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REVIEW

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Effectiveness of facial anthropomorphism design for improving multimedia learning outcomes: systematic review and meta-analysis

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Abstract

A systematic review and meta-analysis were conducted to examine the effectiveness of facial anthropomorphism of learning material design in improving learning and other relevant outcomes. We searched Web of Science, PsycInfo, and PsycArticle for studies published before February 2023. Learning outcomes included transfer, retention, and comprehension. Other relevant outcomes included affective-motivational, effort, and experience outcomes. Outcomes that were reported in at least five independent experiments were meta-analyzed; otherwise, a narrative synthesis was performed. Subgroup analysis by participants' age and material type was employed for learning outcomes. A total of 33 independent experiments from 13 research articles were identified and analyzed. For learning outcomes, facial anthropomorphism yielded significant improvements in transfer (standardized mean difference [SMD] 0.28, 95% CI 0.15 to 0.40, $p < 0.001$), retention (SMD 0.31, 95% CI 0.14 to 0.48, $p < 0.001$), and comprehension (SMD 0.46, 95% CI 0.27 to 0.64, $p < 0.001$). Anthropomorphism yielded stronger effect in retention among juvenile students and for static learning materials. Additionally, anthropomorphism design achieved significantly positive effects in positive affect, intrinsic motivation, intrinsic motivation change, perceived difficulty, intrinsic cognitive load, germane cognitive load, perceived learning outcome, aesthetics, and enjoyment. Nineteen outcomes were narratively analyzed and mixed results were found. Facial anthropomorphism design of multimedia learning materials can induce positive emotions in learners and improve their intrinsic motivation that in turn facilitates learners' transfer, retention, and comprehension performance. The study provides valuable insights that can guide educators and multimedia designers in applying facial anthropomorphism with learning materials to facilitate learning outcomes.

Keywords: Anthropomorphic, Multimedia learning, Meta-analysis, Retention, Transfer, Comprehension

Introduction

In the last decade, emotional design, which refers to the use of design features to promote positive emotions (Norman, 2007) or pleasure in users (Jordan, 2000), has attracted the interest of researchers in many fields (Brom et al., 2018; Cao et al., 2021; Pengnate & Sarathy, 2017; Roy & Naidoo, 2021; Song et al., 2021; Triberti et al., 2017). In multimedia learning settings, emotional design cues (e.g., human-like features and pleasant colors) have been employed to important elements of learning materials (Heidig et al., 2015; Mayer & Estrella, 2014). Such manipulations have the potential to induce positive emotions in learners, attract learners' attention, and enhance learning outcomes (Brom et al., 2018; Mayer & Estrella, 2014; Schneider et al., 2018).

Facial anthropomorphism refers to adding facial elements such as eyes and mouth to non-human graphical elements (Brom et al., 2018). It is assumed that facial expressions can communicate emotions (Ekman & Rosenberg, 1997). Moreover, the baby-face bias suggests that things with baby-faced features are more likely to induce positively-valence reactions (Brom et al., 2018). In educational settings, Mayer and Estrella (2014) employed anthropomorphism design principles in a multimedia lesson on how a virus causes a cold by rendering the host cell and virus each as a round and symmetrical face with eyes; results indicated that the anthropomorphism design improved students' retention. In contrast, other studies did not find that facial anthropomorphic features improved learning outcomes compared to neutral design (Liew et al., 2022; Shangguan et al., 2020b; Slabbert et al., 2022). For example, Liew et al. (2022) examined the effects of anthropomorphic design in learning materials that explain on how a distributed denial-of-service attack occurs (i.e., adding eyes and mouths on the images); results indicated that anthropomorphism influenced learners' affective motivational states but did not affect learners' intrinsic motivation and learning outcomes. Slabbert et al. (2022) indicated that anthropomorphized graphics (i.e., those with human-like expressions) that are decorative in nature may not contribute to learning.

Given the mixed findings, the effectiveness of anthropomorphic design requires more supporting evidence. In 2018, Brom et al. (2018) conducted a systematic review to examine the effects of emotional design (including the use of positive colors and anthropomorphism). The results of the meta-analysis indicated that emotional design had a significant positive effect on several learning and affective-motivational outcomes. Wong and Adesope (2021) replicated Brom's review (2018) by including newly published articles. However, the two reviews used the umbrella term "emotional design" rather than "anthropomorphism design," which may have masked some important differences among design elements (e.g., using pleasant colors versus anthropomorphism). Whether anthropomorphism in multimedia learning materials influences the learning process independently has not been examined explicitly. Moreover, previous reviews have mainly discussed the effects of emotional design on learning and affective-motivational outcomes, leaving other relevant outcomes unexamined. Considering these knowledge gaps, this study systematically reviewed the existing evidence on the effectiveness of facial anthropomorphism design of multimedia learning materials, assessing whether it improved learning and other

relevant outcomes. In addition, we examined how the effects of anthropomorphism differed across learners' ages and types of learning materials.

METHODS

Search strategy

The review was conducted in accordance with the Cochrane Collaboration guidelines for systematic review (Higgins et al., 2019). A systematic literature search was conducted for studies published before February 2023 using the databases Web of Science, PsycInfo, and PsycArticle. The following search terms were used for the search: (anthropomorphi*) and (effect* or impact or examin* or evaluat* or assess* or compar*) and (learning or comprehension or recall or memory or attention or transfer or retention or motivation or effort).

Study selection

Studies were included in the review if they met the following criteria: (1) were based on experimental design, (2) examined the effects of facial anthropomorphism on learning and other relevant outcomes in the context of multimedia learning; (3) reported quantitative data (e.g., means and SDs for the outcomes) for computing standardized effect sizes; and (4) were published in English-language, peer-reviewed journals. The titles and abstracts of the citations identified in the literature search were read to determine their relevance. The full texts of the relevant articles were then reviewed for final inclusion. The reference lists of the studies chosen for inclusion, as well as those of relevant review articles, were also screened to capture any missed articles. The screening of studies for eligibility was performed by KL and PS independently. Any discrepancies were resolved through discussions until a consensus was reached.

Data extraction

The two authors independently extracted the following characteristics from each study included in the review: author(s), publication year, study location, sample size, mean age of the participants, sex ratio, learning materials, anthropomorphism manipulation, and the statistics of learning/performance outcomes. For studies used a two-way factorial design with anthropomorphism and one secondary factor as independent variables, each level of the secondary factor was considered as independent sample. For instance, the study by Shangguan et al. (2020a, b) used a 2×2 between-group design, with learners' prior knowledge (high vs. low) and anthropomorphism design (presence vs. absence) serving as independent variables. We treated participants with high or low levels of prior knowledge as two independent samples, which resulted in two sets of comparisons (i.e., high level prior knowledge + anthropomorphism design vs. high level prior knowledge + neutral design; low level prior knowledge + anthropomorphism design vs. low level prior knowledge + neutral design). For studies with multiple intervention groups relevant to anthropomorphism, we split the "shared" control group into two or more groups to form two or more pairwise comparisons.

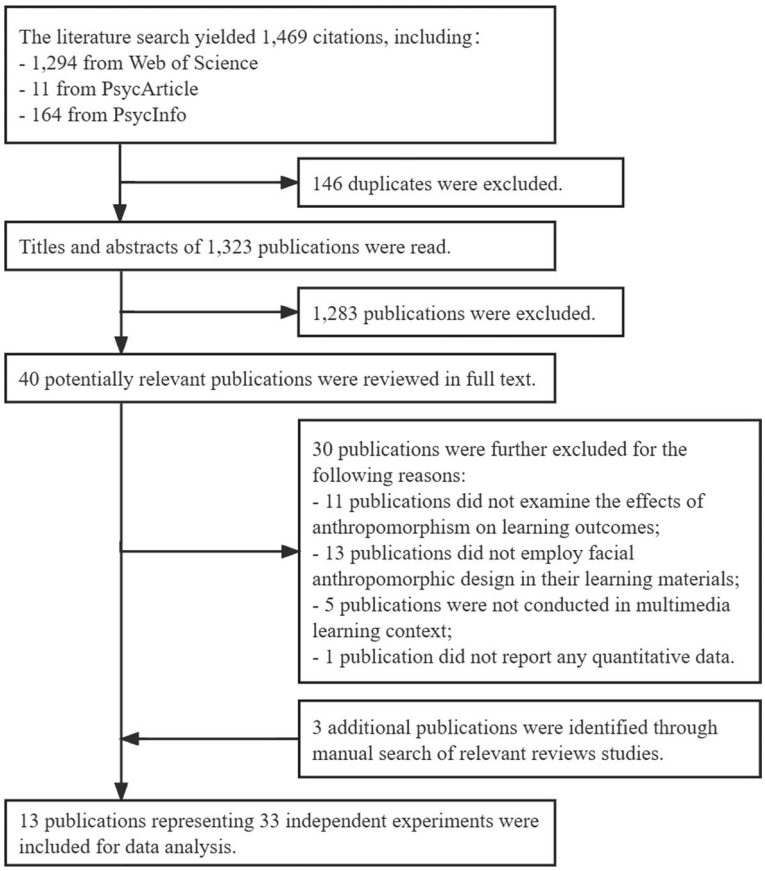

Fig. 1 Flow diagram of the study selection process

Outcome measures

Outcomes were divided into five categories, including learning outcomes (e.g., retention, transfer), affective-motivational outcomes (e.g., positive affect, intrinsic motivation), effort outcomes (e.g., mental effort), attention outcomes (e.g., fixation duration on specific area of interest), and experience outcomes (e.g., satisfaction, aesthetics).

Data analysis

Outcomes were meta-analyzed if they were reported in at least five trials. We pooled data across trials using random effects models and calculated the standardized mean difference (SMD) for each outcome. Heterogeneity was examined using the I^2 statistics, with the values of 25%, 50%, and 75% indicating low, moderate, and high levels of heterogeneity, respectively (Higgins et al., 2003). Publication bias was assessed using the Egger test, with a p value smaller than 0.05 considered as the existence of publication bias (Egger et al., 1997). Subgroup analysis was performed for learning outcomes by learners' age and type of learning material using Comprehensive Meta-Analysis software. Narrative synthesis was performed for outcomes that were reported in less than five trials.

Table 1 Summary of the characteristics of the 33 independent experiments

Characteristics	Value
Year of publication, n (%)	
2014–2015	10 (30.30%)
2016–2020	19 (57.58%)
2021–2023	4 (12.12%)
Study location, n (%)	
North America	4 (12.12%)
Europe	18 (54.55%)
Asia	10 (30.30%)
Africa	1 (3.03%)
Sample size, median (range)	55 (37–90)
Mean age of participants in years, mean (range, SD)	19.11 (11.14–25.20, 4.35)
Proportion of male participants in %, median (range)	40 (10.7–53.2)

RESULTS

Study selection

Figure 1 presents the process of literature search and study selection. We identified 33 independent experiments from 13 research articles (Liew et al., 2022; Mayer & Estrella, 2014; Park et al., 2015; Plass et al., 2014; Schneider et al., 2018, 2019; Shangguan et al., 2020a; Shangguan, Wang, Shangguan et al., 2020a, b; Slabbert et al., 2022; Stárková et al., 2019; Um et al., 2012; Uzun & Yıldırım, 2018; Wang et al., 2023).

Study characteristics

Table 1 presents the study characteristics of the 33 independent experiments. Twenty-three (69.7%) were conducted after 2016. More than half of the experiments were conducted in Europe. The median sample size for the 33 experiments was 55 (range, 37 to 90). Table 2 presents the details of the learning materials.

Meta-analysis results

The meta-analysis results for learning outcomes are presented in Table 3. Forest plots for transfer, retention, and comprehension are presented in Figs. 2 and 3, and 4, respectively. Facial anthropomorphism designs of multimedia learning materials had significant positive effects on transfer (standardized mean difference [SMD] 0.28, 95% confidence interval [CI] 0.15 to 0.40, $p < 0.001$), retention (SMD 0.31, 95% CI 0.14 to 0.48, $p < 0.001$), and comprehension (SMD 0.46, 95% CI 0.27 to 0.64, $p < 0.001$).

Table 4 presents the meta-analysis results for the affective-motivational, effort, and experience outcomes. Among the affective-motivational outcomes, the facial anthropomorphism design of multimedia learning materials had significantly positive effects on positive affect, intrinsic motivation, and intrinsic motivation change. There were no significant between-group differences for positive affect change, valence, and valence change. Among the effort outcomes, anthropomorphism had significant positive effects on perceived difficulty, intrinsic cognitive load, and germane cognitive load. It had

Table 2 Details of the learning materials

Experiment, publication year	Material type/Learning language/Learning topic	Anthropomorphic manipulation	Control
Liew et al., 2022 (Liew et al., 2022)	Video/English/ How a distributed denial-of-service attack occurs?	Human-like visual attributes such as eyes and mouth on the images depicting the malware, bots, and servers + human-like dialogues	No human-like images; no human-like dialogues
Mayer & Estrella, 2014_Exp1, Exp2 (Mayer & Estrella, 2014)	PowerPoint (PPT)/English/ How a virus causes a cold?	Rendering the host cell and virus each as a round and symmetrical face; eyes were added into the host cells and virus + bright colors	Black and white line drawing; without anthropomorphism
Park et al., 2015_1, 2 (Park et al., 2015)	Animation/German/ Immunization	Human-like expression, round shapes, and warm, bright colors were employed to the essential elements (e.g., cells)	Neutral shapes; warm and bright colors; without anthropomorphisms
Plass et al. 2013_Exp1_1, 2 (Plass et al., 2014)	Animation/German/ Immunization	Baby face-like characters, such as round shapes and big eyes, were employed to the essential elements (e.g., cells) + warm color	Grayscale and neutral shapes
Plass et al. 2013_Exp2_1 (Plass et al., 2014)	Animation/German/ Immunization	Round face-like shapes + warm colors	Neutral shapes + warm colors
Plass et al. 2013_Exp2_2 (Plass et al., 2014)	Animation/German/ Immunization	Round face-like shapes + grayscale	Neutral shapes + grayscale
Schneider et al., 2018_Exp1_1, 2, Exp2 (Schneider et al., 2018)	Web page/German/AI	Face-like structures like simplistic drawings of eyes and a mouth	No human-like features (e.g., human faces and arms)
Schneider et al., 2019_Exp1_1, Exp2_1, Exp3_1 (Schneider et al., 2019)	Web page/English/The components of the blood and their function	Simple eyes and a mouth were added to the blood cells	Without a face
Schneider et al., 2019_Exp1_2, Exp2_2, Exp3_2 (Schneider et al., 2019)	Web page/English/The components of the blood and their function	Simple eyes, a mouth, a nose, eyebrows, hair, arms, and legs were added to the blood cells	Without a face
Shangguan et al., 2020a_Exp1, Exp2_1, 2 (Shangguan, Wang, Shangguan et al., 2020a, b)	Animation/Chinese/The formation of lighting	Making the elements (e.g., sun, cloud, electric charge) more expressively anthropomorphic (e.g., adding eyes and mouth)	Achromatic design; without anthropomorphism
Shangguan et al., 2020b_1, 2 (Shangguan et al., 2020)	Animation/Chinese/The formation of lighting	Applying color and anthropomorphism (e.g., adding eyes and mouth) to the cloud, the positive and negative charges	Monochromatic greyscale; without anthropomorphism
Slabbert et al., 2022 (Slabbert et al., 2022)	PPT/Afrikaans/The solar system and planets	Graphics in color and with anthropomorphism (e.g., human-like expression)	Monochromatic greyscale; without anthropomorphism

Table 2 (continued)

Experiment, publication year	Material type/Learning language/Learning topic	Anthropomorphic manipulation	Control
Starkova et al. 2019_1 (Stárková et al., 2019)	PPT/Czech/ How the influenza virus attacks the human body?	Eyes were added into the host cells and virus	Black and white line drawing; without anthropomorphism
Starkova et al. 2019_2, 3 (Stárková et al., 2019)	PPT/Czech/ How the influenza virus attacks the human body?	Eyes were added into the host cells and virus + bright colors	Black and white line drawing; without anthropomorphism
Um et al., 2012_1, 2 (Um et al., 2012)	Animation/English/ How immunization works?	Baby face-like characters, such as round shapes and big eyes, were employed to the essential elements (e.g., cells) + saturated and analogous bright warm color	Monochromatic grayscale and rectangular shapes
Uzun and Yildirim 2018_1 (Uzun & Yıldırım, 2018)	Video/Osmanli/Work, energy, and energy conservation	Expressive anthropomorphism was used for lifeless objects (e.g., a smiling face) + saturated, bright, and attention-grabbing colors	No facial expressions; saturated, bright, and attention-grabbing colors
Uzun and Yildirim 2018_2 (Uzun & Yıldırım, 2018)	Video/Osmanli/Work, energy, and energy conservation	Expressive anthropomorphism was used for lifeless objects (e.g., a smiling face) + saturated, bright, and attention-grabbing colors + interesting sound effects	No facial expressions; saturated, bright, and attention-grabbing colors
Wang et al., 2023_1, China (Wang et al., 2023)	Video/Chinese/The process of lightning formation	Face-like characters, such as smiling eyes and mouths, were added into the essential elements (e.g., water droplets and ice crystals)	Black and white line drawings; without anthropomorphism
Wang et al., 2023_2, China (Wang et al., 2023)	Video/Chinese/The process of lightning formation	Both vibrant and bright colors and face-like characters were added in the essential elements	Vibrant and bright colors were used for the essential elements; without anthropomorphism

Table 3 The meta-analysis results for learning outcomes

Outcomes	N^a	n^b	SMD[c] (95% CI)	*p* value	I^2	Egger test	
						t value	*p* value
Learning outcomes							
Transfer	30	1803	0.28 (0.15 to 0.40)	< 0.001	41	0.28	0.39
Retention	25	1487	0.31 (0.14 to 0.48)	< 0.001	60	0.07	0.47
Comprehension	8	449	0.46 (0.27 to 0.64)	< 0.001	0	1.06	0.16

[a] number of experiments

[b] sample size

[c] standardized mean difference

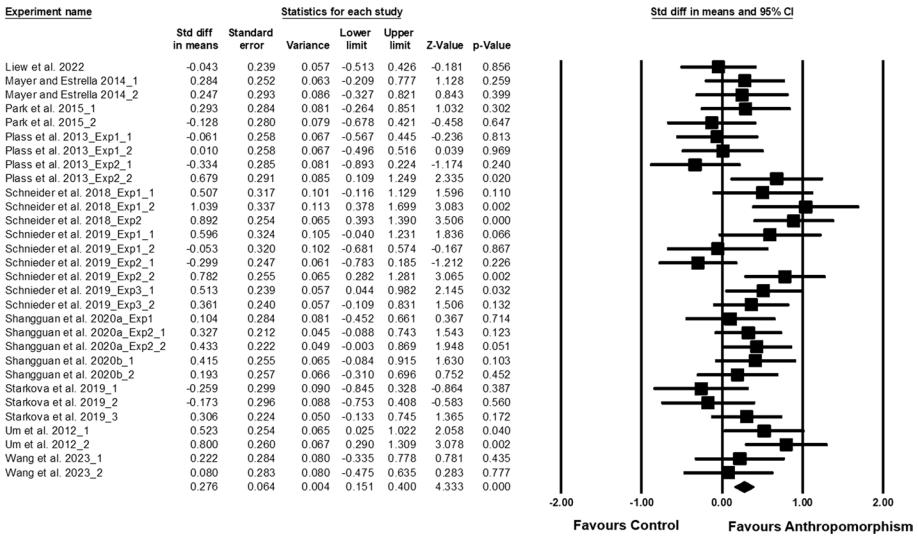

Fig. 2 Forest plot for transfer

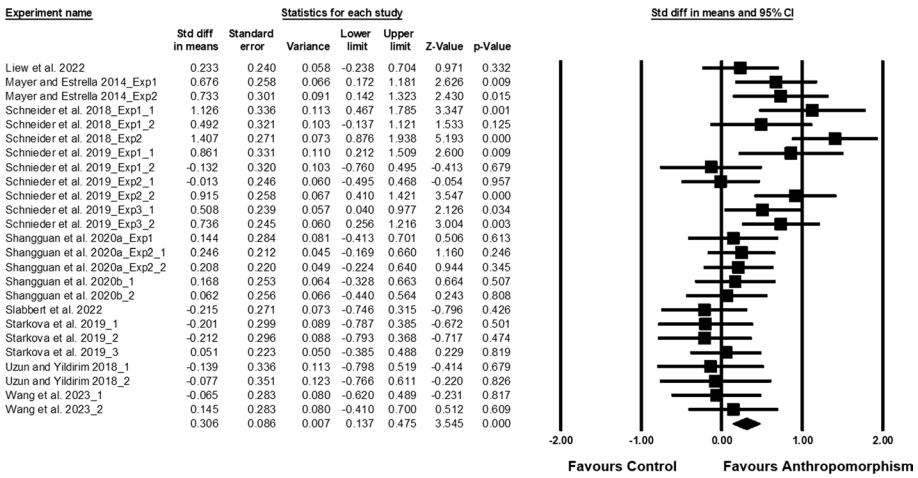

Fig. 3 Forest plot for retention

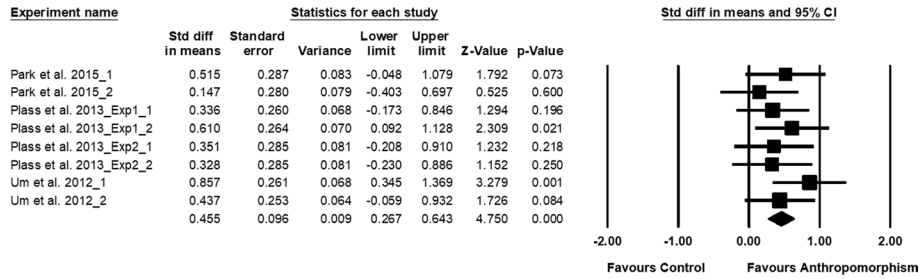

Fig. 4 Forest plot for comprehension

significant negative effects on extraneous cognitive load and no significant effect on mental effort. Among the experience outcomes, anthropomorphism had significant positive effects on perceived learning, aesthetics, and enjoyment. No significant difference was observed between the groups for satisfaction.

Subgroup analysis by age and material type on learning outcomes

The analyses of study outcomes by age and material type (e.g., static material: PowerPoint slide or webpage; dynamic materials: video or animation) were performed on learning outcomes (Table 5). Anthropomorphic design improved retention significantly in juveniles but did not have a significant effect on retention in adults, although it improved transfer significantly in both adults and juveniles. Anthropomorphic design also significantly improved the retention of knowledge from static but not dynamic learning materials. Additionally, it improved transfer significantly in both the dynamic and static groups.

Narrative synthesis results

A total of 19 outcomes were narratively synthesized (Table 6). There were significant differences between the anthropomorphism group and the control group for task-irrelevant thinking and some of the eye movement measures. Schneider et al. (2018) indicated that the anthropomorphism group scored higher on task-irrelevant thinking than the control group. Park et al. (2015) reported that fixation was longer on relevant pictures and anthropomorphic elements. Starkova et al. (2019) indicated that pictures attracted more attention during initial observation (2s) in the anthropomorphic condition. There were no significant differences between the anthropomorphic and control groups for the other outcomes.

Discussion

Main findings

This systematic review identified a total of 33 independent experiments that examined the effects of facial anthropomorphism design in multimedia learning settings. Overall, the meta-analysis showed that the employment of anthropomorphism design achieved better learning outcomes. However, evidence for the improvement of affective-motivational, effort, and experience outcomes was less conclusive. Some of the outcomes favored anthropomorphism and others were not influenced or even negatively affected by anthropomorphic design. Mixed results were also observed in the narrative synthesis.

Table 4 The meta-analysis results for affective-motivational, effort, and experience outcomes

Outcomes	N[a]	n[b]	SMD[c] (95% CI)	*p* value	I^2	Egger test	
						t value	*p* value
Affective-motivational outcomes							
Positive affect	15	877	0.48 (0.06 to 0.90)	0.03	88	5.12	< 0.001
Positive affect change	11	699	0.13 (– 0.09 to 0.34)	0.25	51	1.62	0.07
Valence	9	545	0.23 (– 0.23 to 0.68)	0.33	84	1.88	0.051
Valence change	7	464	0.30 (– 0.02 to 0.62)	0.07	62	0.01	0.49
Intrinsic motivation	21	1310	0.36 (0.20 to 0.53)	< 0.001	53	2.90	< 0.01
Intrinsic motivation change	7	464	0.72 (0.50 to 0.94)	< 0.001	20	2.19	0.04
Effort outcomes							
Mental effort	19	1066	– 0.22 (– 0.63 to 0.19)	0.30	90	4.83	< 0.001
Perceived difficulty	14	843	– 0.15 (– 0.29 to – 0.01)	0.03	2	0.56	0.29
Intrinsic cognitive load	8	534	– 0.30 (– 0.48 to – 0.12)	0.001	4	0.27	0.40
Extraneous cognitive load	8	534	0.62 (0.20 to 1.05)	0.004	81	2.66	0.02
Germane cognitive load	8	534	0.79 (0.54 to 1.04)	< 0.001	45	0.58	0.29
Experience outcomes							
Perceived learning outcome	10	573	0.19 (0.00 to 0.38)	0.047	22	1.31	0.11
Satisfaction	8	472	0.06 (– 0.13 to 0.25)	0.51	8	1.64	0.08
Aesthetics	6	395	0.80 (0.48 to 1.13)	< 0.001	54	0.94	0.20
Enjoyment	5	292	0.31 (0.08 to 0.55)	0.01	0	1.94	0.07

[a] number of experiments

[b] sample size

[c] standardized mean difference

Table 5 Subgroup analysis for learning outcomes by age and material type, respectively

Outcomes	Transfer				Retention			
	n[a]	Standardized mean difference	*p*-value	Between-group difference	n[a]	Standardized mean difference	*p*-value	Between-group difference
Age								
Adult (age ≥ 18)	18	0.21 (0.05, 0.38)	0.01	0.25	13	0.19 (-0.03, 0.41)	0.09	0.17
Juvenile (age < 18)	12	0.36 (0.18, 0.55)	< 0.001		12	0.42 (0.17, 0.67)	0.001	
Material type								
Dynamic (video, animation)	16	0.23 (0.08, 0.37)	0.002	0.41	10	0.13 (-0.04, 0.29)	0.13	0.04
Static (webpage, PPT)	14	0.34 (0.12, 0.55)	0.002		15	0.45 (0.18, 0.71)	0.001	

[a] sample size

Consistent with Brom et al. (2018), we reported small to medium effect sizes for transfer (SMD = 0.28), retention (SMD = 0.31), and comprehension (SMD = 0.46). Such results indicated that employing facial anthropomorphism design in learning materials

Table 6 Narrative synthesis results

Outcomes	Number of experiments showing	
	Significant difference between groups	**No significant difference between groups**
Learning outcomes		
Delayed recall/retention		4 (Slabbert et al., 2022; Stárková et al., 2019)
Delayed transfer		3 (Stárková et al., 2019)
Delayed comprehension		1 (Slabbert et al., 2022)
Affective-motivational outcomes		
Difference in negative affect		3 (Stárková et al., 2019)
External motivation		2 (Schneider et al., 2018)
Difference in external motivation		1 (Schneider et al., 2018)
Effort outcome		
Task-irrelevant thinking	2 (Schneider et al., 2018)	
Experience outcomes		
Acceptance of learning materials		2 (Park et al., 2015)
Appeal of the lesson		2 (Mayer & Estrella, 2014)
Desire for more similar lessons		2 (Mayer & Estrella, 2014)
Situational interest		2 (Park et al., 2015)
Flow		3 (Stárková et al., 2019)
Attention outcomes		
Fixation duration on pictures	1 (Park et al., 2015)	1 (Park et al., 2015)
Fixation duration on anthropomorphic design area of interests (AOIs)		2 (Wang et al., 2023)
Fixation duration on geometrical anthropomorphism elements		2 (Park et al., 2015)
Fixation duration on expressive anthropomorphisms elements	1 (Park et al., 2015)	1 (Park et al., 2015)
Dwell time on the main text/pictorial area		1 (Stárková et al., 2019)
Initial dwell time on pictures	1 (Stárková et al., 2019)	
Time to first fixation on an emotional design AOI		2 (Wang et al., 2023)

was effective in increasing achievement scores (Uzun & Yıldırım, 2018). According to the cognitive affective theory of learning with media (CATLM) (Moreno, 2006; Moreno & Mayer, 2007), the reason for such improvements may be that appealing learning materials motivated learners to engage in appropriate cognitive processing during learning. Incorporating human-like features to anthropomorphize the learning elements also elevated learners' the positive affect (SMD = 0.48). However, the anthropomorphism group did not lead to a significantly larger increase of positive affect than the control group. Non-significant differences in valence and valence change were not observed between groups. The results for effort outcomes were inconclusive. Learners who studied the anthropomorphically designed materials perceived the materials as less difficult and reported lower levels of intrinsic cognitive load and higher levels of intrinsic motivation and germane cognitive load (i.e., perceived understanding), congruently with previous

meta-analyses of emotional design (Brom et al., 2018; Wong & Adesope, 2021). Previous literature also indicated that such manipulations would require less effort to process and would make learners feel that materials were easy to learn (Salomon, 1984; Tractinsky et al., 2000). However, extraneous cognitive load was significantly higher when anthropomorphic features were added to the learning materials, indicating that learners may have perceived the instructions and explanations used in anthropomorphic design as less clear than instructions associated with materials designed differently. The added anthropomorphic features were complex, which may have distracted and overloaded students, but their positive effects were strong enough to overshadow the additional load (Schneider et al., 2019). The learners in the anthropomorphic group reported higher levels of perceived learning, aesthetics, and enjoyment.

In the subgroup analysis, we found that anthropomorphism design yielded significant improvements in retention only among learners younger than 18 years old. Facial features may have increased the concreteness of the learning materials for juveniles, resulting in better recall performance (Plass et al., 2014; Tse & Altarriba, 2009). Brom et al. (2018) also found that the effects of emotional design on intrinsic motivation were stronger for younger children than for college students. In our analysis of learning materials, facial anthropomorphism significantly improved learners' retention when static learning materials were used for study. Learners find static learning materials more difficult than animations or videos and consider that learning from them requires more mental effort (Höffler & Leutner, 2007). Although we found that anthropomorphism facilitated the learning process more in static learning materials than in dynamic learning materials, this result was not in line with previous reviews (Brom et al., 2018; Wong & Adesope, 2021) that found there was no significant difference in retention between the two groups. Further research on the relationship between the material type and learning outcomes is needed.

Our narrative synthesis indicated that anthropomorphic designs significantly influenced task-irrelevant thinking. However, only Schneider et al. (2018) have reported such a result previously, probably because the anthropomorphic features employed in the experiments were complex and therefore induced more irrelevant thoughts, especially for learners with little prior knowledge. Studies have also shown that anthropomorphism has functioned as a process of empathy (Airenti, 2015; Schneider et al., 2018). For eye movement measures, Park et al. (2015) and Starkova et al. (2019) found that anthropomorphic design is attention-arousing and more likely than non-anthropomorphic design to lead to deep information processing. There were no significant differences between their anthropomorphism and control groups for the other outcomes. Given the mixed results, more research is needed to further understand how they are affected by anthropomorphism.

Implications for research

Our review suggests several implications for research. First, most of the experiments examined only the effects of anthropomorphic design on learning and affective-motivational outcomes; few have assessed effort and experience outcomes. Further experiments should focus more on these outcomes to obtain better understanding of whether, how, and to what extent anthropomorphism influences the learning process. Second,

most of the experiments measured affective-motivational and effort outcomes through self-reported surveys, making it difficult to distinguish among different affects and/or load types (De Jong, 2010; Kalyuga, 2011). Future studies may consider assessing learners' affective-motivational and effort outcomes using more objective methods (e.g., ECG and EEG). Third, our systematic review found that few studies have examined the attention-capturing effects of anthropomorphic design on learners (Park et al., 2015; Stárková et al., 2019; Wang et al., 2023). Further examinations of eye-tracking data are required to better clarify how anthropomorphic features influence learners' attention distribution. Also, future experiments should quantify the level of anthropomorphism so that its optimal level can be determined. Fourth, most of the studies examined only immediate learning outcomes. However, delayed learning outcomes, which reflect the extent to which learners can remember and comprehend knowledge after an interval of time, are important to investigate as well. Finally, several factors might have moderated the effects of facial anthropomorphism on the learning process. For example, most of the studies we reviewed assessed the use of anthropomorphism in learning materials for children and/or younger adults. How anthropomorphism affects adults/older adults has received less attention. The effects of learners' cultural backgrounds, familiarity with anthropomorphism design, and prior knowledge on the effects of anthropomorphism also remains unclear (Liew et al., 2022).

Implications for practice

Positive emotion has been regarded as a crucial factor influencing the learning process and outcomes (Liu et al., 2023; Tyng et al., 2017). Our review indicated that facial anthropomorphism design can foster positive emotions among learners and improve learning outcomes. Multimedia designers aiming to improve learners' transfer, retention, and comprehension are encouraged to consider appropriate ways to add facial anthropomorphism to essential elements of the learning materials (Wong & Adesope, 2021). Iterative human factors evaluations are recommended for designers to confirm the optimal degree of anthropomorphism so that learning materials will enhance learning motivation and positive emotions without adding too much cognitive burden.

Limitations

Our systematic review has several limitations. First, the effects of facial anthropomorphism need to be interpreted with caution due to variability in the design of learning materials. For instance, some of the studies we reviewed used only round, face-like shapes in the learning materials, whereas others included eyes, mouth, nose, and eyebrows. In addition, we did not quantify the level of anthropomorphism, so we cannot recommend an optimal level of anthropomorphism for educational materials. Second, the sample available for meta-analysis was relatively small. Nineteen outcomes (e.g., eye tracking metrics, experience outcomes) had to be analyzed using narrative synthesis, by simply measuring their statistical significance. As more research in the field is published, a meta-analysis could be conducted to investigate the effect size and significant level of these outcomes. Third, publication bias was detected for positive affect, intrinsic motivation, intrinsic motivation change, mental effort, and extraneous cognitive load. The

results need to be interpreted with caution for these outcomes. Fourth, we included only articles published in English, which could have led to language and publication bias.

Conclusion

This systematic review examined the effects of facial anthropomorphism on the learning process in multimedia learning settings. Our findings indicate that the facial anthropomorphism design of multimedia learning materials can induce positive emotions in learners and improve their intrinsic motivation, facilitating transfer, retention, and comprehension performance. The use of facial anthropomorphism appears to be more beneficial for learners younger than 18 years old and in the design of static rather than dynamic learning materials. The findings of this study can guide educators and multimedia designers in applying facial anthropomorphism to learning materials to facilitate learning outcomes.

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Author contributions
KL conceived the review and determined the search strategy. KL and PS performed study selection, data extraction, and data analysis. KL wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

Data availability
The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of intrest
The authors declare that they have no competing interests.

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