



VISUAL LEARNING AND COGNITIVE ENGAGEMENT: ANIMATION AS A TOOL FOR KNOWLEDGE TRANSFER IN DIGITAL EDUCATION

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Abstract

In the context of the rapid development of digital technologies, animation is becoming a key tool for visual learning in the modern education system. The article reveals the theoretical foundations of the use of animation in the educational process, based on the cognitive theories of J. Sweller and R. Mayer, and emphasizes its role in reducing cognitive load and increasing student engagement. The psychological aspects of the perception of moving visual images, as well as the principles of inclusive and accessible design are considered. The presented empirical studies demonstrate the positive impact of animation on knowledge acquisition, especially in the context of distance and hybrid learning. In conclusion, practical recommendations for the effective use of animation technologies in the context of digital education are formulated.

Keywords: Animation, visual learning, cognitive load, multimedia learning, inclusion, digital education, interactive content, cognitive engagement, accessibility-first.

Introduction

The scientific novelty of this article lies in the comprehensive and interdisciplinary analysis of animation as a visual learning tool in the context of modern digital educational practices, with a special emphasis on the cognitive and psychological aspects of perception. Unlike the prevailing studies, the work systematizes the provisions of the cognitive theories of J. Sweller and R. Mayer as applied to educational animation, substantiates the need to design animated



content taking into account the principles of accessibility-first and inclusiveness, presents empirical data illustrating the impact of animation on learning motivation and memorization of information in the context of distance and hybrid learning, and offers practice-oriented recommendations for teachers and designers of educational content, thereby strengthening the connection between theory and pedagogical practice.

In today's educational landscape, digital education is becoming increasingly important. In the context of distance and hybrid learning, there is a growing need for interactive and visually appealing means of knowledge transfer. Visual learning, based on the perception of information through visual channels, helps improve cognitive processes, including perception, understanding, and memorization. Animation, as a form of dynamic visual content, has the potential to significantly increase learner engagement and improve the quality of learning. Even in ancient times, philosophers claimed that movement is life itself. The subsequent dynamic and comprehensive development of human civilization has demonstrated that movement is also an art that animation embodies in reality. It is no coincidence that Yu. Norshteyn described animation as a combination of movement and life. He emphasized that the word "animation", which has Latin origins, literally means "revitalization, inspiration" and was originally used in the medical field to denote the moment of animation of the fetus [1, pp. 104-116]. Over time, animation penetrated into other areas of human activity, where its meaning began to be used in a more figurative sense. By endowing inanimate objects with the characteristics of life and setting them in motion, man expanded the scope of animation, as a result of which it began to be interpreted as:

- a method of creating a series of photographs, drawings, images or silhouettes in separate phases of movement, which, when shown on a screen, create the illusion of movement of a creature or object. This illusion is based on the frequency of frame changes and the degree of their detail.
- the process of giving motion or the appearance of life to objects and inanimate bodies in works of art and games.
- animation technology, which is a type of cinematography.



- the display of graphic materials or computer simulation of movement by changing the shape of objects or showing a sequence of images with phases of movement, which finds application in education and computer technology.

In light of the global changes that the paradigm of pedagogical education is undergoing, we can state that, Today, more than ever, the use of animation technologies as an effective means of general media education has become relevant.

Visual learning is the process of perceiving, processing and assimilating information through visual channels. In modern education, it is recognized as an effective method of knowledge transfer, especially in the context of digital learning, where multimedia tools play a key role [2].

One of the fundamental approaches to explaining the effectiveness of visual learning tools is the cognitive load theory (CLT) developed by J. Sweller . According to this theory, human working memory resources are limited, and excessive cognitive load reduces the effectiveness of learning. Visual tools, including animation, help reduce this load by facilitating the perception of complex information by presenting it in a more visual and structured form [3].

TCN distinguishes three types of cognitive load: internal, external and useful. Visual and animation tools help reduce external load by eliminating distracting or redundant elements and increase useful load by stimulating active processing of the material.

R. Mayer developed a theory of multimedia learning that emphasizes the importance of combining verbal and visual information to improve cognitive acquisition. According to this theory, people learn information better when it is presented as a combination of text and images. In this context, animation acts as a dynamic visual element that enhances the clarity and appeal of the material.

R. Mayer identifies the principles of effective multimedia learning, including the principle of multimodality (dual coding) – the use of verbal and visual information to simultaneously activate different channels of perception, which helps improve memorization and understanding.

Cognitive engagement is defined as the degree of mental activity and concentration with which a learner engages with the learning material. Active cognitive engagement is associated with deep understanding and reflection, as



opposed to shallow, passive perception. Visual media, including animation, promote engagement by creating a more visual and interactive experience.

Research shows that animation increases attention, reduces fatigue, and stimulates motivation through visual dynamics and the ability to control playback [4]. In this context, animation is considered not only as a means of conveying information, but also as a tool for activating cognitive processes.

From the perspective of perception psychology, the human brain perceives movement and changes over time better than static images. Animation helps model processes occurring in real time, facilitating the understanding of cause-and-effect relationships. Visual changes and animation effects create conditions for the formation of mental models, which contributes to deep learning.

In digital education, animation is increasingly used as a tool that significantly expands the possibilities of knowledge transfer and improves the quality of learning. Animation in the learning process provides a dynamic presentation of information, which contributes to a deeper understanding of complex concepts and processes.

One of the key benefits of animation is its ability to visualize changes over time and space, which is not possible with static images or text. Such dynamic visualizations allow students to observe the development of processes, model scenarios, and learn cause-and-effect relationships more effectively [5].

Animation elements stimulate cognitive engagement and increase learner motivation. The dynamism and interactivity of animation create a more engaging and interesting learning experience, promoting concentration and reducing fatigue. Animation also promotes inclusive learning, making the material accessible to people with different cognitive and physical disabilities. The principles of “accessibility-first” in motion design take into account the needs of users with disabilities, making learning more universal and fair.

In digital education, animation is used in a wide range of disciplines: from the natural sciences, where it helps to model biological, chemical and physical processes, to the humanities and social sciences to illustrate historical events or social phenomena.

Modern technologies make it possible to create interactive animated learning materials that students can control and adapt to their needs, increasing the



effectiveness of individual learning [6]. Animation can also be integrated into distance learning platforms and mobile applications, expanding access to education outside of traditional classrooms.

Assessing the effectiveness of animation in digital education requires analyzing empirical research data covering various aspects: information perception, learner engagement, content accessibility, and inclusiveness . Below is a table summarizing the results of the most significant studies in this area:

Table 1. Empirical studies on the use of animation in digital education

No.	Author(s), year	Object of study	Methodology	Key findings
1	Mayer & Moreno , 2003 [7]	Students learning with multimedia materials	Experiment, survey	Animation with voice acting reduces cognitive load and increases memorability of information.
2	Lowe , 2003 [8]	Students studying physics	Testing, observation	Dynamic graphics are more effective than static ones, especially when explaining abstract concepts.
3	Kim & Lim , 2022 [9]	Students with hearing impairments	Case study , interview	Animation with visual cues increases engagement and understanding among the hearing impaired.
4	Ho & Pradhan , 2020 [10]	UX designers working with inclusive interfaces	Interviews, case studies	Accessibility-first principles improve interactions for all categories of users.
5	Kriz & Hegarty , 2007 [11]	Students with different levels of preparation	Experiment	Educational animations work best if the structure/outline of the material is given first.
6	Anderson , 2020 [12]	People with neurodiversity (autism, ADHD, etc.)	Interview, UX testing	Adaptive animation reduces overload and improves interaction efficiency.



The results of the analyzed studies confirm that animation can significantly improve the educational process, especially if it is adapted to the cognitive characteristics and needs of students. Of particular importance is the strengthening of inclusiveness, which allows for greater access to education for people with hearing impairments, neurodiversities and other special needs.

The effectiveness of animation increases when the basic principles of multimedia learning are followed, including synchronization of visual and audio channels, and minimization of redundant information. An important factor in increasing effectiveness is also support for user control over animation.

Based on theoretical principles and empirical research findings, a number of practical recommendations can be formulated to improve the effectiveness of animation as a digital learning tool. These recommendations cover both pedagogical design and technical implementation.

Table 2 - Practical recommendations for using animation in digital learning

No.	Recommendation	Description
1	Follow the principles of cognitive load	Simplify your visuals, avoid redundant information and complex animations
2	Apply multimedia teaching principles	Sync audio and video, avoid distractions, control playback
3	Integrate animation into the educational process	Use animations as a didactic tool with tasks and feedback
4	Ensure accessibility and inclusivity	Add subtitles, avoid visual overload, provide contrast
5	Apply the principles of emotional design	Use friendly visuals, colors, characters, gamification to increase engagement

Therefore, to effectively use animation in digital learning, it is necessary to find a balance between visual appeal, pedagogical appropriateness and technical accessibility. Using evidence-based approaches and adapting to the needs of different user groups allows making learning more inclusive, engaging and effective.



Current research confirms that properly designed animations can promote deep understanding, reduce cognitive load, and enhance memory and analysis. It is essential to consider not only psychological and pedagogical aspects, but also the ethical, inclusive, and technical parameters of digital content.

The effectiveness of animation as a teaching tool is greatly enhanced by following certain design and methodological principles, such as R. Mayer's multimedia principles, J. Sweller's cognitive load theory, and emotional design approaches. Therefore, animation in digital learning is not just a visual accompaniment, but a powerful tool of pedagogical influence that can satisfy the diverse cognitive and emotional needs of students, increase motivation and ensure the accessibility of education within the framework of the digital transformation of the educational process.

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