



A Systematic Review: The Impact of Educational Animation on Student Learning Outcome

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ABSTRACT: This systematic review investigates the impact of educational animation and multimedia applications on student learning outcomes by synthesizing findings from sixteen empirical studies published between 2021 and 2026. Using the PRISMA four-phase framework identification, screening, eligibility, and inclusion the study systematically filtered an initial pool of 2,989 articles down to a final dataset of relevant research. The review adopts an integrative analytical approach, combining qualitative, quantitative, and mixed-method studies to identify recurring themes and patterns. Findings reveal that educational animation significantly enhances learning through three primary dimensions: cognitive processing, emotional engagement, and instructional design. First, animation supports cognitive and perceptual processes by simplifying abstract concepts, guiding attention, and reducing cognitive load through multimodal representations such as augmented reality (AR), virtual reality (VR), and dynamic visualizations. Second, animation contributes to increased motivation and emotional engagement, with interactive and emotionally designed content fostering sustained attention, curiosity, and active participation. Game-based and immersive environments, in particular, demonstrate strong motivational effects by stimulating emotional and reward systems. Third, the effectiveness of animation is closely tied to instructional design features, including pacing, interactivity, narrative elements, and alignment with pedagogical theories such as the Cognitive Theory of Multimedia Learning. Evidence suggests that animation alone does not guarantee improved outcomes; rather, its impact depends on purposeful, theory-driven implementation. Overall, the review concludes that educational animation is a powerful instructional tool when strategically designed, offering significant benefits for comprehension, engagement, and learning performance in modern digital education environments.

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I. INTRODUCTION

In the context of digital ecosystems of learning, animation is increasingly adopted in educational settings. Educational animation is considered an effective instructional tool, which has been found to simplify abstract concepts, promote multimodal cognitive processes (e.g., memory, thinking), and involve learners actively. In terms of the Cognitive Theory of Multimedia Learning (Mayer, 2020), well-designed animated content reduces extraneous cognitive load, improves information organisation, and supports knowledge retention by activating both auditory and visual processing channels. Apart from cognitive benefits, animations also promote motivation and emotional engagement, which are essential elements of continuous learning (Plass & Kaplan, 2016). The proliferation of digital learning environments, spanning augmented reality (AR), virtual reality (VR), and interactive video-based teaching, has also extended the reach of animation to become part of everyday teaching practices. Studies across these modalities find that animated and dynamic visuals foster focus, understanding, and performance relative to static and text-based teaching (Fiorella & Zhang, 2022). In VR immersion contexts, for instance, signalling and animated cues assist learners in moving through

complex scenes, staying focused, and with this better comprehension (Mikropoulos & Natsis, 2021). Emotionally designed animations are also found to enhance attention and support persistence when distracted (Um et al., 2012).

Animation has been proven to be effective, but the impact of the animation on learning is variable and depends on several factors such as visual design, interactivity level, emotional appeal, and alignment with pedagogical goals. As earlier investigators claimed, tools like technology are not conducive to learning but to the efficacy of the technologies in a comprehensive instructional design (Clark & Mayer, 2016). And therefore, compiling current empirical findings is crucial to appreciate animation in digital learning and the design elements most positively influencing the learners. To fill this gap, this systematic literature review is conducted to examine the effectiveness of animated, augmented, immersive, and visually enhanced instructional environments in the achievement of student learning goals in sixteen empirical explorations carried out in recent years and their relation to student learning outcomes by identifying patterns, gaps, and themes emerging in the literature. Through studying how students react cognitively, emotionally, and behaviourally to learning with animation-based products this research has brought an up-to-date and holistic perspective of animation's place in educational delivery today.

II. MATERIAL AND METHODS

To obtain relevant research for analysis, the systematic review method was carried out through three essential stages including identification, screening and eligibility.

Identification

Identifying linked and similar terms by dictionaries, thesauri, encyclopaedias and previous research is the critical initial phase in keyword recognition. In this article, the primary keyword selected are animation, learning outcome and education. As detailed in Table 1, search strings were carefully constructed for the Scopus and ScienceDirect databases using these relevant keywords. This identification stage of the systematic review successfully extracted 2,989 publications from the two databases.

Table 1: The Search String

Category	Description
Scopus	TITLE-ABS-KEY (animation AND "learning outcome" AND education OR learning OR pedagogy)
Science Direct	https://www-scencedirect-com.pustakaupsi.idm.oclc.org/search?q=animation+AND+%22learning+outcome%22+AND+education&years=2025%2C2024%2C2023%2C2022%2C2021&subs=true&show=100&articleTypes=REV%2CFLA&lastSelectedFacet=accessTypes&accessTypes=op enaccess

Screening

A total of 46 studies were carried forward into the screening phase, which served as the second critical stage of the systematic review process. During this stage, a meticulous examination of each study's title and abstract content was conducted, with specific exclusion criteria rigorously applied. Articles were systematically excluded if they were not published in English, appeared prior to the 2021 publication year cutoff, were not categorized as formal journal publications, were still marked as 'in-press,' or were inaccessible due to restricted access. Following this initial assessment, a subsequent duplication assessment was performed on the retained records; however, this step did not lead to the removal of any redundant entries.

Eligibility

The eligibility assessment phase commenced with 46 articles identified for initial screening. Following the application of rigorous inclusion or exclusion criteria, 30 articles were excluded. The primary reasons for exclusion were multi-factorial, indicating a high level of selection stringency and included articles being classified as out of scope, possessing insufficient title relevance or containing abstracts that did not address the primary study objective (Refer to Table 2). This systematic filtering resulted in a final dataset of 16 articles remain open for evaluation.

Table 2: The Selection Criterion in Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline	2021 – 2026	< 2021
Literature type	Journal (Article)	Besides Journal
Publication stage	Final	In Press
Open access	Malaysia	Other country

DATA ABSTRACTION AND ANALYSIS

An integrative approach was employed as a key evaluation method in this research, aiming to review and synthesize multiple types of research methodologies, including quantitative, qualitative, and mixed-method studies. The primary objective of this comprehensive analysis was to pinpoint pertinent themes and subthemes within the subject area. The initial phase involved gathering data, which served as the foundation for theme development. As illustrated in Figure 1, the researchers conducted a thorough examination of 16 selected articles, extracting statements and content closely related to the study’s focus. Subsequently, the team critically assessed major existing research addressing the influence of instructional animations and visual graphics on learners’ motivation and academic performance. Both the methodologies and outcomes of these studies were systematically explored. Following this, the lead author worked in conjunction with co-authors to generate themes grounded in the collected evidence within the scope of this research. Throughout the analytical process, a detailed record was maintained to capture all analyses, perspectives, unresolved questions, and interpretative insights. Afterward, the research team cross-examined their findings to identify any discrepancies in the development of thematic categories. If differences in interpretation arose, the authors engaged in discussions to reach consensus. The resulting themes were then refined to achieve uniformity. To ensure the validity and industry relevance of the finalized themes, experts specializing in animation and visual graphics reviewed and endorsed them for clarity, coherence, and alignment with professional benchmarks. In the concluding phase, these specialists provided additional feedback and confirmation, verifying that the themes accurately reflected the intended concepts and satisfied professional standards.

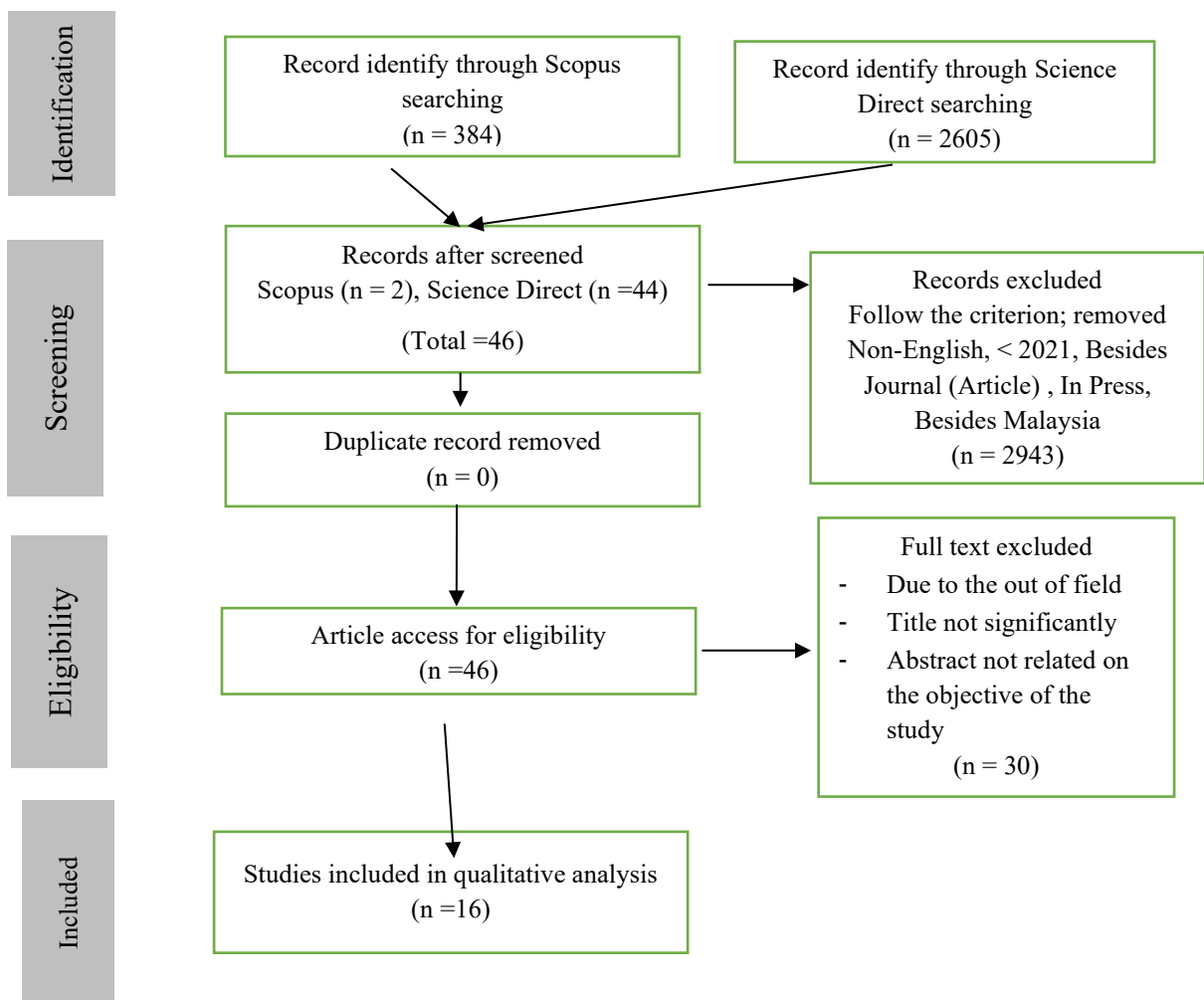


Figure 1: Flow diagram of the proposed searching study (Moher D, Liberati A, Tetzlaff J, 2009)

III. RESULTS

From analyzing the 16 studies which are summarised in Table 3, one can see the same pattern emerge concerning educational animation and its digital multimedia technologies impact upon a child's learning. The table provides a range of methods that comprise augmented reality implementation, virtual reality experiments, eye-tracking studies, podcast-based prosodic cue tasks, large-scale video engagement analysis, storified instructional video interventions and game-based learning strategies. With these diverse applications, the combined results are suggestive of 3 general educational advantages of animation for cognitive processing gains, motivational and emotional involvement, and instructional performance.

The first trend in Table 3 is that of the cognitive benefit of animated and visually dynamic teaching materials. Previous studies including Karim et al., Endres et al., Patrick Albus et al., & Yang and Wang show that AR, VR, and 3D visualization environments contain animations that support conceptual understanding. The FizaAR tool, for instance, made it easier for students to understand abstract physics concepts, by showing animated versions of phenomena that are hard to visualise in the background of still photos. Likewise, VR signalling assisted learners in processing more complex spatial information, which translated into higher recall scores and higher germane cognitive load. Dynamic visualization cues have further been found to affect learners' attentional distribution in eye-tracking studies (Table 3). Although Zhang et al. found that mouse pointing and labelling did not directly enhance test results in the study, eye movement behavior revealed that the animations led learners towards relevant content, thereby upholding the prediction that perceptual attention is a pre-requisite for successful learning.

The second important phenomenon manifested in Table 3 is emotion and motivation by animation in multimedia learning environments. The study by Endres et al. showed that animation use in emotional design for animated videos prevented learners from being distracted, showing the protective effects of animation for sustained engagement. Studies of games and games-based learning (Greipl et al. and Laakso et al.) show that animating activities foster motivation through eliciting emotions and reward-based effects. The digital escape room intervention revealed that animation can create even serious topics and risky behaviours, for example that are more approachable and engaging and lead to better knowledge, more rich discussions and a better mindset. This discovery implies that the emotional aspect of the animation has a positive influence on the involvement of students in academic activities, i.e., the involvement in the active participatory learning processes.

The third dominant phenomenon involves design of instruction and the ways in which the mechanical characteristics of the animation technology affect learning. Table 3, animated media (teaching strategies in action for teaching) is closely related to the quality of the intervention and the way animation is used. The storified instructional videos demonstrate that both the storified and non-storified animations supported credibility evaluation abilities, however the narrative element was not always necessary, indicating that animation delivery may be a task specific to learning purpose and quality can be compromised by animation design. The video pausing behaviour conducted by Merkt et al. emphasizes that learners will pause during moments of cognitive overload in animated instructional videos and the need for pacing that takes into account the processing of learners. Studies with virtual classmates in immersive environments report that animated classmates influence attention distribution as well as social presence, highlighting the critical significance of the collaboration between animation design and pedagogical intent and classroom dynamics. The Table 3 results, across multiple pedagogical contexts, in summary reveal animation to be an actively designed experience, a teaching pedagogy, and an instructional tool to enhance student learning outcomes. Together, they support the understanding that animation has direct effects on cognitive concentration, psychological engagement, instructional efficacy that is all of improved comprehension, motivation and learning experiences.

Table 3: The Research Article Finding Based on the Proposed Searching Criterion

Authors	Title & Year	Source Title	Methodology	Advantages
Karim, S.N.M.; Karim, A.A.; Kamsin, I.F.	FizaAR: An Augmented Reality Learning Kit Integrating Social Cognitive Theory in Learning Physics (2024)	International Journal of Information and Education Technology	Design and Development Research (DDR); implementation of an AR learning kit (FizaAR) based on Social Cognitive Theory (SCT) and Cognitive Theory of Multimedia Learning (CTML).	Improved understanding of abstract physics concepts; better mathematical problem-solving (e.g., escape velocity); peer learning enhanced outcomes; systematic design through DDR.
Za'ba, N.; Ismail, Z.; Abdullah, A.H.Zhou T., Geng Y., Chen J., Pan J., Haase D., Lausch A.	Preparing student teachers to teach mathematics with GeoGebra (2020)	Universal Journal of Educational Research	Between-subjects online experiment comparing anthropomorphized vs. non-anthropomorphized multimedia lessons.	Increased positive affect; reduced perceived difficulty (lower intrinsic cognitive load); slightly longer engagement time.
Patrick Albus, Andrea Vogt, Tina Seufert	Signaling in virtual reality influences learning outcome and cognitive load. (2021)	https://doi.org/10.1016/j.compedu.2021.104154	Between-subjects experiment with VR learning environment, with/without textual annotations.	Annotations improved recall and germane cognitive load; supported processing of information despite no reduction in extraneous load.

Juliette C. D'esiron , Sascha Schneider	Listen closely: Prosodic signals in podcast support learning (2024)	https://doi.org/10.1016/j.compedu.2024.105051	Online experiment using an audio podcast with prosodic cues (volume × pace design).	Prosodic cues improved learning outcomes; slower pace reduced cognitive load; combined cues yielded the strongest learning effect.
Tino Endres, Charlotte Vossing, K. Ann Renninger, Alexander Eitel, Alexander Renkl	Sustaining focus when It's hardest: Emotional design strengthens sustained learning, especially in contexts with attractive alternatives (2025)	https://doi.org/10.1016/j.compedu.2025.105313	2×2×2 mixed design manipulating emotional design, alternative opportunities, and learning phase in a 16-min video.	Emotional design improved learning, especially later in the video; reduced mental load; boosted situational interest; stronger effects with distractions present.
Xiaoxiao Liu, Ying Cui	Eye tracking technology for examining cognitive processes in education: A systematic review (2025)	https://doi.org/10.1016/j.compedu.2025.105263	Systematic review of 313 eye-tracking studies (2012–2024).	Identified common themes and gaps; clarified cognitive processes studied; provided theoretical and practical insights for using eye-tracking in education.
Fang-Ying Yang, Hui-Yun Wang	Tracking visual attention during learning of complex science concepts with augmented 3D visualizations (2023)	https://doi.org/10.1016/j.compedu.2022.104659	AR learning system with mobile eye-tracking; pre/post testing; correlation, regression, and LSA analyses.	Conceptual understanding improved; attention patterns linked to achievement; static 3D model attention predicted learning; highlighted need for guidance connecting representations.
Michael J. Parker, Matt Bunch, Andrew Pike	Is anybody watching: A multi-factor motivational framework for educational video engagement (2024)	https://doi.org/10.1016/j.compedu.2024.105148	Large-scale analysis of 3.1M video views + predictive modeling.	Showed multi-session viewing is common; course context strongly affects engagement; models predict engagement more accurately than video-length-only rules.
Carita Kiili, Kristian Kiili, Eija Raikkonen, Julie Coiro	Explicit video-based instruction enhanced students' online credibility evaluation skills: Did storifying instruction matter? (2025)	https://doi.org/10.1016/j.compedu.2025.105252	Quasi-experimental design comparing storified vs. non-storified video-based explicit instruction.	Both improved credibility evaluation skills; effective for diverse readers; storification not necessary for improvement.
J Shirong Zhang, Bjorn B. de Koning, Fred Paas, a,bia H., Huo J., Fu Q., Duan Y., Lin Y., Jin X., Hu X., Cheng J.	Effects of mouse pointing on learning from labeled and unlabeled split-attention materials: An eye-tracking study (2023)	https://doi.org/10.1016/j.chb.2023.107673	2×2 between-subjects experiment using mouse pointing and labeling; eye-tracking included.	Mouse pointing and labeling changed visual behavior; no improvement in learning but revealed perceptual processing insights.
Riikka Anttonen, Kristian Kiili, Eija Raikkonen, Carita Kiili	Storifying instructional videos on online credibility evaluation: Examining engagement and	https://doi.org/10.1016/j.chb.2024.108385	Four-lesson video-based intervention; storified vs. non-storified design; latent growth curve modeling.	Both maintained situational interest; slight emotion declines but improved credibility evaluation;

	learning (2024)			storification not required for effectiveness.
Martin Merkt, Anett Hoppe, Gerrit Bruns, Ralph Ewerth, Markus Huff	Pushing the button: Why do learners pause online videos? (2022)	https://doi.org/10.1016/j.compedu.2021.104355	Triangulation: logfile analysis + laboratory behavioral data + video characteristics.	Pausing linked to comprehension difficulty and meaningful breakpoints; platform cues were not predictors; provided insight for video-platform optimization.
Lisa Hasenbein, Philipp Stark, Ulrich Trautwein, Anna Carolina Muller Queiroz, Jeremy Bailenson, Jens-Uwe Hahn, Richard Gollner	Learning with simulated virtual classmates: Effects of social-related configurations on students' visual attention and learning experiences in an immersive virtual reality classroom (2022)	https://doi.org/10.1016/j.chb.2022.107282	Large-scale IVR classroom study with eye-tracking; manipulation of virtual peer configurations.	Classroom configurations shaped attention patterns; attention to content predicted performance; insights for IVR classroom design.
Val'ery Bezençon, Alessio De Santo, Adrian Holzer, Bruno Lanz	Escape Addict: A digital escape room for the prevention of addictions and risky behaviors in schools (2023)	https://doi.org/10.1016/j.compedu.2023.104798	Controlled field experiment with pre/post surveys + interviews evaluating a digital escape room intervention.	Increased knowledge (10% gain); encouraged discussion on risky behaviors; heterogeneous positive effects; engaging prevention method.
S. Greipl, E. Klein, A. Lindstedt, K. Kiili, K. Moeller, H.-O. Karnath, J. Bahnmüller, J. Bloechle, M. Ninaus	When the brain comes into play: Neurofunctional correlates of emotions and reward in game-based learning (2021)	https://doi.org/10.1016/j.chb.2021.106946	MRI study comparing game-based vs. non-game-based digital learning tasks.	Game-based learning produced stronger activation in emotional/reward brain areas; supports emotional and motivational benefits of game-based learning.
Noora L. Laakso, Tiina S. Korhonen, Kai P.J. Hakkarainen	Developing students' digital competences through collaborative game design (2021)	https://doi.org/10.1016/j.compedu.2021.104308	Mixed-methods study of collaborative student digital game design; pre/post questionnaires + qualitative analysis.	Increased motivation, collaboration, digital competencies, and connected learning; improved schoolwork practices; fostered interest-driven learning.

Cognitive and Perceptual Processing in Animation-Based Learning

The first theme that emerges as the most prominent aspect of the findings concerns the effects of animations, particularly in relation to cognitive load, attention distribution, and the processing of incoming information. Some eye-tracking studies indicate that animation-based visualizations influence learners' gaze behaviour, directing learners' eye toward relevant components of complex diagrams or 3D models (Yang and Wang, Liu and Cui, Zhang et al.). These elements correlate to multimedia learning principles which claim that animation reduces cognitive load as it involves the process of chunking content into manageable, sequenced elements. The literature on signaling in VR and prosodic cues in audio learning contexts shows that subtle animated or dynamic features are known to enhance recall and conceptual understanding by easing the demands of perceptual processing. Use of text annotations, labelled graphics, and animated transitions helps learners organize information more efficiently, which in turn enables retention and increased mental model construction. In summary, the theme has confirmed that when animation is grounded in cognitive theory, it can make learners perceive, interpret, and mentally integrate instructional content.

Emotional, Motivational, and Engagement Factors in Animated Learning Environments

A second major theme concerns animation's ability to elevate motivation, emotional engagement, and interest. Emotional design, highlighted in the study by Endres et al., showed that visual elements with emotive characteristics sustained attention even when distractions competed for learners' focus. Game-based studies, including those by Greipl et al. and Laakso et al., demonstrate that animated elements stimulate emotional reward centres and foster greater enthusiasm toward learning tasks. Similarly, storified instructional videos and animated classroom representations increased situational interest, reduced anxiety, and encouraged learners to engage more deeply with content. Even in preventative or behavioural educational contexts such as the digital escape room intervention animations helped sustain motivation and stimulated reflection. Collectively, these studies underscore that animations do more than convey information: they elicit emotional resonance, which in turn reinforces persistence, curiosity, and intrinsic motivation.

Instructional Design Features and Their Influence on Learning Outcomes

The third theme concerns the degree to which the design of animated instructional materials such as augmented reality structures, video pacing, storification, peer simulation, and interactive sequences affect learning outcomes. Research like the FizaAR project highlights the need for animation to be in line with some of the theoretical constructs such as Social Cognitive Theory and the Cognitive Theory of Multimedia Learning to remain effective. For instance, video pausing behaviour, the distinction between storified and non-storified instructional videos, or virtual classmates, has been explored, which demonstrates that when the style shifts somewhat, such as based on animation, narrative framing, or even interaction, student attention can be dramatically impacted and comprehension made even minimally. The results of studies repeatedly emphasize that the impact of animation rests on the design choices made during the instruction: clarity, pacing, emotional tone, interactivity, and multimodal alignment. Good animations not only facilitate understanding but also create structured learning environments in which students can connect new ideas to existing knowledge. As such, the pedagogical value of animation is not something static but a function of informed and theory-based design.

IV. DISCUSSION AND CONCLUSION

The key findings of this systematic review demonstrate that educational animation is a frequently effective learning aid regarding improved learning when it fits with current theoretical norms for multimedia learning. Research summarised in Table 3 shows that animations, by steering learners' visual attention to a focus, minimizing redundant cognitive loads and simplifying abstract thinking, match the Cognitive Theory of Multimedia Learning set forth by Mayer (2020). Work on augmented reality, virtual reality, animated signaling and 3D visualizations demonstrated that participants understood information more efficiently when animations were used for highlighting salient information as well as to sequence complex thoughts. While few eye-tracking studies observed direct payoffs from the increased attention, findings in this group seem to uphold the basic premise that better ability to regulate attention is a necessary first step to higher level learning (van Gog & Scheiter, 2010).

The emotional and motivational aspects are also important as to why animation facilitates stronger learning experiences. Emotionally integrated animated videos, game-enhanced environments, and immersive virtual classrooms led to increased interest, enjoyment, and persistence in the animated components in the studies of interest. These results are in line with the claim that affective involvement promotes cognitive engagement via the continuous investment of learner effort, which in turn minimizes the risk of distraction (Plass et al., 2014). Game-centred research provides more support that video scenes (with animated visuals and interactive stimuli) induce reward signals that enhance motivation and recall in a consistent work that found emotionally stimulating multimedia environments have benefits (Hamari et al., 2016). In digital escape rooms, animations even stimulated thinking about sensitive aspects of behaviour, evidence that emotional engagement is more than just entertainment and can contribute to meaningful learning.

Instructional design was also proved to be another factor determining whether animation was effective. Taken together, the studies presented in this review support a consistent argument by Clark and Mayer (2016) that technological tools do not necessarily facilitate learning; instead, learning benefits stem from animation's inclusion in learning when the animations are intentionally incorporated with specific teaching purposes. For instance, they could be visual aids in instruction: both storified and non-storified instructional videos were found to achieve similar learning effects, suggesting that narrative animated works only when narrative aids knowledge, rather than as part or parcel of a teaching skill, in the context of the skill being demonstrated. There is also evidence that when looking at pausing behaviour in animated videos, there is the intuitive feedback learners provide to moderate their cognitive processing speed during cognitively intensive moments, evidence that pacing and segmentation are critical for students in animation instruction (Hasler et al., 2007). These findings indicate that animations need to be carefully orchestrated for their potential effect.

Collectively, these findings suggest that animation supports improving learning through cognitive clarity, emotional engagement, and pedagogic coherence. The convergence of these three dimensions in the sixteen studies, therefore, serves more strongly to prove that the most effective use of animation is also as scaffolding rather than an adornment. It mirrors the previous research indicating

that effective animation depends on the integration between cognitive thinking, pedagogical intention, and multimedia (Fiorella & Mayer, 2021). While when animations are simply visualized, the impact reduces the efficacy, when they have teaching objectives, they lead to much higher performance on comprehension, attention, and learning satisfaction measures.

This review also highlights that animation's role in education is expanding rapidly as digital technologies advance. By using a range of contemporary tools like VR, AR (Augmented Reality), interactive video systems and game-based learning space, new modalities are changing the face of the role played by animations in educational environments. As these technologies provide new opportunities for immersive and personalised learning their efficacy, however, is dependent on the same core cognitive science and instructional design concepts. Therefore, educators and designers need to give preference for pedagogical congruence over novelty when injecting animation to digital learning materials.

The systematic review ultimately supports the idea that educational animation designed purposefully and within the framework of multimedia learning theory can greatly improve student learning results. Future research is needed to investigate further adaptive and AI-based animated environments, perhaps achieving even more refined cognitive load, motivation, and individualized support. Educators can optimize animation to create an authentic digital learning experience by iterating on animation design and leveraging new-age technologies within existing paradigms.

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VI. DATA AVAILABILITY STATEMENT

Data available on request from the authors.

VII. DISCLOSURE

All authors declare no conflicts of interest.

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