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The Effectiveness of an Instructional Video to Enhance Problem-Solving Skills in Elementary Students on Earth Science

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Abstract: This study aimed to develop and examine the effectiveness of an interactive experiment-based instructional video on the topic of the Earth's rotation and revolution to enhance elementary students' problem-solving skills. The research employed a Research and Development (R&D) method using the Four-D model (Define, Design, Develop, Disseminate), implemented at SD Negeri Rantau Pangeran, South Sumatra. The research subjects consisted of 30 sixth-grade students. Data were collected through observation, questionnaires, expert validation, and pretest–posttest assessments, then analyzed using the Likert scale and N-gain calculation. The validation results showed an excellent level of feasibility across all aspects: material (91.20%), language (95.20%), and media (91.53%). The practicality test obtained an average score of 98% (individual test) and 94% (small group test), indicating that the media was easy to use and understand. The effectiveness test showed a significant improvement in students' problem-solving abilities, with the average pretest score increasing from 38.16 to 88.33 on the posttest and an N-gain score of 0.81 (high category). Improvements occurred across all problem-solving indicators, including understanding the problem, planning strategies, executing the plan, and evaluating the results. These findings confirm that the interactive experiment-based instructional video is valid, practical, and effective in stimulating students' critical thinking and problem-solving skills, making it relevant to the 21st-century competency demands.

Keywords: Earth's rotation and revolution; Elementary science learning; Interactive instructional video; Problem-solving; Research and development

Introduction

Education at the elementary school level plays a strategic role in shaping the foundation of students' knowledge, skills, and attitudes. At this stage, children are not only required to master basic knowledge but are also encouraged to develop higher-order thinking skills, one of which is problem-solving ability. This skill is an essential 21st-century competency because it enables students to analyze situations, identify problems, explore alternative solutions, and make appropriate decisions. Globally, 21st-century education emphasizes the importance of critical thinking, creativity, communication, and collaboration as the core competencies needed to face social change and technological advancement. Various comparative studies on competency frameworks have highlighted the need for curriculum and assessment reform to position these skills as primary learning goals (Voogt & Roblin, 2012). Among them, problem-solving lies at the core because it requires students to integrate knowledge, attitudes, and skills when encountering new situations—an insight supported by systematic reviews that define and categorize 21st-century skills in the

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international literature (Chen, 2023). Without this ability, learners tend to become passive recipients of information rather than active learners capable of connecting concepts to real-world phenomena. The literature also stresses that effective measurement and interventions are needed to ensure that the 4Cs (critical thinking, creativity, communication, collaboration) and problem-solving truly develop in schools (van Laar et al., 2020). Specifically, in primary education, systematic reviews have emphasized the necessity of designing instructional practices that explicitly nurture 21st-century skills from an early age to produce sustainable and meaningful outcomes (Chalkiadaki, 2018).

Furthermore, international studies have confirmed that problem-solving contributes not only to academic achievement but also to children's cognitive and socio-emotional development. For instance, validated problem-solving instruments in educational contexts have demonstrated strong correlations between problem-solving skills, academic motivation, creative thinking, and adaptive strategies essential for learning success (Ventura-León et al., 2025). Through problem-solving processes, students are trained to deal with uncertainty, think flexibly, and generate creative solutions. A recent meta-analysis has shown that problem-based learning (PBL) significantly enhances critical thinking skills, which form the core of problem-solving competence (Liu & Pásztor, 2022). Developmental studies on problem-solving strategies also reveal that during the elementary school years, children gradually develop more complex and flexible ways of thinking when engaging in cognitively challenging tasks (Meltzer et al., 1989). Moreover, meta-analyses of problem-based, project-based, and case-based learning approaches have shown that these methods improve student motivation and engagement, which in turn strengthen their cognitive and socio-emotional readiness to face educational and life challenges (Wijnia et al., 2024).

Research also indicates that elementary students are capable of recognizing creative problem-solving stages such as fact finding, problem finding, and solution finding through creativity-based learning approaches (Van Hooijdonk et al., 2023). In addition, the use of heuristic strategies and visual tools such as Problem-Solving Keys has been proven effective in improving mathematical problem-solving abilities in elementary schools (Kaitera & Harmoinen, 2022). A bibliometric study further reveals that global research on problem-solving in primary education continues to grow, underscoring the importance of innovative and evidence-based pedagogical approaches for fostering 21st-century competencies (Suseelan et al., 2022). In the context of science learning, particularly Earth Science, problem-solving skills play a crucial role because students are exposed to real phenomena occurring in their surroundings. One of the essential topics at the elementary level is the rotation and revolution of the Earth, which is directly related to daily life phenomena such as day and night, seasonal changes, and variations in time across different regions of the world. This topic is abstract and cannot be effectively understood through textbooks or lectures alone. Without appropriate instructional approaches, students tend to memorize facts without truly grasping their implications—for example, why daytime lasts longer than nighttime in some regions or how Earth's movement affects climate and human activities.

As a result, students' ability to connect scientific concepts with real-world situations remains limited. The study Analysis of Primary School Students' Knowledge Structures Regarding the Movements of the Earth According to Conceptual Change Theories found that fourth-grade students exhibit conceptual inconsistencies in answering questions related to rotation, revolution, and daily and annual movements of the Earth, indicating an incomplete understanding of these concepts (Kandemir & Apaydin, 2022). Similarly, the study The Use of PAROREB Learning Media to Improve Conceptual Understanding in the Topic of Earth's Rotation and Revolution in Grade VI Elementary School showed that the use of concrete media (PAROREB) significantly improved students' conceptual understanding compared to conventional lecture-based teaching. Another study by Sofia et al. (2024). demonstrated that the problem-based learning model supported by educational media was effective in enhancing both conceptual understanding and problem-solving abilities in this topic.

To address these challenges, innovative learning media are needed—tools that not only present factual concepts but also allow students to explore, analyze, and solve contextual problems. One of the most promising media is the instructional video. In the context of teaching Earth Science in elementary schools, instructional videos have great potential as innovative media that not only convey factual content but also encourage exploration and analytical thinking. For example, research by Novitasari et al. (2023) concluded that problem-based instructional videos were effective for fifth-grade science lessons, significantly improving student learning outcomes compared to traditional methods. Similarly, Wedaswari & Tegeh (2023) found that contextual science videos enhanced both conceptual understanding and student engagement through visual representations and simulations of real phenomena. Instructional videos can present the concepts of Earth's rotation and revolution in a visual, auditory, and

dynamic manner, making abstract ideas more concrete and understandable.

Through animations of Earth's movement, simulations of day and night, and interactive illustrations of Earth's revolution and the changing seasons, students can visualize phenomena that are otherwise difficult to observe directly. Thus, videos not only facilitate comprehension but also stimulate curiosity and engagement in learning. Moreover, instructional videos can help develop problem-solving skills by presenting contextual phenomena—such as why Indonesia experiences rainy and dry seasons, or how time zones are formed—encouraging students to identify problems, analyze causes, predict consequences, and propose solutions. Consequently, instructional videos serve not merely as tools for transmitting information but also as media for cultivating critical, analytical, and solution-oriented thinking. For instance, the study The Influence of Contextual Learning Assisted by Video Media found that using video media to teach the topic of Earth's rotation in sixth-grade students significantly improved conceptual understanding compared to conventional methods (D. Rahayu et al., 2025). Similarly, the development of an animation-based video on Earth's rotation using Powtoon was validated as effective, practical, and motivating for students learning about Earth's rotation and its effects (Kadek Yudik Ariawan et al., 2023).

Additionally, the advancement of digital technology has expanded opportunities for teachers to integrate visual and interactive media in science education. Instructional videos can be combined with active learning models such as inquiry-based or project-based learning so that students are not merely passive recipients of information but active explorers of real-world phenomena. Thus, videos function both as conveyors of abstract content and as stimuli that trigger critical and creative thinking. Furthermore, recent studies (Diana et al., 2025; Jufrida et al., 2024; Widyawati & Kamaludin, 2024) have shown that the use of instructional videos in complex subject matter improves not only conceptual understanding but also student motivation. Motivation is a crucial factor that strengthens learners' engagement in problem-solving activities. With higher motivation, students are more likely to ask questions, seek additional information, and experiment with different problem-solving strategies—ultimately enhancing their learning outcomes. The novelty of this research lies in its focus on examining the effectiveness of instructional videos in improving elementary students' problem-solving skills in the topic of Earth's rotation and revolution.

Unlike previous studies that mainly focused on cognitive learning outcomes or motivation, this research specifically positions problem-solving skills as the primary variable. This is significant because the rotation and revolution of the Earth are not only scientific concepts to be memorized but also foundational principles for explaining various natural phenomena closely related to students' daily lives. Therefore, this study offers both theoretical and practical contributions to the development of innovative science learning strategies aligned with 21st-century competency demands. Based on this rationale, the present study seeks to provide empirical evidence of the effectiveness of instructional videos as learning media that not only strengthen students' conceptual understanding of Earth's rotation and revolution but also enhance their problem-solving abilities. The results are expected to enrich the literature on the use of instructional videos in science education and offer practical recommendations for teachers to integrate technology-based media to improve the quality of learning.

Method

This study employed a Research and Development (R&D) approach with the aim of developing and testing the effectiveness of an instructional video in improving elementary school students' problem-solving skills in Earth Science material. The development model used in this study was the Four-D (4D) model, which consists of four main stages: Define, Design, Development, and Disseminate.

Research Location, Duration, Subjects, and Objects

This research was conducted at SD Negeri Rantau Pangeran, located in Dusun IX, Muara Medak Village, Bayung Lencir District, Musi Banyuasin Regency, South Sumatra. The location was selected based on the need to implement learning innovations in an environment with limited technology utilization, frequent signal issues, and continued use of traditional teaching media. The study took place over ten months, from October 2024 to August 2025, covering the stages of planning, licensing, trial implementation, data collection, and final report preparation. The subjects of this research were all sixth-grade students at the school. The trial implementation was carried out in several stages: one-to-one testing (3 students), small group testing (6 students), and field testing (30 students). Student selection was based on different levels of academic ability (low, medium, and high) to ensure that the developed learning media could be tested comprehensively in terms of effectiveness.

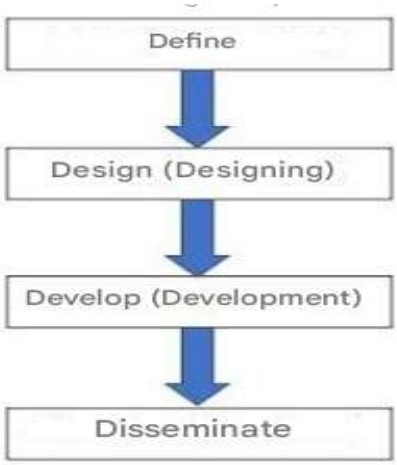

Figure 1. 4D Method Design (Bahosin Sihombing et al., 2024)

Define

This stage aimed to identify and analyze learning needs. The researcher conducted classroom observations of science lessons, teacher interviews, and curriculum analysis to determine the relevant competencies. The focus of the material was on Earth phenomena within the Earth Science topic, which can be linked to real-life problems. In addition, an analysis of the characteristics of fourth-grade students was carried out to ensure that the instructional media aligned with their cognitive development stage.

Design

In this stage, the researcher designed the instructional video by developing a storyboard, script, and presentation flow. The video was designed to include explanations of Earth Science concepts, natural phenomena, and contextual problems that required problem-solving. The design process also involved the selection of visual media, illustrations, animations, narration, and evaluation instruments in the form of a structured problem-solving test based on four indicators: identifying the problem, formulating a solution, evaluating alternatives, and drawing conclusions.

Development

This stage focused on producing the instructional video according to the established design. The video was created using video-editing software that integrated text, audio, animation, and simulations of Earth phenomena. The initial product was validated by material and media experts to assess content accuracy, presentation quality, and suitability for students' characteristics. After revisions based on expert feedback, a series of product trials were conducted: (a) one-to-one test, (b) small group test, and (c) field test in the experimental class.

Disseminate

In the final stage, the product that had been declared valid, practical, and effective was disseminated in a limited scope through classroom implementation and discussions with teachers to explore its potential for wider application.

Data Collection Techniques

This study employed a combination of qualitative and quantitative data collection methods to obtain a comprehensive overview of the development process and the effectiveness of the instructional video. Qualitative data were obtained through observations and interviews conducted in the initial stage to identify learning needs and student characteristics, which served as an essential foundation for product design. In addition, questionnaires were utilized at several stages, including needs analysis, product validation by material and media experts, and practicality testing by teachers and students. Quantitative data were collected through learning achievement tests (pre-test and post-test) designed to measure students' problem-solving skills in the Earth Science subject. By integrating these various data collection techniques, this study produced comprehensive and accurate information, allowing for a thorough evaluation of the product in terms of needs, practicality, and learning effectiveness.

Data Analysis

The data analysis process was conducted according to the type of data collected. Data obtained from observations and interviews were processed and presented descriptively to support the quantitative data obtained from the questionnaires. Meanwhile, most of the questionnaire data were analyzed using a Likert scale, applying the Formula 1.

Table 1. Likert Scale Rating Level

Expert Response	Score
Very Good	5
Good	4
Enough/ Neutral	3
Poor	2
Very Poor	1

Data from the validation sheets fi lled out by the experts can be averaged using the following formula:

$$X = \frac{\text{Score Obtained}}{\text{Score Obtained}} \text{x} 100\% \quad (1)$$

Table 2. Assesment Criteria

Range (%)	Agreement Category	Validity Category	Practicality Category
0 – 20	Strongly Disagree	Very Invalid	Very Impractical
21 – 40	Disagree	Invalid	Impractical
41 – 60	Neutral	Fairly Valid	Fairly Practical
61 – 80	Agree	Valid	Practical
81 – 100	Strongly Agree	Very Valid	Very Practical

Meanwhile, the test was conducted in the form of essay questions, in which students' answers were analyzed based on the following problem-solving skill indicators:

Table 3. Problem Solving Skill Indicator

Indicator	Score 4 (Excellent)	Score 3 (Good)	Score 2 (Fair)	Score 1 (Poor)
Understanding the Problem	Clearly identifies the problem, lists key information, and states what is being asked.	Identifies the problem but misses some important information.	Understands only part of the problem; much information is missed.	Unable to understand the problem or misinterprets the question.
Planning a Solution Strategy	Selects an appropriate, logical, and relevant strategy to solve the problem.	Strategy is fairly appropriate but incomplete or inefficient.	Selected strategy is less appropriate or somewhat confusing.	Unable to develop a plan, or the chosen strategy is irrelevant.
Executing the Plan (Problem-Solving Process)	Carries out the steps sequentially and correctly, producing the expected result.	Most steps are correct, with minor errors.	Attempts to carry out the plan, but with many mistakes or disorganized steps.	Unable to execute the plan or the result is far from expected.
Reviewing and Concluding	Reviews the results thoroughly, identifies and corrects errors (if any), and draws accurate conclusions.	Reviews the results but not in depth; conclusion is mostly correct.	Reviews the results but draws an incorrect conclusion.	Does not review the results and is unable to conclude.

The scoring process will use the following formula: Each question is scored from 1 to 4 points, depending on the quality of the student's response; The maximum total score is 40 points, as there are 10 essay questions, each worth 4 points (4 × 10 = 40); After obtaining the total score for each student, the next step is to calculate the individual N-Gain Score, using the following formula:

$$N_{gain} = \frac{S_{posttest} - S_{pretest}}{S_{maximum} - S_{pretest}} \quad (2)$$

Description:
N-Gain = Normalized N-gain Score
Score pre-test = Avarege score before treatment
Score post-test = Avarege score after treatment Score
Maximum = Score Maximum

Table 4. Ngain Score Criteria

N gain Score	Category
> 0.70	High
> 0.30 <0.70	Mid
<0.30	Low

Result and Discussion

The final Product

The developed instructional video on Earth Science focuses on the topic of the Earth's rotation and revolution, designed to make abstract concepts more concrete and engaging for elementary students. The video integrates narration, visual animation, and contextual problem scenarios to help students connect scientific concepts with real-life phenomena. It was created using a combination of multimedia elements—images, motion graphics, voiceovers, and simulations—to enhance both cognitive understanding and learning motivation. The final product represents a refined version that has undergone expert validation and revision, ready for classroom implementation.

Figure 2 represent the results of the product development process, which combined the use of CapCut Pro for producing video materials and animations with Canva to create an engaging learning medium. This product is not only a simple video but an interactive learning video equipped with various elements such as learning objectives, materials, exercises, and other supporting features. After the production process was completed, the newly

developed product was validated by experts. The aspects validated by the experts included content (material), language, and media.

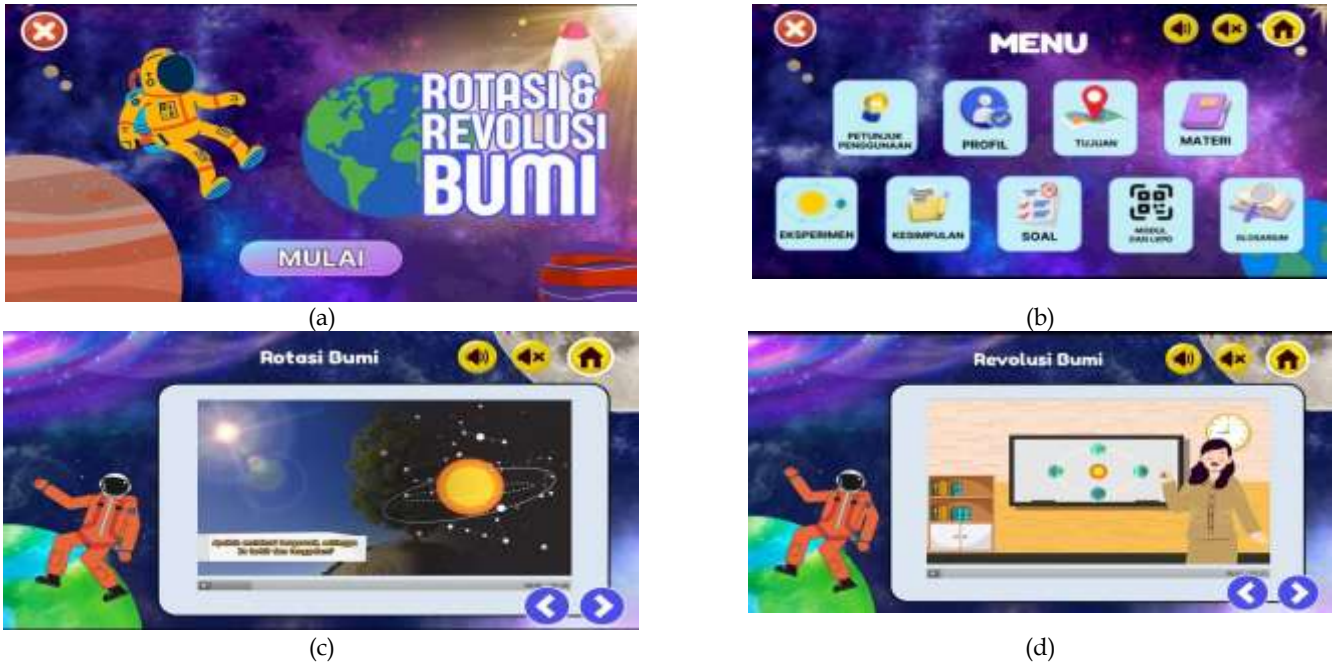

Figure 2. Display of video learing media: (a) Cover; (b) Main menu; (c) Video material; (d) Animation Material

Table 5. Results of Material Expert Validation

Aspect	Obtained Score	Ideal Score	Percentage (%)
Curriculum	15	15	100
Content and Material	27	30	90
Presentation	72	80	90
Average	114	125	91.2

Based on Table 5, a score of 114 out of a maximum of 125 was obtained, resulting in a feasibility percentage of 91.2%. The assessment covered three main aspects: the alignment of the material with the curriculum, the quality and depth of the content, and the presentation feasibility. The average score of these three aspects indicates an excellent level of validity, meaning that the content in the instructional video on the Earth's rotation and revolution meets the eligibility standards for use in the learning process. Therefore, in terms of material substance, the media is considered feasible for further trials, with some revisions suggested by the validator. The expert's recommendations include refining the formulation of learning objectives, adding explanations in the material menu, completing the menu display, adding a video that explains the process of day and night, including video sources, improving punctuation in command sentences, and adding buttons in the experimental video section. The results of these revisions from the material expert validation will be presented in the product revision section.

Table 6. Results of Language Expert Validation

Aspect	Obtained Score	Ideal Score	Percentage (%)
Language Feasibility	67	70	95.70
Readability	52	55	94.54
Average	119	125	95.20

Based on Table 6, a score of 119 out of a maximum of 125 was obtained, with a feasibility percentage of 95.20%. The assessment covered two main aspects: language feasibility and readability elements. The average score from both aspects indicates a very good result, meaning that the content of the instructional video on the topic of Earth's rotation and revolution has met the feasibility standards for use in learning activities. Therefore, from a linguistic standpoint, the media is considered feasible for further testing, with minor revisions recommended by the validator. The suggested revisions include correcting spelling errors, providing additional explanations for specific terms, and adjusting the text size in several video slides that appeared too small. The results of these revisions, based on the language expert's feedback, will be detailed in the product revision section.

Table 7. Results of Media Expert Validation

Aspect	Obtained Score	Ideal Score	Percentage (%)
Layout	26	30	86.6
Typography	20	20	100
Images	17	20	85
Colors	15	15	100
Background	15	15	100
Animation	8	10	80
Interactive Video	8	10	80
Audio	10	10	100
Average	119	130	91.53

Based on Table 7, the media expert validation obtained a score of 119 out of a maximum of 130, with a feasibility percentage of 91.53%. The evaluation included eight main aspects: layout, typography, image selection, colors, background, animation, interactive video, and audio. The overall results show that the developed instructional video meets the media feasibility standards and can be effectively implemented in classroom learning. Thus, from a media perspective, the product is declared suitable for further practical testing, with several revisions to be made according to the validator's feedback. The suggested improvements include adding "Next" and "Back" navigation buttons on each menu, enhancing the conclusion section with relevant animations and images, providing a name input field in the quiz section, adding motivational feedback after quiz completion, including an LKPD (student worksheet) in the media, and creating a single slide with two QR codes for easier access. The results of these revisions, based on the media expert's suggestions, will be explained in the product revision section. After the product is declared valid by all experts, the next stage is to conduct a practicality test to assess its usability and user experience.

Practicality Test

The practicality test was conducted to determine the level of practicality of the developed product when used directly by students. To achieve this, the practicality assessment was carried out in two stages. The first stage involved three individual students, referred to as the One-to-One Test, which aimed to identify initial usability issues and gather feedback on the clarity and ease of use of the learning media. The second stage was the Small Group Test, involving a larger number of students to evaluate the product's overall functionality, engagement level, and effectiveness in a more realistic classroom context.

Table 8. Result of one to one Test

Aspect	Mean Score (%)	Category
Visual and Audio Display	100	Very Practical
Comprehensibility of Material	96.7	Very Practical
Ease of Access	100	Very Practical
Language and Delivery	93.4	Very Practical
Ease of Use	97.8	Very Practical
Overall Mean	97.6	Very Practical

Table 8 presents the results of the first practicality test, which was conducted through expert review to evaluate the feasibility and usability of the developed learning media. The assessment focused on five key aspects: visual and audio display, comprehensibility of the material, ease of access, language and delivery, and ease of use. The findings demonstrate that the media achieved an overall mean score of 97.6%, which falls under the *Very Practical* category. The aspect of *Visual and Audio Display* obtained a perfect score of 100%, indicating that the visual elements and auditory components were designed effectively to attract attention and support understanding. Experts noted that the combination of color, layout, and sound effects contributed positively to user engagement. Similarly, the *Ease of Access* aspect also reached 100%, suggesting that the media is easy to open, navigate, and operate, even for users with limited technical skills.

The *Comprehensibility of Material* aspect received a mean score of 96.7%, which signifies that the content was clear, well-organized, and suitable for the target learners. This implies that the media successfully presented the instructional concepts in a way that facilitates comprehension. The *Language and Delivery* aspect achieved 93.4%, showing that the vocabulary, sentence structure, and explanation style were appropriate, concise, and easily understood by students. Meanwhile, the *Ease of Use* aspect earned 97.8%, reflecting that the interface design and overall navigation system were intuitive and user-friendly. Overall, the consistently high scores across all aspects demonstrate that the developed learning media is highly practical and can be readily implemented in classroom learning without significant modifications. The findings confirm that the product not only meets technical and design standards but also aligns with pedagogical principles that promote ease of use and clarity of content. Next, there would be second test which is small group test. The result of Small group test would be present in Table 9.

Table 9. Result of Small Group Test

Aspect	Mean Score (%)	Category
Ease of Access and Use	83	Very Practical
Clarity and Comprehensibility of the Material	58	Practical
Overall Practicality	94	Very Practical

As shown in Table 9, the *Ease of Access and Use* aspect obtained a mean score of **83%**, which falls under the *Very Practical* category. This result suggests that the learning media is easy to operate, navigate, and understand even when used by multiple students simultaneously. Learners were able to access the media smoothly without significant technical difficulties, and the interface was found to be user-friendly and responsive. These findings indicate that the design and functionality of the media support independent and efficient learning. Meanwhile, the *Clarity and Comprehensibility of the Material* aspect achieved a mean score of **58%**, categorized as *Practical*. Although this score is slightly lower than the access and usability dimension, it still demonstrates that students were generally able to understand the content delivered through the media. Some learners required additional guidance in interpreting certain parts of the material, suggesting that further improvements could be made in the clarity of explanations or the use of supporting visuals.

Overall, the developed media obtained a total practicality score of 94%, which is categorized as *Very Practical*. This indicates that the product not only functions effectively from an expert's point of view but also maintains a high level of practicality when implemented in small group learning situations. In **conclusion**, the results of the small group practicality test confirm that the Canva-based learning media is highly practical and suitable for classroom application. The findings also highlight that minor adjustments in content clarity could further enhance the learning experience and ensure that all students can fully comprehend the material presented.

Effectiveness Test

The effectiveness test was carried out through a field trial, conducted in two stages: the initial stage (pretest) and the final stage (posttest). This test involved 30 sixth-grade students from SD Negeri Rantau Pangeran. In the pretest stage, students were given 10 essay questions designed to assess their knowledge and understanding of the material before using the instructional video. After the implementation of the learning media, the posttest was administered to evaluate students' improvement in problem-solving skills. The following table presents a comparison of students' mastery levels between the pretest and posttest results:

Table 10. Student Learning Achievement

Score Interval (%)	Predicate	Pretest	Posttest
		f (%)	*f (%)*
81–100	Very Good	0 (0)	28 (93.33)
61–80	Good	0 (0)	2 (6.67)
41–60	Fair	3 (10)	0 (0)
21–40	Poor	27 (90)	0 (0)
0–20	Very Poor	0 (0)	0 (0)
Total		30 (100)	30 (100)

Table 10 illustrates the distribution of students' learning achievement categories during the pretest and posttest phases. The data reveal a remarkable improvement in students' academic performance following the implementation of the developed learning media. In the pretest results, it is evident that students initially demonstrated a relatively low level of mastery of the learning material. A total of 27 students (90%) were categorized in the *Poor* range (score interval 21–40), while 3 students (10%) were placed in the *Fair* category (score interval 41–60). No students achieved the *Good* (61–80) or *Very Good* (81–100) levels, and none were classified as *Very Poor* (0–20). These results indicate that, prior to the intervention, the majority of students had not yet grasped the key concepts and skills targeted in the learning objectives. The dominance of the *Poor* category also suggests that traditional learning methods used before the intervention were not sufficiently effective in promoting conceptual understanding and higher-order thinking skills.

Following the application of the developed Canva-based educational game, the posttest results show a dramatic and positive shift in students' performance levels. Twenty-eight students (93.33%) achieved the *Very Good* category (81–100), while the remaining two students (6.67%) reached the *Good* category (61–80). None of the students remained in the *Fair*, *Poor*, or *Very Poor* categories. This distribution clearly demonstrates that all participants experienced significant improvement, moving from lower to higher levels of achievement. The near-complete dominance of the *Very Good* category in the posttest highlights the strong impact of the intervention on students' understanding and engagement. This upward trend reflects that the use of interactive and visually engaging learning media—specifically, the Canva-based educational game—was highly effective in facilitating comprehension, sustaining students' motivation, and enhancing overall

learning outcomes. The improvement from a predominantly *Poor* category in the pretest to a predominantly *Very Good* category in the posttest suggests that the learning intervention successfully addressed previous learning difficulties and created a more meaningful and enjoyable learning experience.

Moreover, the data indicate that the intervention not only improved cognitive achievement but also likely fostered greater participation and enthusiasm among students during the learning process. The elimination of lower categories (*Poor* and *Fair*) after the treatment signifies that all students benefited from the learning approach, thereby reducing performance gaps among individuals. In conclusion, the descriptive results provide strong preliminary evidence of the positive effect of the developed learning media on students' learning achievement. However, to determine the extent and effectiveness of the improvement quantitatively, it is necessary to calculate the normalized gain (N-Gain) score. The N-Gain analysis will help identify the magnitude of learning improvement and categorize the level of effectiveness (low, medium, or high) resulting from the implemented learning intervention.

Table 11. Descriptive Statistics of N-Gain Score

	N	Min	Max	Mean	Std. Deviation
Ngain_ Score	30	0.67	0.92	0.81	0.06
Valid N (listwise)	30				

Based on the results of the descriptive statistical analysis presented in Table 11, the mean N-Gain score obtained from 30 students was 0.81, with a standard deviation of 0.069, a minimum value of 0.67, and a maximum value of 0.92. These results indicate that the increase in students' problem-solving abilities after using the developed interactive learning video falls within the high category. The relatively low standard deviation value suggests that the improvement was consistent across participants, meaning that most students achieved a comparable level of progress. This consistency reflects the effectiveness of the learning video in providing equal learning opportunities and facilitating comprehension for all students. Statistically, an N-Gain score above 0.70 is considered high (Hake, 1998), which confirms that the instructional video significantly enhanced students' conceptual understanding and problem-solving performance on the topic of Earth's rotation and revolution. These findings further support the hypothesis that integrating multimedia-based experimental learning into science education can effectively improve higher-order thinking and conceptual mastery among elementary students. In the aspect of problem-solving, based on the pretest results, students' ability to solve problems related to the concepts of Earth's rotation and revolution was still categorized as low. This indicates that most students had difficulty identifying problems, planning appropriate strategies, and drawing accurate conclusions related to the given phenomena. To illustrate this, the following table presents a detailed analysis of students' problem-solving abilities before the implementation of the instructional video:

Table 12. Analysis of Students' Problem-Solving Ability

Indicator	Pretest	Posttest	% Increase
Understanding the Problem	1.80	3.20	77.80
Planning the Solution	1.90	3.10	63.20
Executing the Plan	1.70	3.30	94.10
Evaluating the Result	1.50	3.00	100

Based on Table 13, there is a clear and significant improvement in students' problem-solving abilities after the implementation of the instructional video on the topic of Earth's rotation and revolution. In the Understanding the Problem indicator, the average score increased from 1.80 to 3.20, showing a 77.80% improvement. This suggests that students became more capable of identifying key information and understanding the questions presented.In the Planning the Solution aspect, the mean score rose from 1.90 to 3.10, an increase of 63.20%, indicating that students demonstrated better logical thinking in formulating appropriate strategies to solve the given problems. The most notable progress occurred in the Executing the Plan indicator, where the score improved from 1.70 to 3.30, equivalent to a 94.10% increase. This reflects that students became more confident and accurate in carrying out their planned problem-solving steps.Lastly, the Evaluating the Result indicator showed the highest increase, from 1.50 to 3.0, or a 100% improvement. This finding reveals that students were able to review their answers more carefully, detect mistakes, and draw more accurate conclusions. Overall, these results demonstrate that the instructional video effectively enhanced students' problem-solving skills across all indicators, supporting its role as an engaging and effective learning medium in improving conceptual understanding in Earth Science.

Discussion

The results of this study indicate that the development of an interactive experiment-based instructional video on the topic of Earth's rotation and revolution provides a highly significant contribution to improving sixth-grade elementary students' problem-solving skills. This improvement is evident from various aspects, including expert validation, practicality testing,

and effectiveness testing involving pretest and posttest evaluations. Upon deeper analysis, the success of this media development can be explained through its connections with several learning theories, educational technology approaches, and interdisciplinary frameworks that complement one another. From the feasibility aspect, the validation results from material, language, and media experts show that the instructional media meets very high-quality standards. The material expert gave a feasibility percentage of 91.20%, indicating that the content on Earth's rotation and revolution aligns with the curriculum, possesses sufficient depth, and is presented coherently and engagingly. The language expert rated it 95.20%, meaning that the language used in the video adheres to linguistic standards, is easily understandable, and highly readable. Meanwhile, media validation scored 91.53%, showing that visual aspects such as layout, typography, color selection, audio, animation, and interactivity fulfill the criteria of good instructional media.

The success of this media can also be linked to Mayer's Cognitive Theory of Multimedia Learning, which posits that learning becomes more effective when information is presented through both visual and verbal channels (P. Rahayu et al., 2024). In line with this theory (Asilestari et al., 2025) found that combining visual and audio elements in multimedia content enhances students' comprehension across different learning contexts. Similarly (Krüger & Bodemer, 2022) demonstrated that applying multimedia design principles—such as the integration of text, images, and audio—allows students to assimilate concepts more effectively through dual-channel information processing. Additionally, a local study by Manulang et al. (2024) reinforced that the use of audiovisual media directly correlates with the improvement of students' cognitive learning outcomes. Thus, the instructional video developed in this research—combining text, visuals, animation, audio narration, and experimental videos to explain abstract concepts like day and night and seasonal changes—not only delivers information but also stimulates critical thinking and imagination in understanding complex scientific phenomena. Furthermore, the practicality test results show that this media is highly practical for both individual and group learning settings. The one-to-one test achieved an average practicality score of 98%, while the small group test reached 94%.

These high scores indicate that the instructional video is easy to use, accessible, and engaging for students, fostering active participation. This finding aligns with the Technology Acceptance Model (TAM) proposed by (Kim et al., 2025; Riyanti et al., 2025), which explains that the successful adoption of educational technology is influenced by two main factors: perceived usefulness and perceived ease of use. Supporting this, (Sprenger & Schwaninger, 2021; Sümer & Vaněček, 2025) reported that after several months of using digital learning technologies—such as classroom response systems, chat tools, e-lectures, and mobile VR—students' perceptions of usefulness and ease of use significantly affected their behavioral intention and acceptance of educational technologies. Similarly Nagy (2018) found that perceived usefulness, perceived ease of use, and users' attitudes toward instructional videos directly influence their utilization and learning satisfaction. Hence, this media successfully meets both criteria by providing clear navigation, an attractive layout, and interactive features such as practice questions, navigation buttons, and experiment videos that facilitate self-directed learning (Alam et al., 2022; Sprenger & Schwaninger, 2023). Beyond practicality, this media also proved effective in improving students' learning outcomes, particularly their problem-solving abilities. The effectiveness test data show a substantial increase in average scores from 38.16 (pretest) to 88.33 (posttest), with an N-gain score of 0.81, categorized as high.

The score distribution also shifted significantly—from 90% of students in the "Poor" category during the pretest to 93.33% in the "Excellent" category in the posttest—demonstrating that the media had a strong impact on students' understanding of Earth's rotation and revolution. This improvement is also reflected in the problem-solving indicators, where students showed better performance in understanding problems, planning solutions, executing strategies, and evaluating results. For instance, after using the instructional video, students were not only able to answer simple questions like "why day and night occur," but could also explain the mechanism of Earth's rotation, its direction of movement, and its relation to time differences across the globe in a logical and systematic manner. Theoretically, these findings support the Problem-Based Learning (PBL) approach, which emphasizes the importance of real-world problems in developing students' critical thinking and problem-solving skills. PBL positions students as active problem solvers who identify learning needs, conduct self-directed learning, and apply newly acquired knowledge to authentic situations, thus fostering flexible knowledge and higher-order thinking skills (Elkington & Chesterton, 2025; Loyens et al., 2023). The experiment-based instructional video developed in this study successfully facilitated contextual and experiential learning, aligning with PBL principles and best practices in STEM education, which highlight active engagement, inquiry, and problem-centered learning

(Ješková et al., 2022; Susiloningsih et al., 2025; Zviel-Girshin & Rosenberg, 2025).

The combination of real-world problems and experimental activities provides opportunities for students to build understanding through hands-on learning and reflection on their problem-solving processes. This learning method has been proven to enhance both science process skills and conceptual understanding, consistent with the findings of Koksal & Berberoglu (2014) on the effect of guided-inquiry instruction on students' achievement and scientific process skills. When linked to Bloom's Revised Taxonomy (Faizin et al., 2024; Widiana et al., 2023), such problem-based and experimental learning promotes higher cognitive levels—not only "remember" or "understand," but also "analyze," "evaluate," and "create"—as students are encouraged to analyze phenomena, evaluate hypotheses, and construct explanations or solutions. Beyond its pedagogical significance, this media development also intersects with multiple disciplines. In geography, the topic of Earth's rotation and revolution connects to phenomena such as seasonal changes, time zones, and climate variations. In mathematics, understanding Earth's motion involves calculations of rotational speed, axial tilt, and time differences across regions. Meanwhile, the development process itself integrates Information and Communication Technology (ICT) tools such as Capcut Pro and Canva, aligning with 21st-century learning skills (4C): critical thinking, creativity, collaboration, and communication. The implications of this study are both practical and theoretical.

Practically, the interactive, experiment-based instructional video can serve as an alternative medium in science education that stimulates Higher-Order Thinking Skills (HOTS) and improves students' understanding of complex scientific concepts. It can also be applied to other science topics requiring visualization, such as the solar system, the water cycle, or photosynthesis. Theoretically, this study reinforces constructivist learning theory, which emphasizes that students understand concepts more effectively when they are actively involved in constructing knowledge through meaningful experiences. Overall, the findings of this study confirm that the interactive experiment-based instructional video is a valid, practical, and effective medium for enhancing elementary students' problem-solving skills on the topic of Earth's rotation and revolution. The significant improvement in posttest results and high N-gain scores demonstrate that this media effectively stimulates higher-order cognitive processes and fosters deeper conceptual understanding. Guided by established learning theories—such as Cognitive Theory of Multimedia Learning, Problem-Based Learning, and Constructivism—this media successfully integrates visualization, interactivity, and experimentation to create an active, enjoyable, and meaningful learning experience. Its success also underscores the importance of integrating pedagogy and technology to develop educational innovations relevant to the challenges of 21st-century learning.

Conclusion

This study successfully developed an interactive experiment-based instructional video on the topic of Earth's rotation and revolution for sixth-grade students. The product met the criteria of being valid, practical, and effective based on expert validation, practicality tests, and effectiveness evaluation. The instructional video demonstrated a high level of validity across content, language, and media aspects, while also being user-friendly and engaging for students. Furthermore, the significant improvement in students' problem-solving skills, as reflected by a high N-Gain score of 0.81, confirms the effectiveness of this media in enhancing conceptual understanding and higher-order thinking. Grounded in the Cognitive Theory of Multimedia Learning, Problem-Based Learning, and constructivist principles, this study highlights the potential of multimedia-based science learning to foster critical thinking and active engagement. The developed video can serve as a valuable alternative learning medium for other science topics that require visualization of abstract concepts.

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References

Alam, A., Astuti, I., & Suratman, D. (2022). Development of Web Programming Interactive Learning Multimedia in Vocational Middle School. *JTP - Jurnal Teknologi Pendidikan*, *24*(1), 50–62. https://doi.org/10.21009/jtp.v24i1.24242

Asilestari, P., Henjilito, R., & Hardi, V. A. (2025). Enhancing Reading Comprehension through Visual Information: A Longitudinal Study in Higher Education. *AL-ISHLAH: Jurnal Pendidikan*, *17*(2), 2415–2434. https://doi.org/10.35445/alishlah.v17i2.7490

Bahosin Sihombing, Zamsiswaya, & Sawaluddin. (2024). Model Pengembangan 4D (Define, Design, Develop, dan Disseminate) dalam Pembelajaran Pendidikan Islam. *Journal of Islamic Education El Madani*, *4*(1), 11–19. https://doi.org/10.55438/jiee.v4i1.135

Chalkiadaki, A. (2018). A systematic literature review of 21st century skills and competencies in primary education. *International Journal of Instruction*, *11*(3), 1–16. https://doi.org/10.12973/iji.2018.1131a

Chen, D. (2023). Toward an understanding of 21st-century skills: From a systematic review. *International Journal for Educational and Vocational Guidance*, *23*(2), 275–294. https://doi.org/10.1007/s10775-021-09511-1

Diana, L., Mauludin, I., & Putri, H. R. (2025). The Development of Learning Video Using Prezi Application on Photosynthesis Material to Improve Learning Motivation for 11 th Grade Students. *Jurnal Penelitian Pendidikan IPA, 11*(8), 910-916. https://doi.org/10.29303/jppipa.v11i8.11862

Elkington, S., & Chesterton, P. (2025). Embedding assessment flexibilities for future authentic learning. *Teaching in Higher Education*, *30*(3), 700–716. https://doi.org/10.1080/13562517.2024.2394605

Faizin, A., Susantini, E., & Raharjo, R. (2024). Application of A Guided Inquiry Learning Model to Improve Students' Scientific Literacy Skills. *IJORER : International Journal of Recent Educational Research*, *5*(2), 490–503. https://doi.org/10.46245/ijorer.v5i2.573

Ješková, Z., Lukáč, S., Šnajder, Ľ., Guniš, J., Klein, D., & Kireš, M. (2022). Active Learning in STEM Education with Regard to the Development of Inquiry Skills. *Education Sciences*, *12*(10), 686. https://doi.org/10.3390/educsci12100686

Jufrida, Furqon, M., Dani, R., Falah, H. S., & Alfaizi, M. H. (2024). Development of Interactive Science Learning Video Based on Ethnoedutour in Muaro Jambi Temple Area. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 8519–8530. https://doi.org/10.29303/jppipa.v10i11.9236

Kadek Yudik Ariawan, Suartama, I. K., & Ndara Tanggu Renda. (2023). Video Animasi Rotasi Bumi dan Akibatnya Berbasis Powtoon. *Jurnal Media Dan Teknologi Pendidikan*, *3*(1), 38–46. https://doi.org/10.23887/jmt.v3i1.52070

Kaitera, S., & Harmoinen, S. (2022). Developing mathematical problem-solving skills in primary school by using visual representations on heuristics. *Lumat*, *10*(2), 111–146. https://doi.org/10.31129/LUMAT.10.2.1696

Kandemir, M. A., & Apaydin, Z. (2022). Analysis of Primary School Students' Knowledge Structures Regarding the Movements of the Earth According to Conceptual Change Theories. *Çukurova Üniversitesi Eğitim Fakültesi Dergisi*, *51*(2), 825–869. https://doi.org/10.14812/cufej.934087

Kim, L., Jitpakdee, R., Praditsilp, W., & Issayeva, G. (2025). Does technological innovation matter to smart classroom adoption? Implications of technology readiness and ease of use. *Journal of Open Innovation: Technology, Market, and Complexity*, *11*(1), 100448. https://doi.org/10.1016/j.joitmc.2024.100448

Koksal, E. A., & Berberoglu, G. (2014). The Effect of Guided-Inquiry Instruction on 6th Grade Turkish Students' Achievement, Science Process Skills, and Attitudes Toward Science. *International Journal of Science Education*, *36*(1), 66–78. https://doi.org/10.1080/09500693.2012.721942

Krüger, J. M., & Bodemer, D. (2022). Application and Investigation of Multimedia Design Principles in Augmented Reality Learning Environments. *Information (Switzerland)*, *13*(2). https://doi.org/10.3390/info13020074

Liu, Y., & Pásztor, A. (2022). Effects of problem-based learning instructional intervention on critical thinking in higher education: A meta-analysis. *Thinking Skills and Creativity*, *45*(June). https://doi.org/10.1016/j.tsc.2022.101069

Loyens, S. M. M., Van Meerten, J. E., Schaap, L., & Wijnia, L. (2023). Situating Higher-Order, Critical, and Critical-Analytic Thinking in Problem- and Project-Based Learning Environments: A Systematic Review. *Educational Psychology Review*, *35*(2), 39. https://doi.org/10.1007/s10648-023-09757-x

Manulang, W., Haifaturrahmah, Linda Sekar Utami, Syaharuddin, & Siti Ala. (2024). The Audio-Visual Media on Cognitive Learning Outcomes. *Jurnal Ilmiah Sekolah Dasar*, *7*(4), 641–648. https://doi.org/10.23887/jisd.v7i4.61138

Meltzer, L. J., Solomon, B., Fenton, T., & Levine, M. D. (1989). A developmental study of problem-solving strategies in children with and without learning difficulties. *Journal of Applied Developmental Psychology*, *10*(2), 171–193. https://doi.org/10.1016/0193-3973(89)90003-8

Nagy, J. T. (2018). Evaluation of online video usage and learning satisfaction: An extension of the technology acceptance model. *International Review of Research in Open and Distributed Learning*, *19*(1), 160–185. https://doi.org/10.19173/irrodl.v19i1.2886

Novitasari, D., Ansori, I., & Widagdo, A. (2023). Effectiveness of a Problem-Based Learning Model with Quizizz Learning Media on Science Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 1179–1185. https://doi.org/10.29303/jppipa.v9iSpecialIssue.6329

Rahayu, D., Sunaengsih, C., & Sujana, A. (2025). Pengaruh Pembelajaran Kontekstual Berbantuan Media Video Untuk Meningkatkan Pemahaman Konsep Siswa Kelas Vi Pada Materi Rotasi Bumi. *EDUPROXIMA : Jurnal Ilmiah Pendidikan IPA*, *7*(3), 1499–1508. https://doi.org/10.29100/.v7i3.7372

Rahayu, P., Marmoah, S., & Budiharto, T. (2024). Analisis penerapan prinsip Mayer pada multimedia digital dalam pembelajaran matematika di kelas iv sekolah dasar. *Didaktika Dwija Indria*, *12*(5), 353–361. Retrieved from https://jurnal.uns.ac.id/JDDI/article/view/90998

Riyanti, A., Ismunandar, A., Pramono, S. A., Hendratni, T. W., Syafrullah, H., & Arsyad, M. (2025). Analysis Of The Effect Of Perceived Usefulness, Trust And Digital Capability On Technology Adoption In The Learning Process: Penelitian. *Jurnal Pengabdian Masyarakat Dan Riset Pendidikan*, *4*(1), 6727–6732. https://doi.org/10.31004/jerkin.v4i1.2865

Sofia, L. E., Anggoro, S., & Firmasyah, J. (2024). Effect Of Problem-Based Learning Supported By Media Edukatıf On İmproving Students' Understanding And Solving Matter Problems Of Rotation And Revolution Of The Earth. *Jurnal Elementaria Edukasia*, *7*(4), 3421–3432. https://doi.org/10.31949/jee.v7i4.11601

Sprenger, D. A., & Schwaninger, A. (2021). Technology acceptance of four digital learning technologies (classroom response system, classroom chat, e-lectures, and mobile virtual reality) after three months' usage. *International Journal of Educational Technology in Higher Education*, *18*(1). https://doi.org/10.1186/s41239-021-00243-4

Sprenger, D. A., & Schwaninger, A. (2023). Video demonstrations can predict the intention to use digital learning technologies. *British Journal of Educational Technology*, *54*(4), 857–877. https://doi.org/10.1111/bjet.13298

Sümer, M., & Vaněček, D. (2025). A systematic review of virtual and augmented realities in higher education: Trends and issues. *Innovations in Education and Teaching International*, *62*(3), 811–822. https://doi.org/10.1080/14703297.2024.2382854

Suseelan, M., Chew, C. M., & Chin, H. (2022). Research on Mathematics Problem Solving in Elementary Education Conducted from 1969 to 2021: A Bibliometric Review. *International Journal of Education in Mathematics, Science and Technology*, *10*(4), 1003–1029. https://doi.org/10.46328/ijemst.2198

Susiloningsih, E., Fathurohman, A., Maharani, S. D., Fathurohman, M. F., Suratmi, & Nurani, D. C. (2025). Integration of STEM Approach in Science Education: Enhancing Students' Critical Thinking, Creativity, and Engagement in Elementary Schools in Palembang. *Jurnal Penelitian Pendidikan IPA*, *11*(4), 10–19. https://doi.org/10.29303/jppipa.v11i4.10615

Van Hooijdonk, M., Mainhard, T., Kroesbergen, E. H., & Van Tartwijk, J. (2023). Creative problem solving in primary school students. *Learning and Instruction*, *88*(April), 101823. https://doi.org/10.1016/j.learninstruc.2023.101823

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2020). Determinants of 21st-Century Skills and 21st-Century Digital Skills for Workers: A Systematic Literature Review. *SAGE Open*, *10*(1). https://doi.org/10.1177/2158244019900176

Ventura-León, J., Lino-Cruz, C., Tocto-Muñoz, S., Sánchez-Villena, A., & Gamboa-Melgar, G. (2025). Problem-solving: Development and validation of a short instrument for higher education. *Frontiers in Education*, *10*(May). https://doi.org/10.3389/feduc.2025.1555167

Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21 st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies*, *44*(3), 299–321. https://doi.org/10.1080/00220272.2012.668938

Wedaswari, N. M. N., & Tegeh, I. M. (2023). Science Learning Videos Based on Contextual Approaches for Grade V Elementary Schools. *International Journal of Elementary Education*, *7*(3), 524–534. https://doi.org/10.23887/ijee.v7i3.61768

Widiana, I. W., Triyono, S., Sudirtha, I. G., Adijaya, M. A., & Wulandari, I. G. A. A. M. (2023). Bloom's revised taxonomy-oriented learning activity to improve reading interest and creative thinking skills. *Cogent Education*, *10*(2), 2221482. https://doi.org/10.1080/2331186X.2023.2221482

Widyawati, F., & Kamaludin, A. (2024). Development of Powtoon Animation Video on Colligative Properties of Contextually Charged Solutions to Increase Student Learning Motivation. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10329–10340. https://doi.org/10.29303/jppipa.v10i12.9360

Wijnia, L., Noordzij, G., Arends, L. R., Rikers, R. M. J. P., & Loyens, S. M. M. (2024). The Effects of Problem-Based, Project-Based, and Case-Based Learning on Students' Motivation: A Meta-Analysis. In *Educational Psychology Review* (Vol. 36, Issue 1). Springer US. https://doi.org/10.1007/s10648-024-09864-3

Zviel-Girshin, R., & Rosenberg, N. (2025). Enhancing Early STEM Engagement: The Impact of Inquiry-Based Robotics Projects on First-Grade Students' Problem-Solving Self-Efficacy and Collaborative Attitudes. *Education Sciences*, *15*(10), 1404. https://doi.org/10.3390/educsci15101404