Jurnal Pendidikan Indonesia Gemilang, Vol.6, No.2, 2026, pp. 181-193
e-ISSN 2807-5285. DOI. 10.52889/jpig.v6i2.853

Using Short Instructional Videos to Improve Mastery of Basic Light Concepts Among Upper-Grade Elementary Students: A Systematic Literature Review

Submitted 12 February 2026, Revised 3 March 2026, Accepted 4 March 2026

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Abstract

Science education in elementary schools plays an important role in fostering curiosity, critical thinking skills, and applied scientific knowledge among students. The abstract nature of light topics often produces difficulties in understanding and misconceptions. Short instructional videos (microlearning) are frequently proposed as a way to visualize scientific concepts and make them more concrete. This article presents a systematic literature review (2018–2025) of articles published in reputable international journals to evaluate the effect of short videos on mastery of light concepts in upper-grade elementary students. The PRISMA method was used to select relevant studies. The review's findings indicate that use of instructional videos particularly animations and short clips consistently improves students' conceptual understanding and science learning outcomes. Several experimental studies and meta-analyses report increases in student motivation, engagement, and cognitive achievement following the use of video media. The discussion presents Mayer's multimedia theory, cognitive load theory, constructivist perspectives, ICAP theory, and a conceptual model describing how short videos trigger student interest, build conceptual understanding, and complement experiential learning. Critical analysis identifies the need for further research on instructional design of short videos specifically for light topics and on measuring long-term impacts.

Keywords: Short Instructional Videos, Concepts of Light, Conceptual Understanding, Elementary School, Systematic Literature Review

INTRODUCTION

Elementary school science instruction plays a strategic role in building the foundations of science literacy from an early age, focusing not only on factual knowledge acquisition but also on development of scientific attitudes and skills (Ismail & Wardi, 2025; Mutch-Jones et al., 2022; van Stekelenburg, 2026; Triyanti & Sulistiyono, 2023). Through science lessons, students are guided to cultivate curiosity about natural phenomena, practice scientific reasoning skills such as observing, asking questions, conducting simple investigations, and drawing logical, evidence-based conclusions (Nehru & Irianti, 2020). This process promotes formation of robust conceptual understanding so that students do not merely memorize concepts but can interpret and connect them to real-world experiences (Asakawa et al., 2025; Fromm et al., 2021; Hendawati & Kurniati, 2017; Minet et al., 2024). Moreover, elementary science contributes to forming scientific attitudes such as objectivity, openness to data, and lifelong learning motivation in early age and essential steps to prepare future generations to face scientific and technological challenges.

Within the Indonesian primary curriculum context, integration of Science and Social Studies into the combined Social Science subject still includes basic physics topics, notably concepts of light, which are empirically known to induce misconceptions among upper-grade elementary students. These difficulties are mainly due to the abstract nature of light concepts such as light sources, reflection, refraction, and images formation which require causal reasoning and spatial thinking that are not yet fully developed at the elementary level and are not always directly observable in students' everyday experience (Kroothkaew & Srisawasdi, 2013; Soeharto & Csapó, 2022; Zulkiffli et al., 2024). Several international studies indicate that these conditions strongly contribute to emergence of misconceptions, especially concerning the nature of light and the process of sightseeing (Fetherstonhaugh et al., 1987; Irianti, 2021; Métioui, 2023; K. C. Smith, 1980; Tytler, 2000). One of the most common misconceptions is the belief that seeing begins with light emanating from the eye toward objects rather than light travels from a light source, reflecting off the object, and then entering the eye, a view consistently identified among elementary students across countries and cultures (Lange, 2024; Mahdiyah et al., 2021; Soeharto & Csapó, 2021, 2022). Diagnostic studies further show this misconception often persists and frequent despite formal instruction because intuitive preconceptions tend to dominate over verbal or textual scientific explanations (Aykutlu et al., 2023; Mbonyiryivuze et al., 2022; Taşkın & Kandil İngeç, 2019). These findings suggest that teaching light concept in Social Science subject at elementary students requires not only content and concept mastery, but also pedagogical strategies explicitly targeting conceptual restructuring so that scientific understanding of light and process of sightseeing can be formed more accurately and sustainably.

Prior research indicates that misconceptions in light topics are not intractable: quantitative studies at the elementary level report high proportions of misconceptions for some subtopics for example, a study testing 112 students found particularly high error rates on indicators related to light sources and light properties, with misconception rates reaching tens of percent in some subtopics (Andini & Kurniawati, 2024; Mahdiyah et al., 2021; Nurfiyani et al., 2020; Soeharto & Csapó, 2022). Cross-cultural reviews show a resemblance in that students frequently perceive light as a "substance" or imagine light to "wrap around" objects, causing misunderstanding of the processes of images formation, reflection, and refraction (Djanette & Fouad, 2014; Fetherstonhaugh et al., 1987; Soeharto & Csapó, 2021). Local studies from the classrooms also prove common misconceptions like problems in associating light sources with images formation, confusing straight-line propagation with refraction, and misapprehending the way mirrors and lenses create images as an evidence of inefficiency of the traditional methods of teaching that do not help form correct science concepts (Fetherstonhaugh et al., 1987; Goldberg & McDermott, 1987; Isik, 2023; Maison et al., 2025; Margunayasa et al., 2021). The conclusion is that a systematic approach to misconception correction should be taken into account in instructional approaches (three-/four-tier test diagnostic, simulation and inquiry-based learning).

Teaching challenges related to the abstract nature of light and light phenomena such as reflection, refraction, and image formation require learning strategies which are able to connect abstract phenomena of this type with concrete representations that are cognitively processable by students. Strategies like that should minimize extraneous load, segment information, and synergistically combine visual and verbal channels of information in order to stimulate deep processing (Mayer, 2024). Within this context, short instructional videos such as micro-videos or "bite-sized" videos become an appropriate tool because they allow (1) visualization of the phenomenon which cannot be observed directly and, consequently, help in mental models creation and (2) segmentation which helps to minimize cognitive load and engage in repeated practice (Trianisa & Wahyuni, 2024; Guo et al., 2014; Kuhlmann et al., 2024; D. P. Smith & Francis, 2022; Zhan et al., 2022). The research on videos' optimal duration and the most effective ways of video design reveals that certain style of production, short duration, and segmentation of videos increase engagement and make videos more effective instructional means in combination with formative quizzes or questions; therefore, short videos can serve not just as entertainment but as instructional tool and contribute to quicker conceptual clarifications in science teaching (Guo et al., 2014). Research on simulations and interactive visualizations also indicates that videos and animations are effective tools to promote conceptual knowledge in science education provided that videos are pedagogically oriented, i.e., used with questions or in exploratory activities (Rutten et al., 2012). Taking into account numerous misconceptions about light described in classical and contemporary literature, using of short videos created in accordance with the multimedia design principles such as segmentation, coherence, and integration of narration and visuals becomes an appropriate and pragmatic solution to concretization of the unobservable phenomena and conceptual change (Fetherstonhaugh et al., 1987; Mayer, 2024).

According to theory, the effectiveness of video usage arises from the merging of multiple theories in educational psychology and science learning. The first theory, known as Multimedia Learning Theory, claims that learning takes place better when information is delivered in a coordinated way in both visual and auditory channels because information is processed using two representational systems as long as the presentation is designed within working memory capacity (Mayer, 2024). Another theory called Cognitive Load Theory highlights the importance of segmentation in making information short and focused so as to minimize extraneous load, thus cognitive resources are available for processing information (Coffman et al., 2025; W. Schneider & Ornstein, 2015; Vandenbroucke et al., 2018). From a constructivist perspective, learning is an active process in which students build new understanding by integrating new information with prior knowledge; thus video media function not merely as transmission devices but as conceptual triggers that provoke cognitive conflict, reflection, and reconstruction of meaning (Chan et al., 2015; Järvelä & Hadwin, 2024; Lackmann et al., 2021; Rasi & Poikela, 2016) . Conceptually, therefore, short, segmented, richly visual instructional videos have a solid theoretical basis to support more effective and meaningful conceptual learning.

Empirical studies and systematic reviews indicate that video-assisted learning positively affects conceptual understanding, motivation, and student engagement in science learning when videos are designed according to sound instructional principles. Systematic reviews and meta-analyses at higher-education levels found consistent learning gains when videos supplemented instruction—including improved retention, transfer, and motivational indicators—while noting that design features such as segmentation, signaling, and integration of formative activities moderate effectiveness (Noetel et al., 2021; S. Schneider et al., 2018). Analysis of MOOC data shows production style and video duration strongly influence engagement: short, interactive formats such as tablet drawing and short cuts tend to yield higher watch times and assessment participation than longer videos (Guo et al., 2014). Contemporary experimental studies in flipped and credit-bearing contexts indicate short videos (micro-videos) increase engagement and can raise final exam scores (Zhu, Yuan, et al., 2022).

Additional evidence from simulation and visualization reviews supports the claim that dynamic representations—videos and animations—facilitate development of scientific mental models when paired with guided tasks (Rutten et al., 2012). However, the literature also notes limitations: heterogeneity of study designs, population differences such as most research conducted just in higher education, variation in outcome metrics like engagement toward long-term retention, and a need for stronger evidence at the elementary level and specifically for light topics. Thus, more controlled research on elementary populations and longitudinal studies are needed to ensure generalizability and to identify the most effective video design

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e-ISSN 2807-5285. DOI. 10.52889/jpig.v6i2.853

features for addressing misconceptions about light. Multimedia Learning and Cognitive Load theories provide a theoretical basis explaining why design features (segmentation, coherence, minimal redundancy, signaling) matter to optimize the benefits of video for conceptual learning in children (Mayer, 2024).

Although international literature consistently reports benefits of instructional video in science education, substantial research gaps remain. First, most studies examine video use generally across various science topics and are concentrated in secondary and tertiary education; reviews specifically focused on light concepts in upper elementary—topics particularly susceptible to misconceptions—are still limited and fragmented (Rutten et al., 2012; Smetana & Bell, 2012). Secondly, research on videos is mostly focused on considering the videos as a technological support, and the majority of the research is comparing the media like video versus texts or lectures without taking into account the internal elements of instructional design of videos like the optimal length of videos, coherence, segmentation principles, and best ways of representation of information visually to the students (Guo et al., 2014; Mayer, 2024; S. Schneider et al., 2018). Hence, the findings of studies on videos become difficult to generalize and reproduce due to lack of theoretical control of design variability of videos. Thirdly, despite the application of learning theories such as Multimedia Learning, Cognitive Load, and Constructivism, which are commonly used in the literature, partial and descriptive use of those theories is common, and those theories have not been utilized in order to make a causative model to empirically prove how video designs affect cognitive load and engagement of learners (Asmara et al., 2024; Noetel et al., 2021; Sweller, 2024). In summary, there is need for research to apply the learning theories in designing and testing short instructional videos on specific topics like lights in elementary school classrooms..

Given the gaps in the literature, this paper will be concerned with the use of short instructional videos in teaching light concepts among high elementary grade students. This paper will seek to (1) examine any empirical support on the effectiveness of using short instructional videos in teaching light concepts, (2) examine the theoretical underpinnings that explain learning through videos, and (3) set the basis for quantitative and experimental studies.

METHOD

This study used a Systematic Literature Review Method. Sources were searched in major academic databases from Scopus, Web of Science, and Google Scholar using keyword combinations such as “short instructional video,” “light elementary science,” “microlearning,” “elementary science video,” and “conceptual understanding light.” Inclusion criteria were peer-reviewed international articles (2018–2025) discussing use of instructional video at the elementary level or equivalent, particularly those relevant to science concepts. Selection followed PRISMA procedures: article identification through database search, title/abstract screening, full-text eligibility assessment, and inclusion based on topical relevance. Selected articles were then analyzed thematically to identify outcome patterns, learning theories used, and research gaps.

RESULT AND DISCUSSION

After applying PRISMA procedures, seven primary articles were identified as directly relevant to effects of short videos on mastery of basic light concepts among elementary students. A summary of the selected studies is presented in Table 1.

Table 1. Selected Studies

Author (Year)	Focus/Media	Method	Key Findings
Putri et al. (2024)	Science animation video (elementary)	Systematic literature review	Animation videos were effective in improving elementary science learning; interactive learning media.
Naimah (2022)	Instructional science videos	Systematic literature review	Video in science instruction improves conceptual understanding and student achievement.
Zhu, Yuan, et al. (2022)	Short videos (5–10 min)	Controlled experiment (flipped)	Short videos increased engagement and final exam scores increases up to 9.0% compared to long videos.
Shao et al., (2024)	Science video vs. hands-on experiment	Pre-post experiment with control class	No significant difference in conceptual achievement between video-watching and hands-on experiment groups.
Yang (2017)	Short vs. long videos (online)	Controlled experiment (flipped)	Short videos preferred, increased engagement and scores; cognitive load reduction not relevant.
Silva et al. (2025)	Microlearning (video, apps)	Systematic review	Microlearning via video/online increases motivation, achievement, and concept retention.
Anindya & Atmojo (2024)	Instructional video for 4th grade science	Quasi-experimental (nonequivalent control)	Video use significantly increased student learning activity (N-gain ≈ 84%) and post-test scores.

Table 1 indicates consistent positive results from instructional video used in science learning. Key points include: (1) Short duration of the video, visual content include animation an or video simplifies difficult concepts and improves student understanding (Putri et al., 2024; Shao et al., 2024) . (2) Short videos stimulate greater attention and motivation than conventional media (Anindya & Atmojo, 2024; Zhu, Yuan, et al., 2022) . (3) Videos can present experiments that are difficult or impossible to run in the class without compromising the learning objectives (Shao et al., 2024). For example, Shao et al. reported that educational videos could substitute for direct experiments with equivalent learning outcomes.

These empirical results can be explained by several theoretical frameworks. Mayer's Multimedia Theory states that dual-channel processing (auditory and visual) can construct coherent mental models if cognitive load is well managed (Herrington & Sweeder, 2025; Shao et al., 2024) . Effective instructional videos use such theories as dual-coding, segmentation, and multimedia coherence in order to avoid cognitive overload (Shao et al., 2024; Zhu, Li, et al., 2022). According to Cognitive Load Theory, fragmented information will decrease extraneous load allowing better creation of conceptual schemas (Monib et al., 2025; Zhu, Yuan, et al., 2022). 5E instructional approach (Engage, Explore, Explain, Elaborate, Evaluate) can be modified in a way to integrate video as an element of the Engage stage. Video shows a demonstration of some phenomena related to light (reflection), after which comes discussion and explanation of concepts with the help of the teacher (Explain). It correlates with constructivism because students construct their understanding through their first-hand experience.

According to the ICAP model (Interactive, Constructive, Active, Passive), the higher degree of activity of students allows greater engagement and learning (Herrington & Sweeder, 2025) . Interactive videos or videos combined with tasks such as predicting video outcomes and group discussion foster constructive or collaborative engagement rather than passive watching. For instance, some teachers use 30–60 second TikTok clips as discussion prompts for playing partial segments and asking students to form hypotheses before finishing the clip (Otto, 2025; Shao et al., 2024; Swerdloff, 2016; Zhang et al., 2024). Such strategies provoke cognitive conflict important for conceptual change (Posner & Snyder, 2024), leading students to build explanations based on their reasoning rather than passively receiving information.

Despite many studies reporting effectiveness of instructional video in science education (Naimah, 2022; Putri et al., 2024) , limitations is still remain. First, most studies address science topics broadly or compare media, with few focusing specifically on light concepts for upper elementary. The peculiar needs of images formation topics are underexplored. Second, video duration and design variations in the video such as animation, live footage; explicit narration, and inquiry prompts require further study. Yang (2017), suggested 6 to 10 minutes as optimal for general online learning, but ideal durations for elementary-level micro-videos may be shorter. Third, few studies measure long-term impacts such as retention or transfer after intervals, comparing video media to alternatives. Fourth, much of the literature emphasizes quantitative outcomes in term of test scores, and N-gain without deep analysis of the cognitive mechanisms involved.

Based on these findings, we propose a simple conceptual model: (1) A short video presents a “wonder” moment about light (engage). (2) Students note observations and pose predictions (active learning). (3) The teacher explains light concepts such as light source, beam, reflection and or refraction using the video as illustration (explain). (4) Discussion or follow-up experiments connect multiple representations (conceptual to macroscopic and symbolic). (5) Evaluation and reflection consolidate understanding. This model integrates Multimedia Learning, constructivism, and the 5E sequence, and can help address some misconceptions through concrete visual representation.

CONCLUSION

This systematic literature review concluded that short instructional videos have strong potential to improve conceptual understanding of light among upper-grade elementary students. Evidence from multiple studies indicates that animation or visual demonstration videos increase motivation, focus, and science achievement. This effectiveness is supported by simultaneous access to visual and auditory channels aiding formation of richer conceptual schemas, and by reduced extraneous cognitive load via segmentation (Cognitive Load Theory). Short video utilization must go together with active learning techniques like discussion, quiz, and experiment to ensure that students actively process information and gain more understanding.

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