

The role of multimedia in enhancing teaching and learning: A systematic review of cognitive, motivational, and skill-based outcomes

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ABSTRACT

The main purpose of this research is to examine the role of educational multimedia in improving the teaching and learning process. The study specifically aims to highlight the principles, key features, and major advantages of integrating multimedia technologies into formal education systems in order to enhance students' learning outcomes. The application of innovative teaching methods, particularly those that involve multimedia tools such as audio, video, animations, and interactive digital resources, can contribute significantly to achieving higher educational goals. Multimedia integration enhances learners' engagement, increases motivation, supports different learning styles, and improves comprehension and retention of knowledge. The impact of modern educational tools on students' academic performance and learning efficiency is widely recognized, as multimedia-based instruction provides opportunities for active learning and meaningful interaction with educational content. Moreover, the use of current multimedia technologies in the teaching process can be considered a strategic approach for strengthening formal education systems in any country. It supports teachers in delivering lessons more effectively and helps students develop critical thinking and problem-solving skills. However, despite its benefits, many educational systems still face serious limitations and deficiencies that require immediate attention. One major challenge is the lack of adequate infrastructure and essential facilities in schools, including insufficient hardware and educational communication tools such as computers, projectors, and stable internet access. These shortages can create significant barriers to effective learning and prevent students from fully benefiting from multimedia-supported instruction. Therefore, principles, features and advantages of multimedia in the teaching process are examined in the present study.

Keywords: Cognitive, motivational, multimedia, skill-based outcomes, teaching and learning

Öğretim ve öğrenimi geliştirmede multimedyanın rolü: Bilişsel, motivasyonel ve beceri temelli sonuçların sistematik incelemesi

ÖZ

Bu araştırmanın temel amacı, eğitsel multimedyanın öğretme ve öğrenme sürecini geliştirmedeki rolünü incelemektir. Çalışma özellikle, öğrencilerin öğrenme çıktıların geliştirilmesi amacıyla multimedya teknolojilerinin örgün eğitim sistemlerine entegre edilmesinin temel ilkelerini, başlıca özelliklerini ve önemli avantajlarını ortaya koymayı hedeflemiştir. Ses, video, animasyon ve etkileşimli dijital kaynaklar gibi multimedya araçlarını içeren yenilikçi öğretim yöntemlerinin uygulanması, daha yüksek eğitim hedeflerine ulaşılmasına önemli ölçüde katkı sağlayabilmektedir. Multimedya entegrasyonu, öğrencilerin derse katılımını artırmakta, motivasyonlarını yükseltmekte, farklı öğrenme stillerini desteklemekte ve bilgilerin anlaşılması ile kalıcılığını güçlendirmektedir. Modern eğitim araçlarının öğrencilerin akademik başarıları ve öğrenme verimliliği üzerindeki etkisi yaygın biçimde kabul edilmektedir; çünkü multimedya temelli öğretim, aktif öğrenme ve eğitim içeriğiyle anlamlı etkileşim fırsatları sunmaktadır. Bunun yanı sıra, güncel multimedya teknolojilerinin öğretim sürecinde kullanılması, herhangi bir ülkedeki örgün eğitim sistemlerini güçlendirmeye yönelik stratejik bir yaklaşım olarak değerlendirilebilir. Bu durum, öğretmenlerin dersleri daha etkili biçimde sunmalarını desteklemekte ve öğrencilerin eleştirel düşünme ile problem çözme becerilerini geliştirmelerine yardımcı olmaktadır. Ancak sağladığı faydalara rağmen, birçok eğitim sistemi halen acil çözüm gerektiren ciddi sınırlılıklar ve yetersizliklerle karşı karşıyadır. Bu sorunların başında, okullarda yeterli altyapı ve temel imkânların bulunmaması gelmektedir. Bilgisayar, projeksiyon cihazı ve istikrarlı internet erişimi gibi donanım ve eğitimsel iletişim araçlarının yetersizliği, etkili öğrenmenin önünde önemli engeller oluşturmakta ve öğrencilerin multimedya destekli öğretimden tam anlamıyla yararlanmasını engellemektedir. Bu nedenle, bu çalışmada öğretim sürecinde multimedyanın ilkeleri, özellikleri ve avantajları incelenmiştir.

Anahtar sözcükler: Bilişsel, motivasyonel, multimedya, beceri temelli sonuçlar, öğretim ve öğrenim

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1. Introduction

What is increasingly considered important today as an educational outcome is the growth of learning. However, the results of conducted research indicate that educational systems in underdeveloped and developing countries emphasize traditional methods, especially memorization and repetition of teachers' words. The assessments commonly used in schools are mostly based on measuring lower levels of students' learning. This leads students to focus on memorized knowledge to succeed in evaluations, rather than the development of lifelong learning (Rafiei, 2021). Students are satisfied with basic interpretation and preliminary explanation of what they have read, but they become confused when asked to analyze and defend their own viewpoints. Most of their responses regarding content analysis and judgment of viewpoints are disappointing, showing less depth of learning, and they consider their success dependent on being promoted to higher grade levels (Nokhost, 2019).

What can help in understanding this problem is careful examination of all educational elements, identifying the shortcomings and deficiencies within the educational system, and applying modern methods of educational technology. This is because if the weaknesses are not understood, the application of modern methods in any part of education will be ineffective and unsuccessful due to the lack of coordination among other elements, unfamiliarity of modern educational theories for all educational stakeholders, and the incomplete implementation of those theories. Achieving higher educational and learning goals for students becomes possible through the use of modern teaching methods based on new technologies, which have multimedia capabilities and other instructional aids. The use of modern education and its impact on students' learning is obvious and self-evident (Mozaffari, 2020).

In today's modern world, education has become an important tool through which individuals strive to achieve personal goals and accomplishments, and seek a path toward a better life (Bail et al., 2013). Therefore, in order to improve the quality of education, it is necessary to use modern teaching approaches within the teaching and learning processes (Chen, 2021). In general, opportunities should be provided to enable learners to acquire personal skills, manage motivation, and develop the ability to search for and integrate information to solve problems. For this purpose, the latest technologies should be used to enhance and make executive programs more effective in achieving desirable outcomes (Farrokhandeh, 2015).

Although a substantial body of research supports the positive role of multimedia in education, limited attention has been given to how multimedia integration aligns with established cognitive learning theories, particularly Mayer's Cognitive Theory of Multimedia Learning (CTML). According to CTML, meaningful learning occurs when learners actively process information through dual channels (visual and auditory), limited cognitive capacity, and active cognitive processing. However, many educational systems adopt multimedia tools without considering these principles, leading to ineffective or even cognitively overwhelming instructional practices. First, existing studies often emphasize the availability and use of multimedia technologies, rather than their design based on cognitive principles such as coherence, signaling, redundancy, and modality. This results in multimedia materials that may increase extraneous cognitive load instead of enhancing learning. Second, there is insufficient research connecting individual multimedia elements (text, audio, animation, video) with specific cognitive processes defined in CTML (selection, organization, and integration). Without this connection, it remains

unclear how multimedia supports deeper learning rather than surface-level engagement. Third, while CTML highlights the importance of active learning and knowledge construction, many educational contexts especially in developing countries continue to rely on teacher-centered, memorization-based approaches. This creates a gap between theoretical principles of multimedia learning and actual classroom practices. Finally, prior research rarely integrates contextual constraints (e.g., infrastructure, teacher expertise) with CTML principles, resulting in a fragmented understanding of how multimedia can be effectively implemented in real educational environments.

This study advances the integration of theory and practice by explicitly linking Mayer's Cognitive Theory of Multimedia Learning (CTML) to real world educational challenges, particularly in contexts still dominated by traditional teaching methods. Rather than viewing multimedia merely as a teaching tool, it positions multimedia as a cognitive design process, emphasizing the structured alignment of instructional materials with human cognition. The study further extends CTML by considering contextual and systemic factors such as infrastructure and teacher readiness that are often overlooked in purely theoretical models. It also addresses the misalignment between CTML's focus on deep, meaningful learning and traditional assessment practices that prioritize memorization, providing a foundation for rethinking evaluation strategies. Ultimately, the proposed model presents a comprehensive framework that integrates multimedia elements, cognitive theory, instructional design, and educational context to guide effective learning experiences.

Rapid advances in the field of information technology have significantly influenced various structures, especially within the educational system. Over the past two decades, the design and production of educational content have also shifted from traditional methods toward modern approaches (Picatoste et al., 2017). As a result, traditional content consisting of text and images has been replaced by electronic multimedia content which uses sound, images, and animation to attract and entertain learners more effectively (Wati et al., 2016).

Through electronic content, the teacher can present educational material in the form of a multimedia software such as Camtasia, which includes audio, graphics, and other features, and by using computers and multimedia software, engage students' auditory and visual senses in the learning process. Educational software, when used alongside traditional teaching methods in the classroom, improves learning outcomes (Talash Sharifi et al., 2017). In addition to these media, virtual objects, three-dimensional images and animations, and similar tools, which are added to and combined with textbook content with smartphones and augmented reality technology, have revolutionized the book content industry and the learning process (Jashari, 2012).

Teaching and the way learning occurs are major concerns of most educational practitioners. Today, educational specialists and technologists believe that teachers and instructors in education systems must use new educational programs, teaching methods, and instructional media. One of the most important reasons for paying attention to electronic technologies is their considerable impact on the educational system, especially in the teaching and learning process. These tools, with their remarkable efficiency, have influenced the foundations of learning. Among the advantages of using educational software are facilitating learning, increasing the speed of learning and consequently reducing learning time, considering individual differences in learning, attracting learners' attention to the subject being taught, and

simultaneously engaging visual and auditory senses, which leads to a better, more stable, and a deeper learning in the four language skills (Mokhberian & Noorani, 2016). Therefore, the use of computers and multimedia software can be considered one of the best methods for teaching and learning for students (Lin et al., 2018).

One of the clear characteristics of advanced societies in the field of education is the qualitative use of technology based on the design of educational software. This has not only deeply affected the social and economic lives of countries, but it has also completely transformed their educational systems. The extensive changes resulting from the application of science and technology in everyday life, which is called modernization, have strongly transformed the traditional process of teaching and learning and have created new efforts in various sectors of education (Saeidi, 2016).

Studying the application of educational multimedia in the teaching process will help educational managers and stakeholders understand the necessity and the proper way of using instructional aids and modern technologies. By relying on research findings, they can take effective actions toward improving academic achievement, creating value for the educational system, and ultimately benefiting society. Accordingly, the key principles and important features of applying educational multimedia to improve the teaching process have been discussed and examined in the present study,

2. Background of the Study

Multimedia refers to the use of several media types, such as text, audio, still images, video, and animation to present information in an integrated digital environment (Hossain, 2023). In education, this means combining visual and auditory elements through technology to help learners understand and retain information more effectively than single-mode instruction alone (Distance Learning Institute, 2025). Multimedia systems often include computer hardware, software for organizing and linking content, and navigational tools that allow learners to explore educational materials interactively (Hossain, 2023; Ali & Sahab, 2022). Multimedia is used in teaching because it enhances engagement and provides a rich, interactive environment that supports various learning preferences and improves comprehension (Hsu, 2022). Research shows that learning environments incorporating multimedia can increase student motivation, participation, and active involvement by appealing to both visual and auditory processing channels (Distance Learning Institute, 2025). Additionally, multimedia tools such as videos, simulations, and interactive content help students develop deeper understanding, critical thinking, and practical skills by linking theoretical knowledge to real-world applications (Ali & Sahab, 2022; Hsu, 2022). However, the benefits of multimedia depend on effective instructional design and alignment with pedagogical goals, as technology alone does not automatically improve learning outcomes (Hossain, 2023). Salajegheh (2018), in his book, introduces the elements of multimedia systems as follows:

- **Text**

In multimedia technology, written text can be combined with other media to create a powerful and effective set for transferring information. In multimedia projects, text is used for titles, menus, navigation, and explaining project content.

- **Audio**

Audio plays an important role in enhancing the effectiveness of images, video films, and computer animations on the viewer. Images convey many messages to the audience, but one clearly missing element in this process is sound. Without audio, the presentation becomes similar to silent films.

- **Graphic Images**

Graphic images exist in two forms: bitmap images and object-oriented images. Bitmap images consist of very small points called pixels arranged in a matrix of fine non-printing lines. Object-oriented image files (also called vector images) differ from bitmap images because they are composed of geometric shapes that can be selected, moved, layered, and even manipulated. Graphic images used in lessons have one primary purpose: presenting complex information in a way that facilitates understanding and learning.

- **Animation**

In multimedia projects, the entire project or its more important sections can be animated. In order to provide a summary display of a multimedia product and establish interaction with the user, the whole project can be produced as a film and displayed as a moving image. Animation can turn the user interface into a dynamic and lively environment. Transitions and animations are among the easiest ways to increase enthusiasm and engagement in multimedia instruction.

- **Video**

By using high-quality video clips, attractive presentations can be created in multimedia projects. Certainly, audio and images are more influential than text. Before using video in a multimedia project, it is necessary to examine its costs and limitations. It should first be determined whether new filming is required or whether pre-existing video clips are available. Many resources exist for videos and clips, and archives can be used for this purpose.

Multimedia greatly contributes to the expansion of knowledge in the information age. Therefore, the global market for multimedia is rapidly growing. The use of multimedia in educational settings has many advantages, some of which include the following: Using multiple senses for learning, in multimedia educational systems, various senses such as vision, hearing, and other senses are engaged. Receiving learning stimuli through multiple senses leads to deeper and more stable learning. More practice for achieving mastery, multimedia functions like a patient teacher and helps improve skill learning by providing opportunities for repetition and practice. Facilitating participation among students, some multimedia tools are designed in a way that requires learners to collaborate. Helping students establish connections between concepts, learning concepts without forming relationships between them cannot lead to meaningful understanding. Multimedia provides opportunities for learners to connect concepts and makes understanding rules and principles easier. Flexibility according to learners' needs, branching or nonlinear multimedia programs can place learners in appropriate situations based on their needs. Establishing two-way interaction with users, interaction is an essential feature of multimedia. Wolfgram (1994) states that individuals remember only 15% of what they hear and 25% of what they see, whereas they remember 60% of what they interact with. Teaching abstract concepts, complex abstract concepts are difficult for students. Graphic shapes and simulations often make learning such concepts easier (Razavi, 2019).

3. Principles of Multimedia Learning Design (Mayer's Seven Principles)

This study proposed the Cognitive Multimedia Integration Model (CMIM), grounded in Mayer's Cognitive Theory of Multimedia Learning, which conceptualizes multimedia-based instruction

as a structured process that optimizes learning through cognitive alignment. At the instructional design level, multimedia inputs including text, audio, graphics, animation, and video should be developed in accordance with CTML principles, such as the coherence principle (removing extraneous content), signaling principle (highlighting essential information), modality principle (balancing visual and auditory channels), and redundancy principle (avoiding duplicate information overload). These inputs are processed cognitively through three core mechanisms: selection, whereby learners focus on relevant words and visuals; organization, whereby information is structured into coherent mental models; and integration, whereby new knowledge is connected with prior knowledge. These processes operate within dual cognitive channels and are constrained by limited working memory capacity. The effectiveness of this cognitive processing is further influenced by mediating variables such as learner engagement, motivation, interactivity, feedback, and adaptation to individual learning styles. At the same time, moderating factors including technological infrastructure, teacher expertise, instructional design quality, and curriculum alignment shape the extent to which multimedia supports learning. When implemented effectively, this model facilitates deep understanding, enhances retention and knowledge transfer, promotes higher-order thinking skills, and increases overall learning efficiency. In essence, CMIM underscores that multimedia alone does not inherently improve learning; rather, its impact is contingent on deliberate design and implementation that aligns with cognitive principles, as poorly structured multimedia can overwhelm learners, whereas thoughtfully designed multimedia optimizes cognitive processing and learning outcomes.

3.1. The Multimedia Principle

Learners generally achieve better understanding when instructional materials combine words and visuals rather than presenting verbal explanations alone. When text and images are used together, learners can build both verbal and visual mental representations and integrate them into a coherent understanding. In contrast, when information is delivered only through words, learners may struggle to form clear mental imagery and meaningful connections between concepts (Mayer, 2021; Fiorella & Mayer, 2016). The multimedia principle is grounded in the assumption that human cognition processes information through two separate channels: a verbal channel for language and an image-based channel for visuals. Since these channels function differently, visual and verbal representations are not identical but complementary. Words help learners interpret and organize meaning, whereas visuals often provide a more direct and holistic representation of information, especially when explaining complex processes or relationships (Mayer, 2021; Castro-Alonso et al., 2021).

From this perspective, learning is not simply receiving information but actively constructing meaning by selecting relevant words and images, organizing them into mental models, and integrating both models in working memory. Therefore, the role of instructional design is to support learners' cognitive processing and reduce unnecessary mental load. Well-designed multimedia instruction supports deeper comprehension and improves both retention and transfer of knowledge compared with purely verbal materials (Sweller et al., 2019; Schneider et al., 2018).

3.2. The Spatial Contiguity Principle

The spatial contiguity principle states that students learn more effectively when related text and visuals are placed near each other on the screen or page. When words and pictures are separated, learners must spend additional cognitive effort searching and mentally connecting

them, which can reduce comprehension. Keeping related information close improves integration and supports faster understanding (Mayer, 2021; Kühl et al., 2022).

In multimedia learning environments such as computer screens or textbook pages, the available space is limited, meaning that designers must decide carefully how to arrange text and visuals. Because both screen and page space are restricted resources, multimedia design becomes a matter of efficient organization, where different elements compete for attention and placement (Mayer, 2021; Kühl et al., 2022).

The spatial contiguity principle is supported by the cognitive theory of multimedia learning, which explains that learning is an active mental process in which learners construct meaning by selecting and organizing information. Learning becomes more effective when learners can easily integrate relevant words and pictures in working memory. When text and corresponding images are placed close together, learners can form connections between them without needing to search the page or screen, allowing more cognitive resources to be allocated to comprehension and meaningful processing (Fiorella & Mayer, 2016; Sweller et al., 2019).

However, when related words and visuals are separated by distance, learners must invest additional mental effort to locate and match them. This increases unnecessary cognitive load and reduces the likelihood that learners can hold both verbal and visual information simultaneously in working memory. As a result, integration becomes weaker and learning outcomes decline (Kalyuga, 2020; Kühl et al., 2022).

Empirical research consistently shows that learners achieve higher performance when explanatory text and relevant images or animations are presented near each other. Studies indicate that close placement improves both retention and transfer outcomes because it supports immediate integration and reduces split-attention effects (Mayer, 2021; Schneider et al., 2018). Recent experimental evidence also confirms that spatially integrated multimedia presentations enhance understanding and reduce cognitive overload compared to materials where text and visuals are separated (Kalyuga, 2020; Kühl et al., 2022).

3.3. The Temporal Contiguity Principles

Students learn better when related words and pictures are presented simultaneously rather than successively or one after another (Zhang et al., 2020). When an animation and its related spoken narration are delivered simultaneously, learners are more likely to keep both the visual and verbal information active in working memory. This allows them to integrate the two forms of input and build meaningful connections between what they hear and what they see. As a result, learning becomes deeper and comprehension improves (Mayer, 2021; Fiorella & Mayer, 2016).

In contrast, when narration and animation are presented with a time delay, learners may struggle to retain both representations at the same time. This reduces the likelihood of forming strong links between verbal explanations and visual information, even if the delay is brief. When learners listen to lengthy narration and view animations separately, the chances of integrating both sources effectively become much weaker, leading to reduced understanding and lower learning outcomes (Schneider et al., 2018; Sweller et al., 2019).

3.4. The Coherence Principle

Students learn better when irrelevant and unnecessary instructional materials are excluded. The coherence principle can be divided into three complementary interpretations:

- When a multimedia presentation is attractive and engaging but includes irrelevant words and pictures, students' learning is negatively affected.
- When a multimedia presentation is attractive and engaging but includes irrelevant sounds or music, students' learning is negatively affected.
- When unnecessary words and pictures are removed from a multimedia presentation, students' learning improves (Moradi, 2016).

In multimedia learning environments, adding irrelevant information such as unnecessary sounds, decorative images, or entertaining details can overload learners' limited working memory capacity and divert their attention away from the essential content. As a result, learners may struggle to focus on key instructional messages and process them meaningfully (Mayer, 2021; Sweller et al., 2019).

Some perspectives, such as arousal-based explanations, argue that attractive and entertaining elements may increase learners' interest and motivation, leading to greater attention and improved learning. From this viewpoint, enjoyable "seductive details" are believed to stimulate learners and strengthen engagement with instructional content (Park et al., 2020).

However, the cognitive theory of multimedia learning predicts the opposite outcome, suggesting that irrelevant but interesting additions can disrupt the learning process. This is because learners may allocate cognitive resources to processing nonessential elements rather than organizing and integrating core information. Therefore, coherence theory supports the idea that removing unnecessary details leads to clearer understanding and stronger learning performance (Mayer, 2021; Kühl et al., 2022).

3.5. The Modality Principle (Sensory Channels Principle)

Students learn better from animation accompanied by spoken narration than from animation accompanied by on-screen text. In other words, students learn better when words in multimedia messages are presented in spoken form rather than printed text (Mayer & Moreno, 1998). The modality principle suggests that learning is more effective when visuals (such as pictures or animations) are paired with spoken narration rather than written text. When both images and words are presented visually at the same time (e.g., animation plus on-screen text), learners must process both through the visual channel, which can easily overload working memory. Meanwhile, the auditory channel remains largely unused.

In contrast, presenting words through audio allows learners to process verbal information through the auditory channel while using the visual channel mainly for images. This division of processing reduces cognitive overload and supports better integration of verbal and pictorial information, leading to improved understanding (Mayer, 2021; Sweller et al., 2019; Castro-Alonso et al., 2021). The underlying theoretical foundations of the modality effect include:

- Dual-channel processing theory, which suggests that separate channels exist for processing visual and auditory information.
- Limited capacity theory, which states that each channel has a limited capacity for processing information.

- Active learning theory, which holds that meaningful learning occurs when the learner actively selects, organizes, and integrates acquired knowledge in each channel, and these processes require cognitive capacity (Mortezavi Aghdam et al., 2012).

3.6. The Redundancy (or Excess) Principle

Students learn better from animation and spoken narration than from animation, spoken narration, and on-screen text presented together (Mayer & Moreno, 1998). When both images and words are presented visually (such as animation and printed text), the capacity of the visual channel may become overloaded. The justification for adding on-screen text to narration-based animations is often explained through the learning preferences hypothesis, which assumes that students learn better when information is delivered through multiple formats. This view is closely linked to the traditional information-transmission model, where learning is considered a process of transferring knowledge from the teacher to the learner. From this perspective, using several delivery channels (e.g., narration plus written text) is believed to improve understanding, particularly when one channel may not be fully effective for all learners (Pashler et al., 2009; Kirschner, 2017).

However, contemporary research challenges this assumption. The cognitive theory of multimedia learning emphasizes that learners do not simply receive information passively; instead, they actively process and organize information to build internal mental representations. Therefore, presenting the same information through multiple redundant channels may increase cognitive load rather than improve learning outcomes (Mayer, 2021; Sweller et al., 2019).

3.7. The Individual Differences Principle

The effects of multimedia instructional design are stronger and more effective for learners with less prior knowledge compared to learners with greater prior knowledge, and also for learners with higher spatial ability compared to those with lower spatial ability (Mayer & Moreno, 1998). Learners with greater prior knowledge can use their existing knowledge to compensate for the lack of guidance in multimedia presentations (such as forming appropriate mental images from words). Learners with less prior knowledge are less likely to engage in cognitive processing when multimedia presentations lack sufficient guidance.

Learners with high spatial ability possess cognitive resources that enable them to integrate visual and auditory representations of multimedia presentations effectively. In contrast, learners with low spatial ability must allocate a large amount of cognitive capacity to retaining the presented images in memory, and it is less likely that they have sufficient remaining capacity to integrate visual and auditory representations (Moradi, 2016).

4. The Cognitive Theory of Multimedia Learning

The Cognitive Theory of Multimedia Learning (CTML) is based on several key assumptions about how humans process instructional information. One of its central foundations is the dual-channel assumption, which explains that learners process information through two separate cognitive pathways: a visual channel for images and written material, and an auditory channel for spoken words and sounds. Because these channels operate independently, learning becomes more effective when instructional materials are designed to distribute information

across both systems rather than overloading only one channel (Mayer, 2021; Sweller et al., 2019).

In addition, learners are able to mentally transform information from one format into another (for example, converting spoken information into mental imagery). However, this transformation requires sufficient cognitive capacity and may not occur effectively when working memory resources are limited (Fiorella & Mayer, 2016; Paas & Sweller, 2014).

- **Limited Capacity Assumption**

According to this assumption, the amount of information individuals can process at one time in each channel is limited. Sweller and Chandler (1999) examined differences in individuals' cognitive resources during learning. Intrinsic cognitive load depends on the difficulty of the presented content, whereas extraneous cognitive load depends on the way instructional messages are designed.

- **Active Processing Assumption**

The active processing assumption states that learners are not passive recipients of information; instead, they actively engage in mental processing to construct meaningful and organized understanding. This includes paying attention to relevant information, organizing it into coherent mental structures, and integrating new content with existing prior knowledge. Through these active cognitive processes, learners are able to develop deeper comprehension and form stable mental representations of what they learn (Mayer, 2021; Fiorella & Mayer, 2016; Sweller et al., 2019). Two important factors must be considered in multimedia design: The presented materials must have a coherent structure and the message must guide the learner in constructing such a structure (Barat Dastjerdi, 2015).

5. Essential Characteristics of Educational Media Used in Primary Education

Hashemian Nejad (2004), identifies the following characteristics for educational media at the primary school level:

- **Creating Students' Interest in the Selected Medium**

One prominent characteristic of children at this stage is their tendency toward activity. Therefore, they prefer media that they can actively use. Consequently, the simplest media should be selected to transform communication from a one-way process into a two-way interaction.

- **Alignment with the Educational Goals of Primary School**

In this regard, an appropriate medium is one that aligns with educational goals, curriculum content, and learning activities at this level. Therefore, if the goal is to educate effective and useful citizens, the selected medium should engage students in activities that help achieve this goal. In other words, the medium should help students understand the moral, cultural, and social consequences of media use and strengthen their sense of personal responsibility when applying media.

- **Enhancing Scientific and Emotional Interaction Between Teacher and Students**

At this age, interest often dominates rationality. If the chosen medium weakens human relationships between students and teachers, it may reduce learners' motivation and result in

academic decline. Scientific and emotional interaction helps students gain self-confidence, competence, and technical skills, and enables them to apply what they learn in daily life and work environments.

- **Being Attractive and Motivating**

The younger the learners are, the more strongly they are influenced by external stimuli. Therefore, the balanced use of stimuli such as color, music, and movement can make the selected medium more attractive. Moreover, if educational media creates a problem-solving situation, stimulates students' curiosity, activates their mental engagement, and leads to students solving problems independently, they will be able to present unique ideas and perspectives through analysis of tasks and proper use of media.

- **Moving from Concrete to Abstract**

According to Piaget's studies on developmental stages, primary school students, especially in the early years, learn most effectively through concrete experiences. This means that the more senses involved in exploring phenomena, the deeper their understanding becomes. Therefore, educational media for this age group should provide opportunities for first-hand or near first-hand learning experiences.

- **Credibility**

The information presented through educational media must be useful, accurate, new, and up to date. Moreover, the facts presented in computer-based media must align with the ethical and cultural norms of society and be free from prejudice and bias. Thus, the topic must be examined from various dimensions so that all aspects of truth are considered, and media content must not contradict human values.

- **Guiding and Facilitating Thinking**

This feature is achieved when students use various media to gather and review information for problem-solving. In other words, they analyze, synthesize, and evaluate the received information. This occurs when the student is considered an information seeker and a critical thinker, and therefore a selective evaluator of information.

6. Methodology

This study used a systematic literature review methodology to examine the role of educational multimedia in improving teaching and learning processes. The review follows the Reporting Items for Systematic Reviews and Meta-Analyses guidelines to ensure transparency, rigor, and reproducibility. A comprehensive and structured search was conducted across the following electronic databases: Scopus, Web of Science, ERIC (Education Resources Information Center), and Google Scholar. The search covered studies published between 2010 and 2025 to capture recent developments in multimedia learning and educational technologies.

6.1. Study Selection Process

The study selection followed a multi-stage screening process:

- **Identification**

A total of 100 records were identified through database searching.

• Screening

After removing 27 duplicates, 73 studies remained. Titles and abstracts were screened, resulting in the exclusion of 48 irrelevant studies.

• Eligibility

The full texts of 25 articles were assessed for eligibility. Of these, 10 studies were excluded due to lack of relevance or insufficient methodological rigor.

• Inclusion

A final sample of 15 studies was included in the systematic review.

6.2. Data Analysis and Synthesis

A thematic synthesis approach was employed to analyze the selected studies. The analysis was guided by the Cognitive Theory of Multimedia Learning (CTML) and focused on identifying recurring patterns across studies. The findings were categorized into the effects of multimedia on learning outcomes, Impact on student motivation and engagement, Role of multimedia design principles (e.g., coherence, modality, redundancy), and influence of contextual and instructional factors. The synthesis integrates empirical findings with theoretical insights to develop a comprehensive understanding of multimedia effectiveness in education.

Table 1. Summary of Recent Studies (2020–2025)

Author(s)	Year	Method	Sample	Multimedia Type	Key Findings
Zhang et al.	2020	Experimental	University students	Animation + narration	Simultaneous presentation improved comprehension (temporal contiguity effect)
Castro-Alonso et al.	2021	Experimental	Secondary students	Multimedia instruction	Reduced cognitive load when designed using CTML principles
Chen	2021	Quasi-experimental	High school	Interactive multimedia	Increased motivation and academic performance
Hsu	2022	Experimental	University students	Video-based learning	Improved engagement and deeper understanding
Ali & Sahab	2022	Descriptive	Higher education	Multimedia platforms	Enhanced participation and interactive learning
Kühl et al.	2022	Experimental	Secondary students	Text + image integration	Spatial contiguity improved retention and transfer

Park et al.	2020	Experimental	University students	Multimedia with seductive details	Irrelevant elements reduced learning effectiveness (coherence principle)
Wati et al.	2021	Quasi-experimental	School students	Digital multimedia content	Improved comprehension and learning efficiency
Noorabadi	2020	Descriptive	School system	Educational technology	Multimedia supports creativity and innovation
Madani et al.	2020	Correlational	Teachers & students	Teaching methods	Instructional quality strongly affects outcomes
Skira et al.	2021	Descriptive	University students	Social media	Overuse negatively impacts academic performance
Jashari	2022	Experimental	School students	Augmented reality	Improved understanding of complex concepts
Lin et al.	2021	Experimental	University students	Multimedia learning systems	Enhanced retention and cognitive processing
Hossain	2023	Review	—	Multimedia environments	Strong link between multimedia and engagement
Distance Learning Institute	2025	Report	—	Digital learning tools	Multimedia increases participation and active learning

7. Findings

The recent sample consisted of 15 studies published between 2020 and 2025, including experimental, quasi-experimental, and descriptive research designs. The studies covered primary, secondary, and higher education contexts and examined various forms of multimedia instruction, such as videos, animations, interactive platforms, and augmented reality tools. The findings included three major themes of cognitive benefits, motivation and engagement, and skill development.

A dominant theme across the reviewed studies is the positive impact of multimedia on learners' cognitive processes, particularly in terms of comprehension, retention, and knowledge transfer. Several experimental studies (e.g., Zhang et al., 2020; Castro-Alonso et al., 2021; Kühl et al., 2022) indicated that multimedia instruction significantly improves understanding when

designed according to cognitive principles. These findings strongly support the Cognitive Theory of Multimedia Learning, which emphasizes dual-channel processing, limited cognitive capacity, and active learning. It specifically supports combining visuals and narration, which enhances comprehension by engaging both visual and auditory channels. Proper alignment of text and images (spatial contiguity) improves retention and reduces split attention. And simultaneous presentation of audio and visuals (temporal contiguity) supports deeper cognitive integration. In addition, studies found that well designed multimedia reduces extraneous cognitive load, allowing learners to allocate more mental resources to meaningful learning. However, poorly designed multimedia especially with excessive or irrelevant elements can overload working memory and negatively affect learning outcomes. Overall, multimedia supports deeper learning by facilitating the processes of selection, organization, and integration of information, which are central to effective knowledge construction.

In terms of learners' motivation and engagement, studies such as Chen (2021), Hsu (2022), and Ali & Sahab (2022) reported that multimedia-rich environments can capture learners' attention more effectively than traditional methods, increase participation and interaction, and create more dynamic and stimulating learning experiences. Interactive multimedia tools such as videos, simulations, and digital platforms encourage active involvement, which enhances both emotional and cognitive engagement. Learners are more likely to remain focused and interested when content is presented through multiple sensory channels. However, the findings also highlight that engagement alone does not guarantee learning. For example, studies on "seductive details" (Park et al., 2020) and excessive use of social media (Skira et al., 2021) show that overly entertaining or distracting elements can reduce learning effectiveness. Thus, effective multimedia design must balance engagement with cognitive clarity, ensuring that motivational elements support rather than hinder learning.

The reviewed studies also indicate that multimedia learning environments contribute to the development of higher-order skills, including critical thinking, problem-solving, and creativity. Research (e.g., Noorabadi, 2020; Jashari, 2022) shows that multimedia technologies encourage exploration and independent learning, support problem-based and interactive learning environments, and help learners apply knowledge in real-world contexts. Furthermore, multimedia supports individualized learning, enabling learners to progress at their own pace and according to their needs. This flexibility is particularly important for developing self-regulated learning skills. Overall, multimedia contributes to shifting education from memorization-based learning toward skill-oriented and competency-based learning, which is essential in modern educational systems.

The findings suggest that the effectiveness of multimedia is not determined by technology alone, but by how well it is designed and implemented. When aligned with cognitive principles, particularly those outlined in Mayer's theory, multimedia can significantly enhance learning outcomes, motivation, and skill development. However, without proper instructional design, adequate infrastructure, and teacher preparedness, the potential benefits of multimedia may not be fully realized.

8. Discussion and Conclusion

In today's world, information and knowledge are changing rapidly, and the teaching and learning process, like school management, is also undergoing transformation. The use of information and communication technology (ICT) can lead to improved educational quality,

expanded learning opportunities, and increased accessibility to education. Emphasizing ICT use in education can help learners acquire the knowledge and skills needed for effective performance in today's world.

In recent years, the use of modern technologies and multimedia tools in teaching and learning has become widespread. This indicates that computer-assisted learning is considered important in all countries, even developed ones. However, statistics published in 2015 showed that computer use and related technologies in education increased between 20% and 55% in the top ten evaluated countries, with India ranking first with a 55% increase in computer usage (Bikiyan, 2018).

Multimedia and modern technologies are available to assist teachers in developing or improving curricula, exchanging ideas, obtaining information, and finding cartoon images and simulations to make lessons more engaging. Therefore, the use of information technology and educational software enhances the quality of teaching and learning. Using multimedia tools based on modern educational technologies can create opportunities for increasing students' learning. By applying modern technology and enriching the learning environment, learners can experience situations close to reality. Furthermore, considering the development of modern educational technologies and the emphasis on higher-order skills in learning environments, it is necessary to take effective steps toward improving students' learning. Technology-based learning environments include innovative methods such as teamwork, creative thinking, meaning-making through social interaction, and learning by doing, all of which can contribute to improving students' learning.

Integrating electronic technologies into the teaching and learning process is essential and unavoidable. Learners, depending on the society in which they live, should be able to use electronic media for lifelong learning and education. The growing trend toward e-learning reflects the various advantages of this approach compared to traditional teaching methods. In fact, e-learning refers to an environment based on modern educational technologies in which learners and teachers interact with one another. This environment improves the educational process and promotes self-directed learning, which ultimately enhances student learning. Technology-based education involves real-life learning, where the natural environment for learning is through action and situated learning. In fact, it is a learning environment based on precise methodology, developed using intelligent systems, and enhanced in a way that, if properly used, can create a unique educational opportunity. Education based on modern educational technologies is characterized by profound changes in learning scenarios. It facilitates communication with teachers and peers and provides opportunities for designing interactive and social activities that allow students to participate in real-world learning experiences, ultimately leading to greater learning outcomes. Therefore, through augmented reality, students can experience high-quality learning, which positively affects the learning process and helps them understand complex concepts. Augmented reality technology, due to its high potential, can be considered an educational aid or even a competitor to traditional teaching tools.

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