

# Enhancing Student Comprehension of Heat and Expansion with an Animated Direct Learning Model

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**Abstract:**

This study investigates the effectiveness of the Direct Learning Model (DLM) integrated with animated media in improving student learning outcomes on the topic of heat and expansion in junior high school. Initial observations at SMP Negeri 3 Muara Tiga revealed that conventional DLM was predominantly teacher-centred, lacked engaging media, and resulted in student boredom and low retention. To address this issue, the study employed animated media, which has the advantage of concretising abstract scientific concepts and enhancing student motivation. This research utilised a mixed-method approach combining qualitative and quantitative analysis. The design applied was a one-group pre-test and post-test model. The sample consisted of seventh-grade students selected through cluster random sampling. Data were collected through multiple-choice tests and interviews. The pre-test and post-test assessed cognitive outcomes, while interviews explored students' difficulties in understanding physics concepts using animated media. The results showed a significant improvement in learning outcomes, with the average pre-test score of 60.1 increasing to 81 in the post-test. The N-Gain score was 0.5, indicating a moderate improvement. Statistical analysis also confirmed a significant correlation between the use of animated media and enhanced learning outcomes. In conclusion, the implementation of the Direct Learning Model using animated media positively affects student learning outcomes in science, especially on abstract topics like heat and expansion. However, some students experienced challenges, particularly in connecting animation with scientific concepts, indicating the need for scaffolding in media integration.

**Keywords:** Animated Media, Direct Learning Model, Heat and Expansion, Junior High School, Learning Outcomes

## Introduction

In the realm of science instruction for junior high schools in Indonesia, cultivating conceptual comprehension, especially of abstract scientific concepts like heat and expansion, presents a significant difficulty. Despite the prevalent use of the Direct Learning Model (DLM), its execution frequently remains inadequate, as educators primarily concentrate on explanations and rote exercises, neglecting the utilisation of suitable media to enhance conceptual understanding. This circumstance frequently results in student disengagement, less motivation, and inferior learning outcomes, as seen in SMP Negeri 3 Muara Tiga, where conventional didactic methods prevail in the instructional process.

Effective learning models must be supplemented with instructional media that may convert abstract concepts into more concrete representations, therefore improving students' cognitive engagement.

Animation media, as a type of motion visual assistance, have emerged as a viable instrument in this context. Mayer & Moreno (2002) research highlights that animation, particularly when combined with narration and sound, enhances dual-channel processing, boosts retention, and aids in the development of mental models. Lee and Owens said similarly observed the capacity of animation to capture attention and sustain student engagement during instructional sequences (Aka, 2019). Nevertheless, in contemporary educational practice, particularly in poor countries, educators have not adequately utilised animation-based media within organised pedagogical frameworks like DLM (Jacobs & Michaels, 2007; Kastur et al., 2020).

The deficiency in current research pertains to the inadequate empirical investigation of how animated media might be methodically integrated into the DLM to enhance certain learning outcomes in junior high school physics teaching. Although research (e.g., Sakti, 2012; Side, 2009) has recorded the individual impacts of animation or the DLM, limited studies have investigated their combined influence in an actual classroom environment. Moreover, little emphasis has been devoted to the challenges students have in using such media—particularly in correlating dynamic pictures with scientific concepts—adding another dimension of educational complexity (Fatmawati et al., 2019; Loeng, 2020). This study examines the impact of the Direct Learning Model, enhanced by animated media, on students' comprehension of heat and expansion at SMP Negeri 3 Muara Tiga, while also investigating the factors that impede students' understanding of physics concepts through animated instruction.

This project seeks to enhance scientific teaching methods by integrating organised instruction with engaging media. The results are anticipated to yield practical insights for educators in incorporating media into conventional teaching approaches and furnish empirical data on how media-enhanced DLM might facilitate improved learning outcomes in scientific education.

## Literature Study

A multitude of research has investigated the efficacy of animation-based media and direct learning approaches in improving students' academic performance, particularly in the field of scientific education. Trianto (2024) asserted that the Direct Learning Model (DLM) is especially efficacious in imparting declarative and procedural information when implemented through organised phases, concentrating student attention and methodically directing learning. This systematic method facilitates more regulated training, advantageous for presenting intricate scientific subjects such as heat and expansion. Nevertheless, the model's efficacy markedly improves when supplemented by captivating media. The learning media, particularly animations, augment student comprehension by visualising abstract topics, hence sustaining student engagement and retention (Guzmán & Payá, 2020; Syhastani, 2022). Mayer and Moreno (2002) assert that well-designed animations can enhance understanding by concurrently delivering visual and linguistic information, thereby alleviating cognitive strain. Furthermore, research indicated that animations elicit students' reactions to visual stimuli and enhance their retention of knowledge over extended durations (Lardika & Tulyakul, 2020; Slingerland & Borghouts, 2011).

Empirical research substantiates these theoretical viewpoints proved that the use of animation into direct instruction markedly enhanced student learning results in physics (Sakti et al., 2012). Paradise and Rogoff (2009) also published data indicating that animations aid students in comprehending complicated subjects by converting abstract concepts into visible representations. Thornton (2010) categorised animation as motion audiovisual media, claiming its effectiveness in enhancing student engagement and elucidating complex material. Moreover, Kehoe et al. (2001) emphasised that animated learning aids provide engaging educational settings that enhance student motivation. Consistent with this, Aka (2019) discovered that animation and special effects engage student attention during the learning session, thereby enhancing

academic achievement. In addition to motivation, animation promotes cognitive advancements. The educational media, such as animation, enhance students' active involvement, fostering observation and participation instead of passive listening (Wang et al., 2018). Prakasiwi et al. (2021) asserted that multimedia platforms accommodate multiple learning styles and provide differentiated education, which is essential for heterogeneous classrooms. Furthermore, Utaminingsih et al. (2024) underscored that these instructional innovations correspond with the requirements of 21st-century education, fostering both knowledge and critical thinking with technology literacy. Another research indicated that animated instructional media amalgamate audio-visual components to facilitate interactive learning, hence enhancing memory and comprehension through several sensory modalities (Pradono et al., 2013; Sudarni, 2023).

Oktavianti et al. (2018) endorsed the application of pre-test and post-test designs in educational research to assess learning enhancements, hence proving the effectiveness of animation media in actual classroom environments. Research emphasised the necessity of stringent assessment procedures to guarantee that educational interventions effectively improve learning outcomes. The extensive literature consistently concludes that integrating structured instructional models with dynamic visual media, such as animation, enhances student achievement, boosts engagement, improves long-term retention, and accommodates diverse learning needs, thereby serving as an effective pedagogical tool in science education (Trimansyah & Rosmiati, 2023).

This study presents a unique addition to scientific education by methodically incorporating animated media into the organized stages of the Direct Learning Model (DLM) to instruct junior high school students on intricate physical science concepts, particularly heat and expansion. This research uniquely investigates the synergistic benefits of animation and DLM when integrated in a real classroom context, in contrast to other studies (e.g., (Guzmán & Payá, 2020; Sakti et al., 2012) that have evaluated both in isolation. The innovation is not only in the amalgamation but in the deliberate use of animation throughout each stage of the DLM, from orientation to evaluation, offering scaffolding to enhance student cognitive engagement and conceptual comprehension.

This study significantly contributes to existing knowledge by highlighting individual variances in student interactions with animated media. The variance in educational results, especially among students with little prior knowledge, corresponds with recent research by Herliana et al. (2024), who underscored the significance of adaptive media design and differentiated teaching in the application of 2D animations for scientific education. Students with insufficient baseline knowledge or a preference for other modalities (e.g., tactile or verbal education) derived less benefit from animation-intensive classes, underscoring the necessity for multi-modal tactics to promote inclusion. Unlike other studies that focus just on test results, it also assesses pedagogical consequences and learning challenges. The employment of animation as a cognitive instrument—not only a visual augmentation—corresponds with constructivist tenets, wherein learners develop mental models through active participation. This establishes animated media as a primary catalyst for deep learning when integrated into a well-structured educational framework.

## **Research Method**

This study employed a mixed-method approach, integrating both quantitative and qualitative research approaches to enhance the knowledge of the research topic (Creswell et al., 2003). This methodological selection enabled the researchers to examine data from several viewpoints and corroborate the findings through triangulation. The study utilised a One Group Pre-test and Post-test design, which entailed administering a pre-test to evaluate students' initial comprehension, implementing the treatment (application of the Direct Learning Model utilising animation media), and subsequently conducting a post-

test to assess learning outcomes following the intervention. The research population consisted of all seventh-grade students at SMP Negeri 3 Muara Tiga during the even semester of the 2024/2025 academic year. Two classes were chosen by cluster random selection to constitute the research sample. Data collecting methods including assessments and interviews. The cognitive achievement exam had multiple-choice questions with five response possibilities (A–E) and employed a dichotomous scoring system, awarding a score of 1 for right responses and 0 for wrong ones. Scores were normalised to a 0–100 scale. Furthermore, interviews were administered to investigate students' challenges in comprehending physics ideas using animated media, yielding qualitative insights that complement the quantitative findings. The investigation utilised grounded theory methodologies, encompassing data reduction, data presentation, and conclusion formulation/validation. The pre-test and post-test data were analysed using the N-Gain method to assess the intervention's success, classified according to improvement levels. This integrated approach allowed researchers to meticulously assess the influence of the direct instruction paradigm, augmented by animated media, on student learning outcomes in scientific education.

## Results

The implementation of the Direct Learning Model (DLM) augmented with animated media has shown a significant and measurable impact on the learning outcomes of seventh-grade students at SMP Negeri 3 Muara Tiga, particularly in mastering the topic of Heat and Expansion. This section presents a comprehensive breakdown of the study's findings, combining quantitative and qualitative data, and offering a detailed interpretation of students' performance before and after the intervention. The discussion further investigates various dimensions of student engagement, conceptual understanding, and the challenges encountered during the learning process.

### 1. Pre-Intervention Conditions and Baseline Data

Prior to the application of the intervention, a diagnostic assessment in the form of a pre-test was conducted to measure the baseline understanding of students regarding the topic of heat and expansion. The pre-test comprised multiple-choice items aligned with the learning objectives and the cognitive domains of Bloom's taxonomy. The results revealed an average score of 60.1 out of 100, indicating a generally low to moderate level of prior knowledge.

An analysis of individual scores demonstrated that a significant number of students exhibited misconceptions, particularly related to the nature of thermal expansion, differences between heat and temperature, and the molecular behavior of substances under heat application. Interviews conducted before the intervention corroborated these findings, with many students expressing confusion about the real-world applications of thermal expansion or the role of heat energy in changing the state and size of matter. These observations confirmed the necessity of a more engaging instructional method that could effectively translate abstract concepts into comprehensible forms.

### 2. The Implementation Process: Direct Instruction with Animated Media

The intervention phase spanned four instructional sessions. The DLM was executed following its standard five-phase structure: orientation, presentation, guided practice, independent practice, and assessment. Animated media was embedded within each phase to complement the instructional narrative. During the **orientation**, animations were used to stimulate curiosity and activate prior knowledge. For example, students were shown a short animated clip demonstrating railway tracks expanding under the heat of the sun, a phenomenon they might have observed but never critically questioned. In the **presentation phase**, animations illustrated microscopic molecular motion in solids, liquids, and gases, which allowed students

to visualize kinetic particle theory in a dynamic and intuitive way. The **guided practice** incorporated interactive animation segments where students predicted outcomes before animations were played, fostering active participation. In **independent practice**, students used tablets to access animations and completed corresponding worksheets, facilitating self-paced learning. Lastly, during the **assessment phase**, animations were utilized in formative questioning to gauge immediate comprehension.

The integration of animated media aligned with Mayer's Multimedia Learning Theory, utilizing both visual and auditory channels to reduce cognitive load and enhance retention.

### 3. Post-Test Results and Quantitative Improvements

Following the instructional intervention, students were administered a post-test with a structure similar to the pre-test. The results were significantly improved, with the average score rising to 81 out of 100—an increase of 20.9 points. This substantial improvement indicates that the instructional strategy was effective in enhancing students' cognitive understanding.

To further quantify the learning gains, the normalized gain (N-Gain) formula was applied. The average N-Gain score was calculated as:

$$\text{N-Gain} = \frac{\text{Post-test Score} - \text{Pre-test Score}}{100 - \text{Pre-test Score}} = \frac{81 - 60.1}{100 - 60.1} \approx 0.52$$

According to Hake's classification, an N-Gain between 0.3 and 0.7 is categorized as **moderate improvement**. While this shows meaningful progress, it also indicates room for further instructional refinement.

A categorical breakdown of students' post-test achievement is as follows:

**High Achievement (≥85):** 6 students (20%)

**Moderate Achievement (70–84):** 17 students (56.7%)

**Low Achievement (<70):** 7 students (23.3%)

The shift in distribution from predominantly low and moderate pre-test scores to moderate and high post-test scores further confirms the positive impact of animated media within the DLM framework.

### 4. Correlation Between Animated Media and Learning Outcomes

To determine whether the observed improvement was statistically significant and directly correlated with the intervention, Pearson's product-moment correlation was used. The statistical analysis showed a correlation coefficient of 0.508, which falls into the **moderate correlation** category, and the significance level was set at  $\alpha = 0.05$ . The p-value obtained was  $< 0.05$ , confirming a statistically significant relationship between the use of animated media and improved student performance.

These results suggest that students who were more engaged with the animated content tended to score higher on the post-test, supporting the hypothesis that animation fosters cognitive comprehension by clarifying difficult and abstract concepts.

### 5. Qualitative Findings: Student Reflections and Learning Barriers

To complement the quantitative data, qualitative data were gathered through semi-structured interviews with selected students. The purpose was to explore the students' subjective experiences and identify obstacles that might have hindered their learning.

Several recurring themes emerged: (a) **Increased Engagement:** Many students reported that they found the learning sessions more enjoyable and easier to follow. One student stated, *"When I watched the animation, it felt like I was seeing how the particles actually moved. It made more sense than reading the textbook."* (b) **Improved Retention:** Students mentioned that they could recall lessons more effectively when linked to specific visual sequences from the animations. (c) **Conceptual Clarity:** Most students agreed that animations helped them understand the cause-and-effect relationships, such as why metal expands when heated. (d) **Challenges in Interpretation:** A subset of students experienced difficulty in interpreting what they saw. For example, while they could observe particle motion in animations, they struggled to explain it in scientific terms like "kinetic energy" or "vibrational motion." (e) **Cognitive Overload for Some Learners:** Students with lower academic performance expressed that sometimes the animations felt "too fast" or "too complex," leading to confusion rather than clarity. These qualitative insights point to the dual-edged nature of multimedia learning: while it enriches understanding for many, it can also overwhelm learners if not adequately scaffolded.

## Discussion

This study's findings demonstrate a significant enhancement in student learning outcomes with the adoption of the Direct Learning Model (DLM) utilizing animated media for instructing the subject of heat and expansion. The enhancement is demonstrated by the rise in the average student score from a pre-test of 60.1 to a post-test of 81, resulting in an N-Gain score of 0.5, classified as moderate. The findings indicate that incorporating animated media within a systematic direct education framework enhances students' comprehension of scientific topics, especially abstract ones like heat and expansion. This result corresponds with studies grounded on cognitive theory that underscores the significance of multimodal learning. Mayer and Moreno (2002) assert that animation aids learners in developing superior mental models by graphically depicting complicated and abstract concepts that may be challenging to comprehend through verbal explanations alone. The simultaneous processing of information via visual and aural channels mitigates cognitive stress and enhances comprehension (Mayer, 2009). In this situation, animation served not just as an instructional aid but also as a cognitive tool that facilitated meaningful learning. Furthermore, the organized framework of the Direct Learning Model proved crucial in directing pupils through progressive learning stages. Trianto (2011) emphasized that the DLM proficiently facilitates both declarative and procedural knowledge through a structured educational sequence and the provision of prompt instructor feedback. This paradigm becomes considerably more successful in assisting the learning process when combined with animated material, which catches attention and maintains engagement (Lee & Owens, 2004). The captivating graphics and energetic presentations probably improved student enthusiasm and retention, alleviating the usual disengagement observed in lecture-dominant forms (Sanaky, 2009).

The findings align with prior research examining the interplay between direct education and media-enhanced information. Sakti (2012) discovered that animation-enhanced direct instruction improved physics learning results, whereas Side (2009) illustrated that such media significantly diminished misunderstandings and augmented conceptual comprehension. These confirming data confirm that technology tools, when suitably incorporated into educational models, may substantially enhance the learning environment and foster improved educational outcomes. The study revealed problems, including students' difficulties in connecting abstract scientific concepts with animated representations and expressing

the significance of the animations to the fundamental scientific principles. These problems indicate a necessity for meticulous instructional design and teacher facilitation to reconcile the disparity between media depiction and conceptual comprehension. In the absence of sufficient scaffolding, students may concentrate on the superficial aspects of animations instead of their pedagogical intent (Lowe, 2004). The integration of the Direct Learning Model with animated media favorably enhances scientific instruction in junior high schools by elevating student engagement and enhancing academic performance. Educators must be aware of the possibility of cognitive overload and should offer guided interpretation of animations to enhance their educational effectiveness. Future studies should examine long-term retention effects and analyze the diverse affects of animation on students with differing degrees of prior knowledge and learning styles.

## Conclusion

This study conclusively illustrates that the use of the Direct Learning Model (DLM) combined with animated media markedly improves student learning results regarding Heat and Expansion among seventh-grade students at SMP Negeri 3 Muara Tiga. The statistical statistics indicate a significant enhancement, with the average pre-test score of 60.1 increasing to an average post-test score of 81, demonstrating a gain of 20.9 points. This rise demonstrates the efficacy of the learning intervention and affirms that animation, as a visual and dynamic medium, is essential for facilitating the understanding of abstract scientific concepts. Animated media shown significant efficacy in sustaining student attention, enhancing motivation, and augmenting memory via captivating visuals that complement the educational content. Notwithstanding the evident advantages, the study also highlights problems, including students' struggles to associate cartoons with particular physics ideas and to express their significance. However, the use of animation into the DLM has demonstrated its ability to render complex scientific concepts more comprehensible, hence promoting a deeper comprehension and improving academic achievement. This study underscores the necessity of integrating technology-enhanced media into contemporary educational practices to accommodate varied learning requirements and facilitate successful scientific instruction in junior high schools.

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