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Development of Animated Science Learning Videos Based on Deep Learning to Improve Student Learning Outcomes

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Abstract: This study aims to improve student learning outcomes through animation-based learning videos with a deep learning approach. Conventional teaching methods are less effective for science lessons, resulting in less engagement and achievement of student learning outcomes. The integration of deep learning implemented through animated videos has an impact on teacher success in learning through visualization, adaptive, automatic narration, and intelligent synchronization, making lessons interactive. This study uses the ADDIE model development method. Data collection is based on expert validation, teacher and student responses, and pretest posttest tests. The results show that the level of student learning success through animated videos meets very good feasibility standards, with an average score of 92% for media experts and 89% for material experts. Student responses increased by an average of 91%. Animated videos in the implementation process are very effective with a score from the pretest results of 68.3 to the posttest increasing to 86.7 with an N-Gain score of 0.58 in the moderate category. Based on learning outcomes during the implementation process, animated videos for science lessons are feasible and interesting, but also effective in improving student learning outcomes, offering innovative digital resources to support meaningful science education

Keyword: Videos, Deeplearning, Outcomes

INTRODUCTION

The integration of artificial intelligence (AI) and deep learning into education has transformed conventional learning environments into more dynamic, adaptive, and learner centered systems (Sari, 2023). Education is no longer confined to the traditional classroom where the teacher is the sole source of knowledge (Daulai et al., 2023). The emergence of smart technologies is enabling a shift toward data driven and personalized learning experiences that can adapt to each student's needs, abilities, and learning style (Caella & Yulianto, 2024). In this context, science education has received particular attention, as it involves complex and abstract phenomena that often require visualization and simulation to fully understand (Kasmini et al., 2024). Science, as a discipline, emphasizes not only factual knowledge but also process skills such as observation, experimentation, reasoning, and problem solving (Bengio et al., 2021).

Conventional instructional approaches such as textbook-based explanations or static images often fail to effectively convey the dynamic nature of scientific processes. Students often struggle to visualize microscopic or invisible phenomena, such as atomic interactions, energy transformations, or biological mechanisms. These limitations result in shallow

understanding, low conceptual retention, and a limited ability to apply knowledge in real world contexts (Sari, 2023). To address these challenges, researchers and educators are increasingly turning to innovative learning media, including animated instructional videos, simulations, and virtual laboratories. Among these media, animated instructional videos have proven particularly effective in illustrating complex scientific concepts spatially and temporally. Through a combination of visual movement, narration, and sound effects, animation enhances dual-channel learning (visual and auditory), reduces cognitive load, and helps students build coherent mental models of scientific phenomena (Putri & Admoko, 2022). Most existing educational videos are designed in a linear, static format that presents the same content to all learners regardless of their level of understanding or learning progress. This "one-size-fits-all" approach limits the potential of multimedia learning, as students have varying cognitive capacities and prior knowledge. To address this gap, integrating deep learning algorithms into animated instructional videos offers a promising solution. Deep learning, a subfield of AI, can process vast amounts of data from student interactions (e.g., viewing patterns, quiz results, and engagement metrics) to identify learning behaviors and predict learning outcomes (Bintoro et al., 2021).

This allows the system to dynamically adjust the content, pace, and level of explanation to suit each learner's needs. This adaptive mechanism creates an intelligent learning ecosystem that fosters personalized learning experiences, enhances motivation, and supports continuous assessment. The application of deep learning in educational animation is a crucial step towards Education 5.0, where technology not only delivers information but also learns from learners to provide more meaningful and individualized support (Fahri et al., 2022). This research focuses on the development of animated science learning videos enhanced with deep learning technology to bridge the gap between abstract scientific content and students' understanding, ultimately aiming to improve learning outcomes and engagement in science education (Hartini et al., 2023).

Education is one of the human needs. In accordance with developments in all areas of life, education always experiences changes, developments, and improvements. Education has undergone many changes and improvements, including the implementation of education in the field (quality of teachers and educators), quality of education, curriculum devices, facilities and infrastructure, and quality of education management. These changes also include the use of more creative learning methods and approaches. The purpose of these changes and improvements is to improve the quality of education in Indonesia. Learning activities do not determine education. Learning is the process of observing, reading, imitating, trying, listening, and following a certain direction. Thus, learning is the process of actively changing behavior, responding to situations around someone, leading to a goal, and acting through various experiences (Siregar et al., 2022).

Creating a fun learning environment for students is very difficult because they are predominantly visual learners. In fact, several factors contributing to poor educational outcomes in Indonesia include the lack of professionalism of teachers and education personnel, particularly in their field. Many are underqualified and misinformed in their delivery of material, making them incapable of providing a good education (Rustamovna, 2020). The results of research observations from interviews with teachers who have used video learning media but have never made their own videos can be arranged into several key findings, such as the use of existing videos, Teachers have used learning videos from (Rahmawati & Atmojo, 2021), various sources, such as YouTube and other educational platforms, to support teaching materials. The videos are selected based on their suitability to the topic being taught and are considered effective in clarifying the explanation of the material. Integrated with learning media, videos are used more as additional media that enrich the way the material is delivered. Videos are considered to be able to help students who need visualization to understand abstract or difficult concepts, but are not always the main part of the learning process. Through this, the

author thought about conducting research by developing animated science learning videos to improve in-depth learning for elementary school students.

METHOD

This study employed a Research and Development (R&D) design using the ADDIE model, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation (Sugiono, 2016). This model was chosen because of its systematic and iterative nature, thus improving student learning outcomes. The purpose of this study was to develop an immersive learning based animated video by validating the media quality and assessing its effectiveness in improving science learning outcomes. The advantage of this learning video lies in its flexibility, which can improve student learning outcomes based on their learning experience, and the resulting animated video is effective and interesting for students. The applied research sample consisted of 30 students at SD Negeri 16 Banda Aceh, Development of animated science learning videos based on in-depth learning using the ADDIE development method

approach. In the initial stage, an analysis was carried out to understand the needs of science learning in schools, including students' understanding of the material and the difficulties encountered during the learning process. The design stage is to create animated videos and validate the product by material, media and language experts, the development stage of this research tests small and large scales on the resulting product, the implementation stage of this research is to teach the material with the help of validated video media and the final stage is evaluation by assessing student learning outcomes after using the developed learning video as a learning medium.

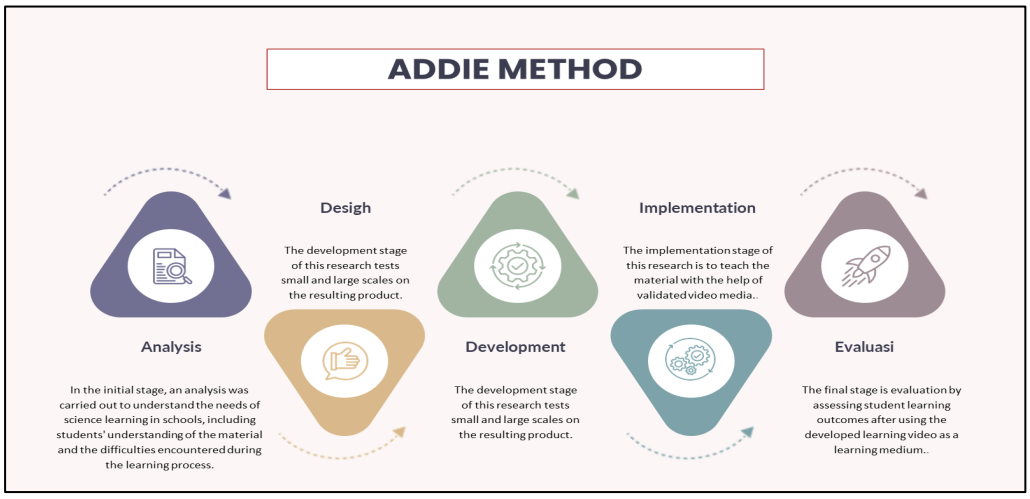

Figure: 1. ADDIE Method

RESULTS AND DISCUSSION

The results of the trial of animated videos for science learning based on immersive learning at SD Negeri 16 Banda Aceh showed a significant increase in students' understanding of the material being taught. Before using animated videos, the majority of students had difficulty understanding science lessons such as ecosystems, the water cycle, and the structure of living things. However, after using animated videos, students showed greater enthusiasm in participating in learning. Before learning began, this study began with a pre-test to determine the level of student interest in science lessons using conventional learning methods, namely theory, questions and answers, and evaluation. After the learning media was validated, students were given learning treatment using animated videos for science learning. The results of student achievement scores after using animated videos increased, students showed interest in learning,

and the effectiveness of learning videos could help students understand the material and improve learning outcomes.

1. Analysis Phase

The initial analysis involved identifying students' learning difficulties in understanding abstract science concepts such as energy transformation and environmental cycles. Data collected through interviews, pre-tests, and questionnaires involving 30 students revealed that: 80% of students had difficulty connecting theory to application. 83% preferred learning with visual and motion-based media. Teachers noted that conventional methods (text and static images) were insufficient to stimulate motivation and understanding. The results of the study indicated the need for animated learning media that integrates Deep Learning technology to personalize learning and provide feedback.

2. Desigh Phase

During the design phase, learning objectives and materials were developed based on the Fifth Grade Elementary Science Curriculum and Bloom's Taxonomy. The design elements. Animated stories using characters, interactive quizzes, and visual simulations. Deep Learning Integration: A recommendation system to adapt the video flow based on student performance and interaction. Three media experts and two content experts validated the design, achieving an average validity score of 89% (very valid), indicating that the designed product meets both pedagogical and technical requirements.

Figure: 2. Desigh Video Animation

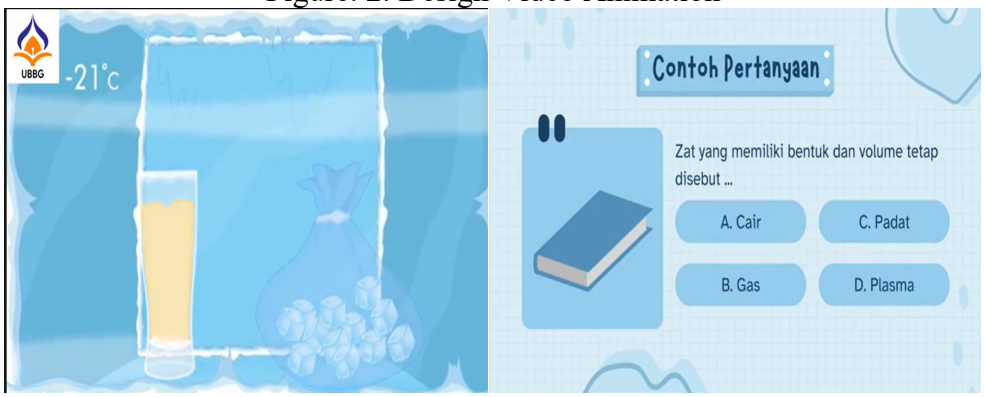

Figure: 3. Processing Content

3. Development Phase

This animation was developed using Adobe Animate, Camtasia, and TensorFlow for Deep Learning integration. The video is enriched with 2D/3D animation and narration. Interactive questions address key points in the material. The YouTube link can be accessed here: https://youtu.be/p6Jx5pZo4cs?si=LP2AFGAmr4Y6VY9T

Table: 1. Validation results

Aspect	Validator Score	Category
Content Feasibility	88%	Very Valid
Media Display	91%	Very Valid
Language	87%	Valid
Average	**88.7%**	**Very Valid**

Table: 2. Data Score N-Gain Category

Indicator	Value
N (Students)	30
Average Pretest Score	65.0
Average Posttest Score	85.0
Average Gain	20.0
Average N-Gain	0.57
N-Gain Category	*Medium*

The development and implementation of immersive learning-based animated science learning videos significantly improved student learning outcomes in science education. The average comprehension score increased from 65.0 (pre-test) to 85.0 (post-test), with an average N-Gain of 0.57, which is categorized as moderate effectiveness according to Hake standards. These results indicate that the integration of immersive learning in the implementation of animated video-based learning provides an adaptive and interactive learning experience that supports conceptual understanding and knowledge retention. By combining visualization, movement, and adaptive feedback, this learning medium helps bridge the gap between abstract scientific concepts and students' cognitive representations. The use of intelligent animation allows for continuous performance analysis, allowing the system to provide personalized learning recommendations and real-time feedback. This not only improves academic achievement but also encourages motivation, curiosity, and engagement in science learning. Future research should focus on extending this model to the various learning areas studied, evaluating long-term learning retention, and exploring its integration with virtual or reality learning for a more immersive learning experience.

Tabel: 3. N-Gain Score Value

Group / Measure	Pretest (⟨pre⟩)	Posttest (⟨post⟩)	Change (post−pre)	N-Gain	N-Gain Category
Average Comprehension Score	65.0	85.0	+20.0	0.57	Medium

Stuudents was 65.0, indicating a moderate level of initial understanding before the learning intervention. After the implementation of the immersive learning-based animated science learning videos, the average posttest score increased to 85.0, indicating a 20-point increase. This significant increase indicates that the use of animated videos contributed to students' better understanding of science concepts. The calculated N-Gain value of 0.57 categorizes the increase as moderate, according to Hake's (1999) classification. This indicates that the intervention was quite effective in improving learning outcomes. Although the increase did not reach the "high" category, the moderate range indicates that most students made progress and benefited from the learning media and had an impact on immersive learning. The N-Gain analysis was conducted to measure the effectiveness of learning using the formula (post − pre) / (100 − pre). The calculation yielded an N-Gain score of 0.57, which falls into the medium category according to Hake's classification. This indicates that the animated learning videos were effective in helping students bridge the gap between their initial knowledge and

the expected learning outcomes. The increase from 65 to 85 demonstrates not only a quantitative improvement but also supports the idea that animated videos with deep learning integration can make abstract science concepts easier to understand. The medium high N-Gain score also suggests that most students benefited considerably from the intervention, although there remains room for further improvement. In conclusion, the use of deep learning-based animated science videos proved to be effective in enhancing students' comprehension, as evidenced by the substantial increase in posttest scores and the N-Gain score within the medium high category.

Table: 3. Implementation Aspect Value

Aspect	Before Using Animated Videos	After Using Animated Videos	Change
Student Engagement	60% active in discussions	90% active in discussions	+30%
Interest in Learning	70% interested in science	95% interested in science	+25%
Understanding of IPAS Concepts	50% had difficulty understanding	80% understood concepts well	+30%
Positive Feedback (Students)	65% found the material difficult	90% felt the material was easier to understand	+25%
Positive Feedback (Teacher)	No visual learning method	80% considered animated videos effective	+80%

Based on the table above, the results of the aspects studied are explained again as follows:

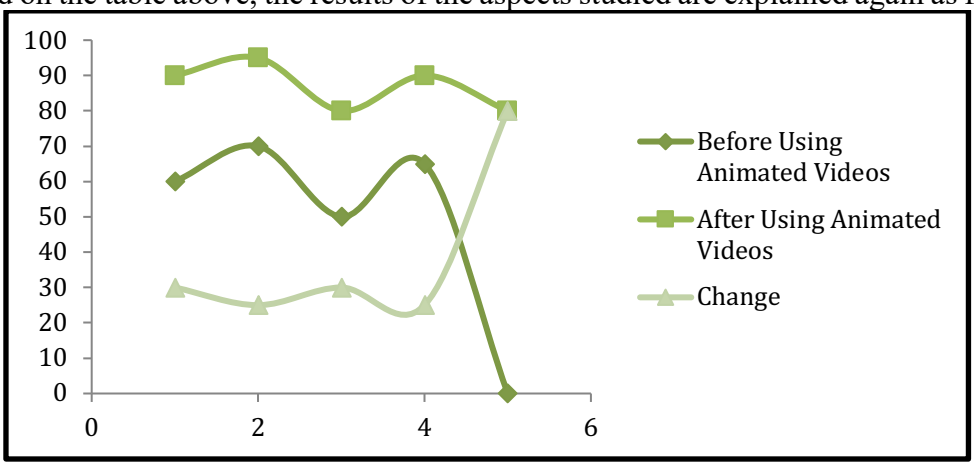

Chart: 1 Presentation Implementation Aspect Velue.

Observational and questionnaire data showed significant improvements in various non-test aspects after the use of animated science learning videos. In terms of student engagement, the proportion of students actively participating in discussions increased from 60% before the intervention to 90% after, representing a 30% increase. This indicates that animated videos are able to create a more interactive and motivating learning environment. Student learning interest also showed positive growth, with the percentage of students expressing interest in science increasing from 70% to 95%, a 25% increase. These findings suggest that the integration of visual and animated content can enhance the appeal of learning materials, especially for abstract science concepts. Similarly, student understanding of science concepts improved significantly. Before the intervention, 50% of students still had difficulty understanding the material, while after using animated videos, 80% of students demonstrated good understanding, representing a 30% increase. This aligns with the notion that visual learning resources help reduce cognitive barriers in understanding scientific ideas. Positive feedback was also received from both students and teachers. From a student perspective, the percentage of students who found the material easy to understand increased from 35% (65% still found it difficult) to 90%, indicating a 25% increase in positive perceptions. Teachers also provided strong support, with 80% reporting that animated videos were effective compared to the absence of previous visual learning methods. These findings contribute to the use of immersive learning based animated videos not only improving student learning outcomes but also positively impacting their engagement, interest, and attitudes toward science learning, while also receiving positive immersive learning from teachers.

Figure: 4. Procesing Of Deeplearning and Implementation

Discussion of development animated science learning videos in this study utilized deep learning techniques to enhance adaptability, interactivity, and personalization in the learning process (Sari et al., 2023). The integration of deep learning impacted the system by analyzing student behavior, performance patterns, and engagement levels, allowing content delivery to be tailored to each student's needs (Sari, 2023). The development of animated science learning videos in this study utilizes deep learning techniques to enhance adaptability, interactivity, and personalization in the learning process (Bengio et al., 2021). Deep learning integration enables the system to analyze student behavior, performance patterns, and engagement levels, allowing content delivery to be tailored to each student's needs (Kumala et al., 2023). Through this processing approach, deep learning serves as the intelligence core of impactful learning video implementation, transforming it not only as a visual aid but also as an adaptive learning environment (Adam, 2023). This integration can be a solution for teachers' teaching materials based on animated learning media (Fitas, 2025), leading to an intelligent and responsive learning experience that effectively improves conceptual understanding and student learning outcomes (Gabriel, 2024).The implementation phase focused on integrating immersive learning-enhanced animated science learning videos into the classroom learning environment.

The purpose of this implementation was to examine how animation-based media supported by animated videos can improve students' conceptual understanding, motivation, and engagement in science learning and their learning outcomes (Yang & Taele, 2025). The implementation of immersive learning enhanced animated learning videos demonstrated that the media can effectively transform traditional science learning into a more interactive, personalized, and visually rich experience (Fitas, 2025). This not only improves students' academic performance but also fosters their critical thinking and independent learning skills. The successful implementation of animated learning videos highlights the potential of combining educational technology, animation, and immersive learning to create adaptive and meaningful learning environments (Olsson, 2020). This approach has been shown to be effective in improving understanding, engagement, and the overall quality of learning in science education (Desania et al., 2020).

Animated videos equipped with interactive elements allow students to participate more actively in the learning process, thereby improving their understanding. In addition, feedback from students and teachers showed that these animated videos succeeded in attracting students' attention in a fun and interesting way. Students felt that the animated videos shown were easier to understand because they combined clear visual explanations with simple and easy-to-follow narratives. Interactivity in the videos, such as quizzes and questions that invite participation, also helped students to be more involved in the subject matter. Teachers also gave positive assessments of the use of these animated videos, because they were considered to help explain difficult material in a way that was more interesting and easy for students to digest (Sari, 2023). However, there are some areas that need to be improved to increase the effectiveness of the animated video. Although the animated video successfully attracted students' attention, some students still found it difficult with the material that was too complex or did not fully understand the material even though there was a visual explanation. Therefore, further improvements are needed, such as adding more in-depth explanatory elements or using more dynamic animations that are more appropriate to the students' ability level. In addition, although the interactive features are quite helpful, variations in the form of more varied questions and assignments can make the learning experience more interesting and effective. With these improvements, it is hoped that this animated video can be more optimal in improving the quality of learning at SD Negeri 16 Banda Aceh (Pratiwi & Kasriman, 2022). Data analysis table that can be used to show the results of the test of the deep learning-based science learning animation video at SD Negeri 16 Banda Aceh. This table describes the data collected from student understanding tests, observations, and feedback from teachers and students.

CONCLUSION

This study concluded that the integration of deep learning technology into animated science learning videos had a significant impact on improving students' understanding and learning outcomes in science education. The findings showed that the average pre-test score of 65.0 increased to 85.0 in the post-test, resulting in an average increase of 20 points and an N-Gain value of 0.57, categorized as moderate effectiveness according to Hake's criteria. This improvement indicates that deep learning-based animated videos provide a more adaptive, interactive, and personalized learning experience compared to conventional learning methods. Through the use of deep learning algorithms, the learning system is able to analyze student engagement patterns, predict areas of difficulty, and provide targeted feedback or additional visual explanations. This adaptation allows students to better visualize abstract scientific concepts, leading to deeper understanding and long-term retention. The visual and auditory elements embedded in the animated videos encourage higher motivation and engagement, creating a fun and meaningful learning environment. Students become more active participants in the learning process, demonstrating curiosity, reflection, and improved critical thinking skills. Overall, this study provides empirical evidence that AI-based animation media and deep

learning can transform science learning into a more dynamic, responsive, and effective process. These findings highlight the potential of combining educational technology and artificial intelligence to address conceptual difficulties in science learning and support 21st-century learning competencies. This study shows that immersive learning-based animated science videos not only improve academic achievement but also foster essential 21st-century competencies, including self-regulation, critical thinking, creativity, and digital literacy. This innovation bridges the gap between educational technology and cognitive science, paving the way for an intelligent, inclusive, and human-centered learning ecosystem. This study demonstrates that immersive learning-based animated science videos not only improve academic achievement but also foster essential 21st-century competencies, including self-regulation, critical thinking, creativity, and digital literacy. This innovation bridges the gap between educational technology and cognitive science, paving the way for an intelligent, inclusive, and human-centered learning ecosystem. From a pedagogical perspective, the results of this study highlight that animated media aligns with constructivist learning theory, which emphasizes the active construction of knowledge through experience and interaction. Through immersive learning, it functions as a "digital scaffold," continuously monitoring learners' progress and providing adaptive feedback that supports the development of deeper conceptual understanding.

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