TUNAS
JURNAL PENDIDIKAN GURU SEKOLAH DASAR
http://journal.umpr.ac.id/index.php/tunas
Vol. 11, No. 1, December 2025, PP. 6-12
ISSN: 2477-6076 (print); 2685-8169 (online), DOI: 10.33084/tunas.v11i2.11563

Deep Learning Based Interactive Edpuzzle Improves Science Learning Outcomes on Energy in Elementary School Students

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Article Information
Received: November 2025
Accepted: November 2025
Published: December 2025

ABSTRACT
Background: Science learning in elementary schools still faces challenges because many materials—particularly energy concepts—are abstract and difficult for students to understand, resulting in low learning outcomes. This condition requires learning media that provide more interactive and meaningful learning experiences. *Aim:* This study aims to examine the effect of using Edpuzzle as an interactive video-based learning medium supported by a deep learning approach, which in this study refers to deep conceptual learning rather than the use of artificial intelligence algorithms. *Method:* The research employed a quantitative method with a one-group pretest–posttest design involving 30 fourth-grade students from SDN Banjaragung 3 Jombang. The research instrument consisted of validated and reliable multiple-choice learning outcome tests, and the data were analyzed using a paired sample t-test at a 0.05 significance level. The findings show a significant increase in students' average scores, rising from 58.20 on the pretest to 82.40 on the posttest. Prerequisite tests confirmed that the data met normality and homogeneity assumptions, while hypothesis testing produced a significance value of 0.000 < 0.05, indicating a meaningful difference between pretest and posttest scores. Therefore, the use of Edpuzzle supported by a deep conceptual learning approach is effective in improving students' understanding of energy concepts and their science learning outcomes.

Keywords: Interactive Edpuzzle, Deep Learning, Learning Outcomes, Energy Science, Elementary School

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Citation Information: Fransiska, S. M., & Nuruddin, M. Deep Learning Based Interactive Edpuzzle Improves Science Learning Outcomes on Energy in Elementary School Students. *Tunas: Jurnal Pendidikan Guru Sekolah Dasar*, 11(2), 6–12. https://doi.org/10.33084/tunas.v11i2.11563

INTRODUCTION

Science learning in elementary schools plays an essential role in developing students' conceptual understanding of natural phenomena and applying these concepts in everyday life (Tokan et al., 2022). In practice, however, the implementation of IPAS learning still encounters various challenges. The content in IPAS often includes abstract and complex ideas—such as energy transformation, force, and simple machines—that require higher-order cognitive processing (Kemendikbudristek, 2025). These abstract characteristics make it difficult for students to construct accurate conceptual understanding, particularly when learning resources and instructional media do not sufficiently support visualization and concrete representation (Waluyo et al., 2025). Consequently, these learning barriers contribute to students' limited comprehension of key scientific concepts at the elementary level.

The challenges in IPAS learning are reflected in various national assessments focusing on primary education. According to the national Assessment of Minimum Competency (Asesmen Kompetensi Minimum/AKM), many elementary students demonstrate limited mastery of scientific reasoning skills, particularly in interpreting data, understanding causal relationships, and applying concepts in daily contexts (Kemendikbudristek, 2023). These findings indicate that difficulties in understanding abstract IPAS material have a direct impact on students' learning outcomes at the elementary level. This aligns with school-level evaluation reports stating that teachers must continually strengthen instructional strategies to ensure that students achieve the expected learning competencies set in the national curriculum (Kemendikbudristek, 2025).

The phenomenon of low learning outcomes is also evident in the local context. Initial observations at SDN Banjaragung 3, the site of this research, indicate that fourth-grade students continue to experience difficulties in understanding energy-related material, as reflected in the low average learning score (63), which falls below the school's Minimum Mastery Criterion (KKM) of 75. These challenges are closely related to the learning practices in the classroom, which remain predominantly teacher-centered, relying on lectures and question–answer sessions with limited opportunities for student participation. Such conventional approaches restrict students' active engagement and hinder the development of deeper conceptual understanding. This condition is consistent with the findings of (Zafirah et al., 2025),

who reported that teacher-centered instruction is still widely practiced in elementary science classrooms in Indonesia, resulting in minimal student involvement and weaker mastery of scientific concepts.

In response to these challenges, 21st-century learning frameworks emphasize the integration of digital technologies to foster student engagement, develop higher-order thinking skills, and support independent learning. These competencies are particularly important in science education, where students are required to analyze, interpret, and apply concepts to real-world situations. Therefore, the incorporation of interactive digital media becomes essential for creating learning experiences that are more engaging and cognitively demanding. Interactive learning media contribute significantly to the effectiveness of instruction because they enable students to interact directly with the presented material, thereby increasing motivation, attention, and knowledge retention (Seprie, 2024). The cognitive theory of multimedia learning (Adnyani et al., 2025) states that learning becomes more effective when information is presented simultaneously through text, visuals, and audio, allowing students to process material through dual channels. This principle highlights the importance of selecting media that can reduce cognitive load and make abstract concepts more accessible. In the context of elementary science learning—particularly on energy topics that require students to visualize processes that cannot be directly observed—multimedia-based interactive media provide structured support to help students connect conceptual representations with real-world phenomena. Therefore, the use of interactive video platforms such as Edpuzzle becomes relevant because they can present abstract concepts in concrete, multimodal forms that align with the way students construct understanding.

Several previous studies have shown the potential of Edpuzzle as an interactive learning medium. (Tokan et al., 2022) and (Lutfiana et al.,2025) reported that the platform effectively increases student engagement and supports the comprehension of basic science concepts, while (Shidiqqa et al., 2025) highlighted its positive influence on learning motivation, particularly in energy-related lessons. Research at the secondary level also demonstrates its benefits; (Chahnia et al., 2025) found that the integration of interactive questions in Edpuzzle assists students in developing analytical skills. Likewise, Sabililah (2024) noted that interactive video-based instruction helps students connect scientific concepts to everyday contexts.

Although these studies consistently indicate that Edpuzzle contributes to improved learning outcomes, most of them focus primarily on measuring engagement, motivation, or general conceptual understanding. They do not explicitly incorporate a structured deep learning approach that emphasizes deeper conceptual processing, reflection, and meaningful integration of ideas. This gap is important because abstract science concepts—such as energy—require students not only to recall information but also to actively construct and relate concepts at a deeper cognitive level. Therefore, the present study extends previous research by integrating Edpuzzle with a deep learning approach (in the pedagogical sense of promoting deep conceptual understanding) to explore whether this combination can more effectively support students' mastery of energy concepts in elementary science learning.

The concept of deep learning used in this study refers to a pedagogical approach, not an artificial intelligence algorithm. In education, deep learning emphasizes meaningful learning processes in which students develop conceptual understanding, make connections across ideas, and apply knowledge in new situations (Waluyo et al., 2025). (Wibowo et al., 2022) note that this approach encourages critical, reflective, and analytical thinking—competencies that are essential for understanding abstract scientific concepts.

In the context of energy learning in elementary schools, deep learning enables students to move beyond memorizing definitions toward explaining relationships among concepts, such as understanding how thermal energy can be transformed into mechanical energy in daily life. Although studies on Edpuzzle rarely address deep learning explicitly, several findings show that interactive video tools can support deeper cognitive processing when integrated with appropriate instructional strategies. For example, Edpuzzle's embedded questions and reflective prompts can guide students to analyze, interpret, and relate concepts rather than passively watch videos. This aligns with principles of deep learning, where structured questioning and multimodal representations help students construct more meaningful conceptual frameworks. Therefore, the integration of Edpuzzle with a deep learning approach in this study is positioned as a pedagogical innovation aimed at fostering deeper conceptual understanding of energy in elementary science learning.

The integration of digital technology is becoming one of the solutions to address these challenges (Hasanah et al., 2024). Deep learning in education is defined as a learning approach that emphasizes cognitive engagement, reflection, and meaningful application of concepts, so that students do not merely memorize information but are also able to connect knowledge with real-life experiences. One emerging innovation is the use of interactive video media such as Edpuzzle, which enables teachers to embed questions, quizzes, and notes directly into video content (Choerul Anwar, 2023). With this approach, students do not simply watch passively but are actively involved in processing information, analyzing concepts, and relating them to real experiences (Febrianti & Saputra, 2022). This advantage aligns with the principles of deep learning–based instruction, which emphasizes cognitive engagement, reflection, and meaningful concept application.

Several previous studies highlight the potential of integrating deep learning into elementary education by demonstrating how deep, meaningful processing can

strengthen students' understanding of fundamental concepts at the primary level. Studies on literacy development, mindful learning, and AI-supported learning each provide evidence that deep learning principles—such as reflection, conceptual connection, and active cognitive engagement—can be effectively applied to support elementary students' learning processes. Although conducted in different domains, these studies collectively show that deep learning fosters deeper comprehension and helps young learners build stronger conceptual foundations. (Nabila et al., 2025) reported that game-based interventions supported by deep learning significantly improved elementary students' literacy skills. Furthermore, (Dewi, 2025) emphasized that deep learning approaches integrating mindful, meaningful, and joyful learning elements can foster critical, creative, and reflective thinking skills, while also increasing students' motivation and engagement. Meanwhile, (Wibowo et al. 2022) found that elementary school teachers have begun utilizing AI-based instructional materials oriented toward deep learning, although implementation remains limited by training and infrastructure constraints.

In addition to the deep learning approach, the influence of Edpuzzle as interactive video media has been demonstrated by several studies. (Nabilah, 2023) showed that the use of Edpuzzle can improve students' understanding of science concepts, particularly abstract material. (Shidiqqa et al., 2025) added that interactive video media enhance student engagement in learning, thereby positively affecting learning outcomes. (Shabrina and Wati, 2025) further asserted that digital media based on visualization are more effective in fostering science learning motivation compared to traditional print-based media.

However, the literature review reveals certain gaps. Research that specifically integrates interactive Edpuzzle with a deep learning approach in science learning—particularly on energy material at the elementary level—is still very limited. Most previous studies only highlight the general use of interactive media or Edpuzzle without deep learning support, while studies related to deep learning mostly focus on secondary and higher education levels. This underscores a research gap in the elementary school context, indicating the importance of conducting this study to provide more adaptive learning media with the potential to improve student learning outcomes.

The urgency of this study lies in the effort to present an innovative alternative for science learning in elementary schools that aligns with the Merdeka Belajar policy and the demands of twenty-first-century learning (Mahirotul Hasanah et al., 2024). The integration of interactive Edpuzzle with a deep learning approach is expected to create a more meaningful, interactive, and student-centered learning experience (Choerul Anwar, 2023). In addition, the findings of this study are expected to serve as a reference for teachers in utilizing digital technologies to support effective, contextual, and adaptive science learning.

This study aims to determine the influence of integrating interactive Edpuzzle with a deep learning approach in teaching science on energy topics in elementary schools. Specifically, this research is directed toward identifying how the integration of both can create a more adaptive and interactive learning experience suited to the characteristics of elementary students, while also evaluating its contribution to enhancing conceptual understanding and learning outcomes.

METHOD

This study employed a quantitative approach using a one-group pretest–posttest design. This design was selected because it aligns with the objective of examining the effect of an interactive Edpuzzle integrated with a deep learning approach on improving science learning outcomes in the energy topic. In this design, students were first administered a pretest, then participated in a learning session involving the Edpuzzle intervention, and finally completed a posttest. The results of both tests were compared to determine changes following the treatment. Since the design does not include a control group, the interpretation of findings focuses on describing improvements within the same group rather than comparing outcomes across different groups.

The study population consisted of 30 fourth-grade students at SDN Banjaragung 3, Bareng District, Jombang Regency, during the first semester of the 2025/2026 academic year. A saturated sampling technique was applied because only one fourth-grade class was available, and therefore the entire population was included as the research sample. This technique is appropriate for studies in which the population is limited and homogeneous; however, the use of a single class from one school restricts the generalizability of the findings. Accordingly, the results should be interpreted within the specific context of this study and may not represent broader elementary school populations.

The independent variable (X) in this research was defined as the use of Edpuzzle integrated with a deep-learning–oriented instructional design. Operationally, this variable referred to three components: (1) cognitive engagement, where Edpuzzle videos were embedded with analytical and reflective questions that required students to think beyond factual recall; (2) conceptual connection, implemented through prompts encouraging students to relate energy concepts—such as forms and transformations of energy—to everyday contexts; and (3) meaning-making, represented by teacher-guided feedback within Edpuzzle to help students refine their understanding after answering questions. The learning process was categorized as deep learning when students demonstrated the ability to explain relationships between concepts, justify answers, or connect scientific ideas with real phenomena during the interactive video tasks.

The dependent variable (Y) was students' science learning outcomes on the energy topic. The research instrument consisted of pretest and posttest multiple-choice items totaling 25 questions developed according to fourth-grade science competencies. Although multiple-choice items are often associated with lower-order thinking, this study designed the items using scenario-based stems, reasoning-required distractors, and concept-application contexts to assess students' ability to interpret, analyze, and apply energy concepts. Several items required students to determine energy transformations in daily-life situations, evaluate the correctness of statements, or choose explanations that best represent conceptual relationships. Therefore, the instrument remained aligned with the study's intention to capture elements of deep conceptual understanding rather than mere factual memorization. Instrument validity was established through expert judgment (content validity) involving a science education lecturer and a fourth-grade teacher, followed by empirical testing using item–total correlation. Data collection was conducted after both the pretest and posttest results were obtained. Of the 25 items, 22 were declared valid with correlation coefficients greater than 0.30. Instrument reliability was measured using Cronbach's Alpha, yielding $\alpha = 0.82$, indicating high reliability (≥ 0.70) based on Nunnally's (2023) criteria. The validated and reliable instrument was then used to collect the pretest and posttest data.

Data were analyzed using SPSS 27. The analysis included (1) descriptive statistics to determine the mean, median, mode, and standard deviation; (2) prerequisite tests consisting of normality and homogeneity tests; and (3) hypothesis testing using a paired-sample t-test at a 5% significance level ($\alpha = 0.05$). The paired-sample t-test was applied because the same group of students was assessed under two different conditions (pretest and posttest). This procedure made it possible to determine not only whether a difference existed but also the extent to which the use of the interactive Edpuzzle with a deep learning approach influenced the improvement of science learning outcomes.

RESULTS AND DISCUSSION

Results

The use of interactive Edpuzzle media based on deep learning not only provides positive benefits during classroom instruction but also has the potential to serve as a tool for independent learning outside regular school hours. Through flexible access, students can review the material, respond to embedded questions, and strengthen their understanding of energy concepts at their own learning pace. This condition supports more meaningful learning because students do not merely receive information passively but actively engage with the content.

The research findings show a significant improvement in students' learning outcomes following the use of Edpuzzle media. A comparison between the mean pretest and posttest scores illustrates a clear difference between students' initial abilities and their final achievements. Descriptive analysis was conducted to provide an overview of student performance before and after the treatment. A summary of the pretest and posttest results is presented in Table 1.

Table 1. Descriptive Statistics of Student Learning Outcomes (n = 30)

Statistic	Pretest	Posttest
Minimum score	40	65
Maximum score	75	95
Mean	58.20	82.40
Median	58.00	83.00
Mode	60	85
Standard deviation	8.75	7.20

Source: Processed Data (2025

Table 1 shows that the average score increased from 58.20 on the pretest to 82.40 on the posttest. This indicates an improvement in learning outcomes after the use of interactive Edpuzzle media based on deep learning.

After obtaining a descriptive overview of the difference between pretest and posttest scores, the next step was to conduct prerequisite tests. These tests ensure that the data meet the basic assumptions of parametric analysis so that the hypothesis testing results can be scientifically justified. The results are shown in the following table:

Table II. Prerequisite Test Results

Assumption Test	Statistic/Test	Sig.	Criteria	Conclusion
Normality	Kolmogorov–Smirnov	0.200	Sig. > 0.05	Normally distributed
Homogeneity	Levene's Test	0.324	Sig. > 0.05	Homogeneous

Source: Processed Data (2025)

Based on Table 2, the normality test using Kolmogorov–Smirnov yielded a significance value of 0.200 > 0.05, indicating that the data are normally distributed. The homogeneity test (Levene's test) produced a significance value of 0.324 > 0.05, indicating that the data are homogeneous. Thus, the data meet the assumptions required to perform a paired sample t-test.

Since the data were confirmed to be normally distributed and homogeneous, the analysis proceeded to hypothesis testing using a paired sample t-test to determine the significance of the differences between pretest and posttest scores. The results of the paired sample t-test are presented in Table III.

Table III. Paired Sample t-test Results

Comparison	t-value	Sig. (2-tailed)	Description
Pretest–Posttest	-18.542	0.000	Significant

Source: Processed Data (2025)

Based on Table 3, the significance value of 0.000 < 0.05 indicates a significant difference between the pretest and posttest results. Therefore, the use of interactive Edpuzzle media based on deep learning has a positive effect on improving fourth-grade students' science learning outcomes on energy concepts.

Discussion

The findings of this study show that the use of Edpuzzle contributed to improving students' science learning outcomes on the energy topic. In this research, the integration of "deep learning" refers to a pedagogical approach, not to artificial intelligence algorithms or adaptive technological features. The approach was implemented through several instructional strategies embedded in the Edpuzzle videos, such as providing questions that required students to interpret information, identify relationships between concepts, and apply ideas to everyday situations. These strategies encouraged students to go beyond recalling facts and instead engage in deeper cognitive processing. Although the study did not directly measure critical or reflective thinking indicators, the improved posttest scores suggest that the interactive elements helped students process energy concepts more meaningfully compared to conventional, passive learning methods.

The findings of this study indicate that the integration of interactive Edpuzzle media supported by deep learning contributes meaningfully to students' conceptual understanding of energy. The improvement in learning outcomes reflects the way interactive video-based learning can guide students to process information more deeply, as suggested by Mayer's Cognitive Theory of Multimedia Learning, which emphasizes dual-channel processing and active engagement. Through Edpuzzle's embedded questions and adaptive features, students are encouraged to think critically, revisit misconceptions, and construct knowledge more effectively. This result aligns with previous studies that reported the positive impact of interactive multimedia on elementary students' science achievement, while offering novelty through the incorporation of deep-learning-based personalization. Thus, the effectiveness found in this research reinforces the view that technology-enhanced instruction can strengthen conceptual mastery when designed to actively involve learners in the cognitive process.

These findings support constructivist theory, which emphasizes that knowledge is developed through active engagement in the learning process (Lutfiana et al., 2025). Through Edpuzzle, students are not merely passive recipients but active explorers and reflective learners, thereby strengthening memory and conceptual understanding. This aligns with the findings of (Shidiqqa et al., 2025), which show that interactive video-based learning increases student participation and concentration in understanding abstract science concepts.

The integration of deep learning principles in Edpuzzle in this study refers to a pedagogical approach that encourages students to engage cognitively with scientific concepts rather than passively memorizing definitions. In practice, this involved presenting questions and prompts that required students to analyze energy concepts, identify relationships between phenomena, and relate them to familiar contexts encountered in classroom activities. Although the study did not directly measure higher-order thinking skills, the improvement in post-intervention performance suggests that students were able to process information more deeply and construct a more coherent understanding of energy concepts. This supports the idea that instructional designs emphasizing conceptual connections and active engagement can enhance meaningful learning, in line with the principles of deep learning in education (Wibowo et al., 2022).

The results of this study show similarities with previous research, such as (Nabilah, 2023), who found that Edpuzzle can enhance motivation and learning outcomes in science lessons, and (Zafirah et al., 2025), who reported that deep learning approaches facilitate conceptual understanding through independent knowledge construction. However, it is important to note that methodological differences—such as grade level, sample size, and instructional context—limit the direct comparability of these findings. While the current study supports the potential of integrating interactive technology with pedagogically oriented deep learning strategies, it also highlights a gap in research regarding how these approaches function in diverse elementary school settings, particularly with regard to long-term retention and application of scientific

concepts. This perspective emphasizes that, although the findings confirm the positive impact of Edpuzzle in this context, further studies are needed to explore potential variations, challenges, or contradictory results across different classroom environments.

Several factors contributed to the successful implementation of this media, including the combination of video visualization, cognitive engagement, and the role of teachers as digital learning facilitators. However, this research also faced limitations, such as reliance on internet connectivity and variations in students' digital literacy skills. Therefore, technological infrastructure support and teacher training are necessary to ensure optimal and sustainable implementation of interactive media.

Overall, interactive Edpuzzle-based learning with a deep learning approach creates an adaptive, meaningful learning experience that aligns with the demands of the Merdeka Belajar curriculum. This media can serve as an alternative learning strategy that promotes collaboration, creativity, and deep mastery of scientific concepts

Future research may employ a larger and more diverse sample, include a comparison group, or use performance-based assessments to measure higher-order thinking skills more comprehensively. These enhancements will help strengthen the generalizability of findings and provide deeper insights into how deep learning–based interactive media function across different school contexts..

The novelty of this study lies in the direct integration of Edpuzzle as an interactive video media with a deep learning approach in elementary school science learning, an area that has rarely been examined. While previous studies tended to focus on either Edpuzzle alone or deep learning separately, this study combines both to produce a learning strategy that emphasizes cognitive engagement and independent knowledge construction among elementary students.

Theoretically, this study contributes to strengthening constructivist theory and deep learning concepts within the context of primary education. The application of Edpuzzle, which incorporates analytical and reflective components, expands understanding of how technology-enhanced learning can support the development of deep conceptual comprehension. Practically, this study provides a reference for teachers in designing interactive learning that is adaptive to 21st-century student needs and aligned with the Merdeka Belajar curriculum.

CONCLUSION

Based on the findings of the study, it can be concluded that the use of deep-learning–based interactive Edpuzzle media has a significant impact on improving the science learning outcomes of fourth-grade students at SDN Banjaragung 3 Jombang. Students' average scores increased from 58.20 to 82.40 after the learning intervention, and statistical analysis confirmed a significant difference (Sig. 0.000 < 0.05). These results indicate that integrating Edpuzzle with a deep learning approach enhances students' conceptual understanding, particularly in connecting the concept of energy to real-life phenomena.

Beyond improving cognitive achievement, this media also contributes to strengthening students' motivation, active participation, and critical thinking skills. Therefore, deep-learning–based interactive Edpuzzle can serve as an innovative science learning tool that aligns with the demands of 21st-century education. The novelty of this research lies in the direct integration of interactive Edpuzzle video media with a deep learning approach in the context of elementary science learning, an area that has been rarely explored in previous studies. This combination creates an instructional model that focuses not only on cognitive outcomes but also on students' deeper and more reflective cognitive engagement, thereby expanding the understanding of how digital technologies can be effectively implemented in primary education. Theoretically, this study enriches modern constructivist perspectives and technology-based learning theories by emphasizing the importance of deep learning as the foundation for developing interactive media. Practically, the findings provide guidance for teachers and schools in designing digital, student-centered learning that is adaptive to the needs and characteristics of 21st-century learners.

ACKNOWLEDGMENTS

The author expresses gratitude to God Almighty for His guidance and blessings throughout the completion of this research. The author gratefully acknowledges the support provided by the institutions involved in this study. Appreciation is also extended to SDN Banjaragung 3 Jombang for granting permission to conduct the research and to all participants whose cooperation contributed to the completion of this work.

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