 2021). The emotional state parameters examined in emotional design studies also differ, and all of the different concepts used are examined as emotion. In the reviewed articles, mostly affect, valence, and arousal were analyzed, and the emotions of the participants were explained through these concepts. In these analyses, the selected emotional parameter was not adequately explained in terms of features such as scope, duration, and limit (Beege et al., 2018; Chung & Cheon, 2020). In the studies, it is necessary to explain in detail the features such as the definition of emotional state parameters, what they are, and how they occur. Emotions are an essential element of the learning process, it is claimed that there is a strong relationship between emotion, cognition and behavior (Graesser, 2020). The analysis of emotional state parameters highlights the complexity of measuring emotions in educational contexts. The use of scales such as PANAS and PANAVA-KS indicates a reliance on self-report measures, while the incorporation of neuroimaging techniques like EEG suggests a growing interest in objective measurements. Future research could explore the validity and reliability of different measurement tools and their implications for understanding emotional responses in multimedia learning.

Various techniques have been used in studies to examine the effects of emotional design. In the reviewed studies, positive vs. neutral emotional design was mostly used. In the positive emotional design, human-like features such as eyes, mouth, hands, arms, and other human qualities were added to non-human objects, rounded lines were used instead of sharp lines, and warm colors were used for the basic objects on the screen. In neutral emotional design, the objects were designed without adding human-like features. Sharp lines and grayscale were used. There have also been studies examining the effects of positive versus negative emotional design on variables. In this design technique, design elements containing negative emotions (anger, sadness, anxiety, etc.) were used. In recent studies, it was determined that emotional design techniques related to different elements in multimedia learning material were examined (Chung & Cheon, 2020; Liew et al., 2022). The effects of different components such as instructor, sound, text, dialogues were tested (Horovitz & Mayer, 2021; Schneider et al., 2018a; Uzun & Yıldırım, 2018). Emotional design techniques have shown different results in relation to different parameters.

In the meta-analysis study on emotional design research reported that the use of anthropomorphism and colors in multimedia learning can have a positive impact on learning outcomes, such as retention and transfer of knowledge. The effectiveness of facial anthropomorphisms and colors may depend on the type of emotion elicited, with positive emotions generally being more effective than negative emotions (Wong & Adesope, 2021). The discussion of emotional design techniques reveals a diverse range of strategies employed to evoke emotional responses in learners. Positive vs. neutral and positive vs. negative emotional design, color manipulation, anthropomor-

phism, and sound effects are among the techniques explored. The differential effects of these techniques on learning outcomes, motivation, and cognitive load underscore the importance of considering design features in multimedia materials. The findings presented in the discussion section can inform educational practitioners and instructional designers about the potential benefits of incorporating emotional design techniques into multimedia learning materials. By understanding how design elements influence emotional responses and learning outcomes, educators can create more engaging and effective learning experiences for students across diverse educational settings.

In the findings related to the fourth research question, emotion measures used in emotional design studies were analyzed. The reviewed articles tried to explain the effect of emotional design by making measurements on emotion, affect, valence, arousal, and mood. For the measurement of emotions, the PANAVA-KS was the most widely used in reviewed studies. This scale was based on the PANAS that was the second most used emotion scale in reviewed articles. Apart from scales, emotion was investigated with positive emotion self-report inventory.

Emotional design studies have examined many variables other than emotion. The most chosen variables were learning outcomes, followed by motivation and cognitive load. Learning outcomes in multimedia emotional design research have been examined through various means. These include assessments of retention or recall tests, tests for transfer of knowledge, evaluations of learning achievement, comprehension assessments, and examinations of prior knowledge. These measures help researchers understand the effectiveness of emotional design techniques in enhancing learning outcomes such as knowledge retention, transferability of learned material, comprehension levels, and overall learning achievement. Results of 18 studies showed that positively valanced design fosters learning (retention or transfer) performance (Li et al., 2020; Schneider et al., 2016). In 10 studies no effect was found in terms of learning outcomes (Bülbül & Kuzu, 2021). Half of the reviewed studies investigated the effects of emotional design on motivation. In meta-analysis studies, it has been reported that emotional design improves learning (Brom et al., 2018; Wong & Adesope, 2021). The effectiveness of emotional design may depend on the learner's individual differences, such as their prior knowledge and motivation (Bülbül & Kuzu, 2021). The Motivation Scale (Isen & Reeve, 2005) and The Intrinsic Motivation Inventory (IMI) (Deci & Ryan, 2013) scale were mostly used. Results of 18 studies measuring motivation showed that positive emotional design contributes to motivation in the learning process (Horovitz & Mayer, 2021; Kumar et al., 2019; Navratil et al., 2018). The results of four studies showed that it did not make any positive contribution to motivation (Schneider et al., 2020). Lastly, cognitive load was examined in nearly half of reviewed studies. Cognitive load was mostly measured using the Cognitive Load Subjective Experience Questionnaire developed by Paas, 1992. In five studies, cognitive load was measured using a six-item 9-point Likert scale (Leppink et al., 2013). Research results examining the effect of emotional design on cognitive load also differed. In the reviewed studies, seductive details were mostly found to be the factor differentiating cognitive processing of multimedia information. Eye-tracking metrics contribute to emotional design studies in terms of providing objective data beyond the data collected as self-reports with scales and tests (Javora et al., 2021).

5 Implication for future research

Many studies have been conducted to highlight the effectiveness of emotional design in multimedia learning. This section provides suggestions for future research. This study provided a systematic review of emotional design techniques. In doing so, it also highlights research gaps. The reviewed studies were mostly conducted with higher education students. It's crucial to study young learners' knowledge construction processes, as their characteristics differ from those of adults. It is thought that elements such as anthropomorphism and color in emotional design techniques should be more interesting for young learners and will have a greater effect on emotions. The limitation of studies on multimedia learning is the predominance of higher education students as participants, making it challenging to generalize the results to other populations. Although this situation is similar in many multimedia learning studies, these studies should be replicated in younger age groups (Alemdag & Cagiltay, 2018; Coskun & Cagiltay, 2022). Studies with younger age groups, whose learning processes develop differently and whose emotional states are more affected by external factors, will make a great contribution to interpreting emotional design techniques. Furthermore, it may be recommended to conduct studies on different learning characteristics and even different disability groups, such as those with learning disabilities. Multimedia learning studies are generally conducted mostly in Europe (Alemdag & Cagiltay, 2018). Emotional design research has been similarly conducted in Germany. Research results show that there are differences in emotional states and learning, even in the same region. Future studies to be conducted in different cultures are very important in terms of evaluating the differences in research results. Studies in different regions and cultural contexts are valuable to broaden the scope of future research.

Emotional design studies have continued to increase in popularity since 2012 and have become a subject of interest to researchers from many different fields. Materials designed mainly on STEM were used in the reviewed studies. In emotional design studies, it is recommended that research be conducted with materials in non-STEM, social science, or other areas as a learning domain. Furthermore, computer-based materials are frequently used in research, and conducting studies on the effects of interactive or collaborative materials on emotions can provide socially different investigations. Another gap in multimedia learning research on emotional design is that the learning process is too short to reflect many situations in the context (Mayer, 2020); therefore, analyzing longer learning processes will enable us to obtain clearer results.

The results of the present study indicate that there is a tendency to examine the effects of shapes and colors. The effect of elements such as text and sound on positive emotion should be tested in more studies. It can be suggested to conduct studies on the effects of the instructor's emotions on the learner's emotions. Studies on the effects of emotional design in multimedia assessment or game-based materials is another research topic that will contribute to this field (Mutlu-Bayraktar, 2019; Yilmaz & Bayraktar, 2018). Experimental research using various videos and images for emotional induction provides a different perspective on emotional design studies. It has been reported that self-report results were frequently used in experimental processes in emotional design research. In addition, objective measurements such as neuroimaging

provide different results in emotion recognition. More objective measures are expected to be included in future studies. It is also recommended to use measurements such as physiological (Mayer, 2020), facial recognition by video analysis (Taub et al., 2020), behavioral patterns obtained by analysis of log records (Graesser, 2020) in emotion measurement.

There is a need for studies that address different elements as emotional design techniques. Although the effects of text and sound elements have been examined in a few studies, more research is needed. It is recommendable to conduct studies investigating the effect of the instructor and his emotions on students' emotions and cognitive processes. It is suggested that multiple emotional design techniques be examined, diverse materials such as multimedia assessment or game-based resources be utilized, objective measurements be employed to assess emotional states, and the effects of material designed for social science subjects be considered.

Data availability In this study, data about the research questions were collected by reviewing the articles on emotional design in multimedia learning. Since these data were obtained from published and indexed articles, the data were not shared by the authors. Data cannot be shared openly but are available on request from authors.

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