Visualizing Mathematics: Using Short Videos to Connect Math with Science and Society

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Abstract

This article examines the pedagogical potential of short videos as tools for illustrating the application of mathematics across natural sciences and interdisciplinary domains within STEAM education. Grounded in multimodal learning theory, the study explores how video-based resources can enhance conceptual understanding, foster engagement, and bridge abstract mathematical ideas with real-world contexts. Emphasis is placed on the design principles for effective video integration, including clarity, contextual relevance, and cognitive load considerations. Preliminary findings suggest that short videos support active learning and interdisciplinary thinking, offering a scalable strategy for modern mathematics education. Implications for curriculum development and teacher practice are discussed.

Keywords: Mathematics Education, STEAM Integration, Video-Based Learning, Interdisciplinary Pedagogy

Introduction

The integration of mathematics within the broader framework of STEAM (Science, Technology, Engineering, Arts, and Mathematics) education has become a central theme in contemporary pedagogical discourse. Mathematics, often perceived as abstract and detached from practical contexts, underpins scientific inquiry, technological innovation, and artistic expression. However, traditional teaching approaches frequently fail to convey these interdisciplinary connections, leading to a gap between theoretical understanding and real-world application.

Recent research emphasizes the importance of multimodal learning strategies in bridging this gap (Mayer, 2021). Among these strategies, short videos have emerged as powerful tools for illustrating mathematical concepts in authentic contexts. Videos facilitate dynamic visualizations that support cognitive processing, reduce abstraction, and foster engagement (Paivio, 1986; Moreno & Mayer, 2007). When carefully designed, they align with cognitive load theory, ensuring learners focus on essential information without being overwhelmed (Sweller, 2011).

In STEAM-oriented curricula, short videos can demonstrate how mathematics underpins phenomena in physics, chemistry, biology, and creative fields such as architecture and music. This approach enhances conceptual understanding and promotes interdisciplinary thinking and problem-solving skills—competencies essential for 21st-century education (Perignat & Katz-Buonincontro, 2019). Furthermore, video-based learning supports diverse learning styles and offers flexibility for both classroom and online environments.

This paper explores the pedagogical rationale for using short videos in mathematics education, identifies design principles for effective implementation, and examines their potential impact on student engagement and learning outcomes. By situating mathematics within meaningful, real-world contexts, video-based strategies can transform how learners perceive and interact with mathematical ideas.

Educational Films in Mathematics Teaching: Theoretical Foundations, Evidence, and Design Principles

The use of educational films in mathematics education has gained prominence as educators seek strategies to make abstract concepts more accessible and engaging. Mathematics is often perceived as detached from real-world contexts, yet its applications permeate science, technology, engineering, and the arts. Short videos and films offer a multimodal approach to bridge this gap, providing dynamic visualizations that complement symbolic representations and verbal explanations. The theoretical basis for this approach draws on the Cognitive Theory of Multimedia Learning (Mayer, 2021), which posits that learners process information through dual channels—verbal and visual—within the constraints of limited working memory. Effective video design supports active cognitive processes such as selecting, organizing, and integrating information, thereby promoting meaningful learning. Similarly, Dual-Coding Theory (Paivio, 1986) explains how combining verbal narration with visual imagery strengthens memory and comprehension. These frameworks align with Cognitive Load Theory (Sweller, 2011), which emphasizes reducing extraneous load and managing essential load through design features such as segmentation, signaling, and coherence.

Empirical evidence supports the pedagogical value of video-based learning. Meta-analyses indicate that videos are most effective when used as supplements to traditional instruction rather than as replacements (Noetel et al., 2021). In mathematics education, short films illustrating applications in physics, biology, architecture, or everyday problem-solving contexts have been shown to enhance engagement and conceptual transfer. However, research also highlights that passive viewing alone yields limited benefits; pairing videos with generative activities such as problem-solving, prediction, or explanation significantly improves retention and higher-order thinking (Fiorella & Mayer, 2020).

Design principles for mathematics-focused educational films derive from multimedia learning research and large-scale analytics on learner engagement. Studies show that shorter videos—ideally under six minutes—maintain attention and reduce cognitive overload (Guo et al., 2014). Effective films adhere to principles of coherence by eliminating extraneous details, use signaling to highlight key steps in derivations, and synchronize narration with dynamic visuals. Techniques such as dynamic drawing, where instructors write equations or sketch graphs in real time, have proven particularly effective for mathematics because they model the reasoning process rather than presenting static solutions. A conversational tone and visible instructor presence can further humanize the content and sustain motivation. Learner control features, such as pause and replay options, mitigate the transient nature of video and allow students to process complex steps at their own pace.

Integration into classroom practice is critical. Educational films work best within structured pedagogical sequences, such as flipped classrooms or inquiry-based STEAM projects. Pre-class videos can introduce concepts, freeing classroom time for collaborative problem-solving and discussion. In mathematics lessons, films can demonstrate how differential equations model physical systems, how geometry informs architectural design, or how statistical reasoning applies to real-world data. Embedding guiding questions or low-stakes quizzes within or after the video encourages active engagement and reinforces learning objectives.

Despite their promise, educational films are not a panacea. Research cautions against equating engagement metrics with learning outcomes; shorter videos may attract more views but do not guarantee deeper understanding. Moreover, effects vary by learner prior knowledge and task complexity, underscoring the need for adaptive design. Future research should explore optimal segmentation for complex proofs, the role of student-created videos in fostering mathematical communication, and scalable strategies for embedding generative prompts within video lessons.

In sum, educational films offer a powerful means to contextualize mathematics and promote interdisciplinary thinking when grounded in cognitive theory and integrated with active learning. Their effectiveness depends not only on production quality but on thoughtful alignment with pedagogical goals, making them a valuable component of modern STEAM-oriented mathematics education.

Methodology and Practical Guidelines for Using Educational Films in Mathematics Education

The process begins with goal definition: each video should target a specific mathematical concept or application, such as demonstrating how differential equations model population growth or how geometry informs architectural design. Clear learning objectives guide both content selection and video structure. Next, storyboarding and scripting ensure logical sequencing and alignment with multimedia principles. Scripts should adopt a conversational tone and avoid unnecessary complexity, while storyboards visualize the progression of explanations, examples, and real-world applications.

Production involves choosing appropriate tools—ranging from screen-recording software for dynamic derivations to video editing platforms for integrating animations or real-life footage. Teachers should apply cognitive load theory by segmenting content into short clips (ideally under six minutes) and using signaling techniques such as highlighting key steps in proofs or equations. Narration should synchronize with visuals to maintain temporal contiguity, and extraneous details should be eliminated to preserve coherence.

Educational films are most effective when embedded in active learning environments. In flipped classrooms, videos can introduce new topics before class, freeing time for collaborative problem-solving. During lessons, short clips can serve as demonstrations, illustrating how mathematical models apply to scientific experiments or engineering designs. To prevent passive viewing, teachers should integrate generative activities such as prediction questions, guided note-taking, or problem-solving tasks immediately after viewing. Embedding interactive elements—quizzes, pause points, or prompts for reflection—further enhances engagement.

Accessibility and learner control are essential. Providing options to pause, replay, and navigate chapters allows students to manage the transient nature of video and revisit complex steps. For STEAM projects, videos can showcase interdisciplinary applications, encouraging students to connect mathematics with creative and scientific domains. Finally, evaluation should include both formative assessments (e.g., short quizzes) and reflective tasks to measure conceptual understanding and transfer.

Common challenges include technical limitations, time constraints for production, and insufficient teacher training. Solutions involve leveraging open educational resources, collaborating on video creation within teaching teams, and using simple tools such as tablet-based annotation rather than high-end editing software. Professional development programs can equip educators with skills in multimedia design and integration strategies.

Discussion

The findings from the literature and classroom practice suggest that short educational films can play a transformative role in mathematics education when integrated thoughtfully. Their primary strength lies in making abstract concepts tangible by linking them to real-world applications in science, technology, and the arts. This contextualization aligns with STEAM principles, fostering interdisciplinary thinking and motivating learners who often struggle to see the relevance of mathematics beyond the classroom.

However, the effectiveness of videos depends on more than production quality. Research consistently shows that passive viewing yields limited benefits; active engagement strategies—such as embedded questions, prompts for prediction, and follow-up problem-solving—are essential for deeper learning. Moreover, design principles rooted in multimedia learning theory, such as coherence, signaling, and segmentation, are critical to managing cognitive load and supporting comprehension of complex mathematical ideas.

Despite these advantages, challenges remain. Videos can inadvertently encourage surface learning if used as isolated resources without integration into broader pedagogical sequences. Teachers must therefore position films within structured activities that promote discussion, application, and reflection. Additionally, while short videos improve engagement, their impact on higher-order skills such as proof construction or modeling requires further empirical investigation.

Conclusion

In conclusion, educational films offer significant potential for enriching mathematics instruction, particularly in STEAM-oriented curricula. Their success hinges on thoughtful design and purposeful integration, ensuring that technology serves as a catalyst for active, meaningful learning rather than a passive substitute for traditional teaching.

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