



Project-Based Learning with Interactive Video: Effects of Fifth-Grade Science Literacy Viewed from Self-Regulation

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Abstract: This study aims to examine the effect of a Project-Based Learning (PjBL) model assisted by interactive video on elementary students' science literacy, with self-regulated learning as a moderating variable in the IPAS subject. A quasi-experimental design with a pretest–posttest control group was employed. The population consisted of all fifth-grade students in Cluster IV, Sukawati District, during the 2025/2026 academic year (N = 260). The sample was selected through simple random sampling and comprised 39 students from SD Negeri 1 Batubulan Kangin and 40 students from SD Negeri 2 Batubulan Kangin. Science literacy data were collected using a test instrument, while self-regulated learning was measured using a non-test instrument. Data were analyzed using two-way analysis of variance (ANOVA) in SPSS. The results indicated that the PjBL model assisted by interactive video had a statistically significant main effect on students' science literacy ($F(1,76) = 249.416$, $p < 0.001$). Additionally, a significant interaction effect was observed between the learning model and students' self-regulated learning on science literacy outcomes ($F(1,76) = 6.363$, $p = 0.015$). These findings suggest that interactive video–assisted Project-Based Learning is an effective instructional approach for enhancing science literacy in elementary education.

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Introduction

Education in the 21st century requires students not only to master conceptual knowledge but also to develop higher-order thinking skills such as critical thinking, problem solving, creativity, and collaboration. In this context, science literacy becomes a key competence that must be possessed by students to face global challenges, including rapid technological development, environmental issues, and health crises (Suparya et al., 2022). Meaningful and contextual science education is therefore essential to ensure that students are not only able to understand scientific information but also apply it responsibly in everyday life (Melinda & Zainil, 2020; Undari et al., 2023). Science learning in elementary schools, particularly through the IPAS subject, is designed to develop scientific reasoning and connect scientific concepts with social and environmental contexts, making science literacy a central indicator of educational success. Science literacy refers to the ability to use scientific knowledge, identify questions, and draw conclusions based on evidence to understand natural phenomena and make informed decisions in daily life (Lüsse et al., 2022).

Despite its importance, science literacy among Indonesian students remains relatively low. Data from the Programme for International Student Assessment (PISA) 2022 indicate that Indonesia's average science literacy score (383) is still far below the OECD average (485), with only a small proportion of students reaching the minimum proficiency level



(Ariani, 2023). These findings indicate that many students struggle to understand scientific concepts, relate them to real-life contexts, and apply them in evidence-based decision-making. Previous studies have identified several contributing factors, including teacher-centered instruction, limited use of interactive learning media, low student engagement in inquiry-based activities, and socio-economic disparities in access to quality education (Ginting et al., 2021; Ke et al., 2021; Permana et al., 2023; Rati et al., 2025). Observations in elementary schools also show that science learning often relies heavily on textbooks and static visual media, with minimal integration of interactive digital resources, resulting in limited opportunities for students to explore scientific concepts actively and independently.

The development of innovative learning models has been widely discussed as a strategy to improve science literacy. Project-Based Learning (PjBL) has gained considerable attention as an instructional approach that encourages students to investigate real-world problems, construct knowledge collaboratively, and produce meaningful learning outcomes (Anggreni et al., 2020). Previous studies report that PjBL can improve conceptual understanding, higher-order thinking skills, and science literacy. Research has shown that students engaged in project-based activities demonstrate better engagement and deeper comprehension of scientific concepts compared to conventional approaches (Anggreni et al., 2020; Arum et al., 2024; Hidayat et al., 2025; Permana et al., 2023). In addition, interactive video has been increasingly integrated into science instruction to support visualization of abstract concepts and enhance students' learning experiences through audiovisual and interactive features (Ainullah et al., 2023; Ginting et al., 2021).

However, most existing studies examine PjBL or interactive media separately, and only a limited number investigate the integration of PjBL with interactive video, particularly in elementary science learning contexts. Furthermore, internal student characteristics such as Self-Regulated Learning (SRL) have not been widely positioned as moderating variables in studies examining the effectiveness of instructional models on science literacy. SRL refers to students' ability to plan, monitor, and evaluate their own learning processes. Students with strong self-regulation skills tend to be more independent, goal-oriented, and persistent in completing complex learning tasks (Abror, 2022). This aspect is particularly important in learning environments such as PjBL integrated with interactive video, where students are required to actively manage learning activities, explore digital content, and reflect on their understanding. According to Social Cognitive Theory, learning is influenced by the interaction between personal factors, behavior, and environmental conditions, in which self-regulation and self-efficacy play essential roles in determining students' engagement and performance (Bandura, 1986). Similarly, Self-Regulated Learning Theory explains that effective learners go through cyclical phases of planning, monitoring, and self-reflection during the learning process (Zimmerman, 2002). Therefore, SRL is expected to play a crucial role in determining how effectively students engage with project-based activities and utilize interactive video to construct scientific knowledge (Erayani & Jampel, 2022).

The scientific novelty of this study lies in the integration of three key components: Project-Based Learning, interactive video as a supporting learning medium, and Self-Regulated Learning as a moderating variable in improving elementary students' science literacy in the IPAS subject. This study does not merely test the effectiveness of a learning model, but also examines how internal learner characteristics interact with instructional strategies to influence learning outcomes. By positioning SRL as a moderating factor, this research provides a more comprehensive understanding of the mechanisms underlying science literacy development.



Based on the background and state of the art, this study aims to examine the effectiveness of Project-Based Learning assisted by interactive video in improving students' science literacy in elementary school contexts. In addition, this study seeks to analyze the interaction between the learning model and students' Self-Regulated Learning (SRL) in influencing science literacy outcomes, as well as to compare the effectiveness of the learning model among students with different levels of SRL. The contribution of this research lies in extending previous studies by integrating Project-Based Learning with interactive video and positioning SRL as a moderating variable in science learning. Furthermore, this study provides empirical evidence on how technology-supported project-based instruction can enhance science literacy while considering students' internal learning characteristics, thereby offering pedagogical insights for teachers in designing more effective and adaptive learning environments.

Research Method

This study employed a quasi-experimental approach to examine the effect of Project-Based Learning assisted by interactive video on students' science literacy, viewed from the level of Self-Regulated Learning. The research design used was a pretest–posttest non-equivalent control group design, in which intact classroom groups were assigned as experimental and control classes. The experimental group received instruction using Project-Based Learning supported by interactive video, while the control group was taught using conventional learning methods. In addition, the study adopted a 2×2 factorial design to investigate the interaction between the learning model (Project-Based Learning and conventional learning) and students' Self-Regulated Learning (high and low) on science literacy outcomes. The categorization of students' Self-Regulated Learning levels was determined using a median split method based on the SRL questionnaire scores, in which students with scores above the median were classified as having high SRL, while those with scores below the median were categorized as having low SRL.

The research was conducted in public elementary schools within Cluster IV of Sukawati District, Gianyar Regency, Bali Province, during the first semester of the 2025/2026 academic year. The population of this study consisted of all fifth-grade students of public elementary schools in Cluster IV Sukawati, totaling 260 students distributed across eight classes in seven schools. The sampling technique employed was simple random sampling at the classroom level, considering that the subjects were already organized into intact classes. Based on the random selection, Grade V students of SD Negeri 2 Batubulan Kangin (40 students) were assigned as the experimental group, while Grade V students of SD Negeri 1 Batubulan Kangin A (39 students) served as the control group.

Data were collected using two main instruments: a science literacy test and a Self-Regulated Learning questionnaire. The Self-Regulated Learning (SRL) questionnaire used in this study was adapted from a standard instrument, namely the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich et al. (1991), which has been widely used to measure students' motivational orientations and self-regulated learning strategies. The science literacy test was developed based on indicators covering scientific knowledge, competence, and context, while the Self-Regulated Learning questionnaire measured students' ability to plan, monitor, and evaluate their learning processes. Learning implementation in the experimental class was conducted through project-based activities supported by interactive videos, allowing students to explore concepts, engage in inquiry, and produce learning products collaboratively.



Hypothesis testing was conducted using two-way analysis of variance (ANOVA) with a treatment-by-level (2×2) design to determine: (1) the effect of the learning model on science literacy, (2) the effect of Self-Regulated Learning on science literacy, and (3) the interaction effect between the learning model and Self-Regulated Learning. All statistical analyses were carried out using SPSS version 26.0 for Windows, and decisions regarding hypothesis acceptance or rejection were based on a significance level of 5%.

Results and Discussion

Table 1. Two-Way ANOVA Results on the Effects of Learning Model on Science Literacy

Source	Sum of Squares	df	Mean Square	F	Sig.
Class (PjBL Model*Conventional)	829,060	1	829,060	249,416	0,000
Error	156,229	76	3,324		
Total	324844,000	79			

The first scientific finding indicates that Project-Based Learning assisted by interactive video produces higher improvement in science literacy compared with conventional learning. This is evident from the relatively similar initial ability shown in the pretest scores, while the posttest scores of the experimental group are higher than those of the control group after treatment. This improvement is also supported by the average N-gain score of the experimental class, which falls into the high category, whereas the control class falls into the moderate category. Statistically, the difference is significant as shown by the two-way ANOVA results, which indicate a very high F value with a significance level below 0.05. This means that the improvement in science literacy did not occur by chance but was influenced by the learning model applied.

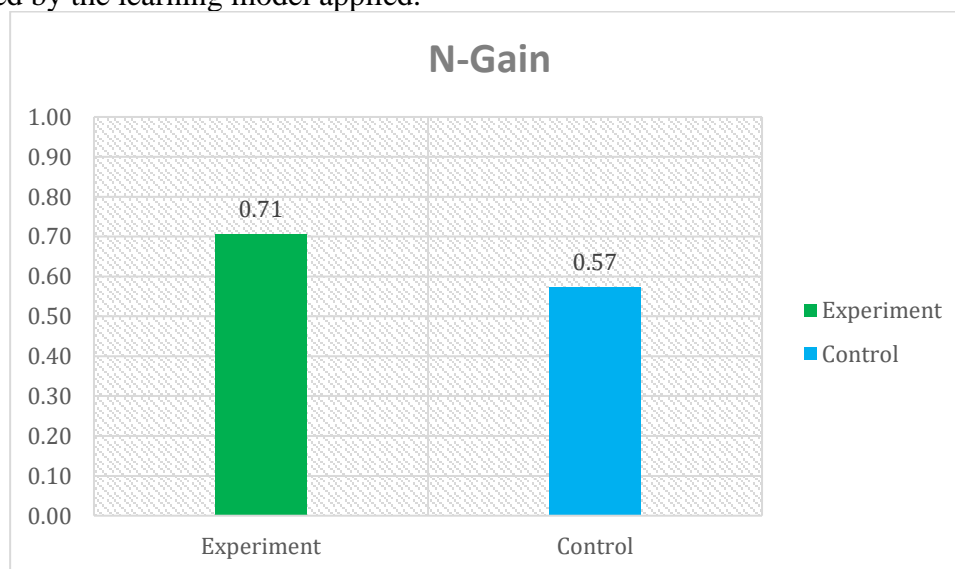


Figure 1. N-Gain Results of Science Literacy in Experimental and Control Classes

Scientifically, this occurs because Project-Based Learning positions students as active learners who construct knowledge through investigation, information processing, discussion, and project production. This process aligns with the characteristics of science literacy, which require the ability to understand concepts, use evidence, and apply knowledge in real contexts (Kusadi et al., 2020). In ecosystem topics, students do not merely memorize food chains or ecological structures but analyze relationships among ecosystem components and explain the



impact of imbalance. Project-based activities encourage students to use scientific reasoning and evidence-based arguments, which are central to science literacy (Setemen et al., 2023).

Interactive video strengthens this mechanism by serving as cognitive support and visual representation that bridges abstract concepts into more concrete forms (Lasmawan & Kertih, 2025). Energy flow, interactions among producers, consumers, and decomposers, and ecosystem imbalance scenarios become easier to understand through dynamic visualization that students can replay and review (Tika & Agustiana, 2021). As a result, not only do mean scores increase, but the score distribution in the experimental group also becomes more consistent, indicating that students' understanding is more evenly developed due to structured learning stimuli.

This finding is consistent with previous studies stating that Project-Based Learning encourages students to engage in inquiry processes similar to scientific practice (Anggreni et al., 2020; Arum et al., 2024; Hidayat et al., 2025). The results also support studies showing that Project-Based Learning improves science literacy by promoting critical thinking and contextual understanding (Permana et al., 2023; Singh et al., 2025). Furthermore, the findings reinforce research indicating that interactive video enhances engagement, conceptual understanding, and retention through multimodal learning presentation.

Table 2. Two-Way ANOVA Results on the Effects of Learning Model, Self-Regulated Learning, and Their Interaction on Science Literacy

Source	Sum of Squares	df	Mean Square	F	Sig.
Class * Self Regulation Learning	21,150	1	21,150	6,363	0,015
Error	156,229	76	3,324		
Total	324844,000	79			

The second scientific finding shows a significant interaction between the learning model and Self-Regulated Learning on science literacy. This indicates that the effectiveness of Project-Based Learning assisted by interactive video does not operate independently but is influenced by students' self-regulation abilities. Empirically, students with high Self-Regulated Learning achieve higher science literacy scores than those with low Self-Regulated Learning in both experimental and control classes. However, the most substantial improvement occurs in the combination of Project-Based Learning and high Self-Regulated Learning. The two-way ANOVA confirms that this interaction is significant because the significance value is below 0.05.

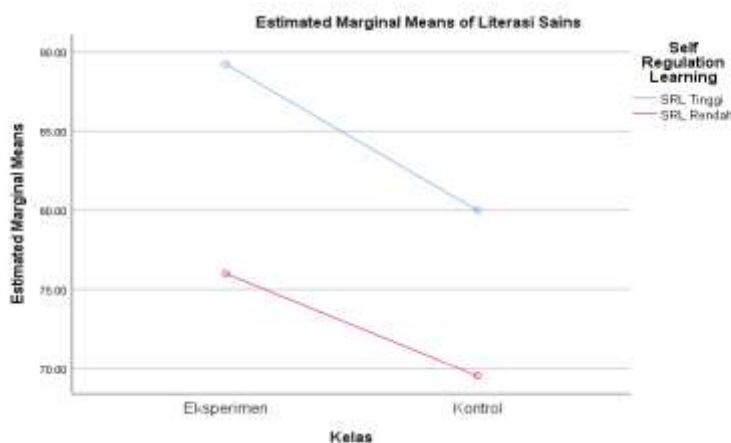


Figure 2. Interaction Graph of Learning Model



Scientifically, this occurs because Project-Based Learning requires students to manage their learning processes, such as planning project steps, dividing tasks, monitoring progress, overcoming obstacles, and revising outcomes. These demands correspond directly to the components of Self-Regulated Learning, namely planning, monitoring, and evaluation (Ghofur, 2022). Students with strong self-regulation tend to set learning goals, focus when processing information from interactive videos, and consistently complete project tasks. Students with lower self-regulation still benefit from the model, but they tend to require more guidance and have not fully optimized independent learning strategies. This explains why the impact of the learning model varies across levels of Self-Regulated Learning.

This finding aligns with literature indicating that active and project-based learning produces stronger outcomes when students possess good learning autonomy (Ghofur, 2022; Hidayat et al., 2025). It also supports the argument that internal student factors play an important role in determining the effectiveness of instructional models, making the analysis of science literacy more comprehensive by incorporating both pedagogical and psychological dimensions (Ke et al., 2021; Kusadi et al., 2020).

Table 3. Pairwise Comparison Viewed from Group of High Self Regulated Learning

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig. ^d
Experiment High SRL	Experiment Low SRL	13.231 ^{*,b,c}	.771	.000
	Control High SRL	9.231^{*,b,c}	.771	.000
	Control Low SRL	19.692 ^{*,b,c}	.771	.000

The third scientific finding indicates that among students with high Self-Regulated Learning, Project-Based Learning assisted by interactive video produces significantly higher science literacy outcomes compared with conventional learning. Follow-up pairwise comparison analysis shows a significant mean difference between the experimental high Self-Regulated Learning group and the control high Self-Regulated Learning group, with a significance value below 0.05. The improvement is also evident from the N-gain analysis, which falls into the high category for the experimental group and the moderate category for the control group.

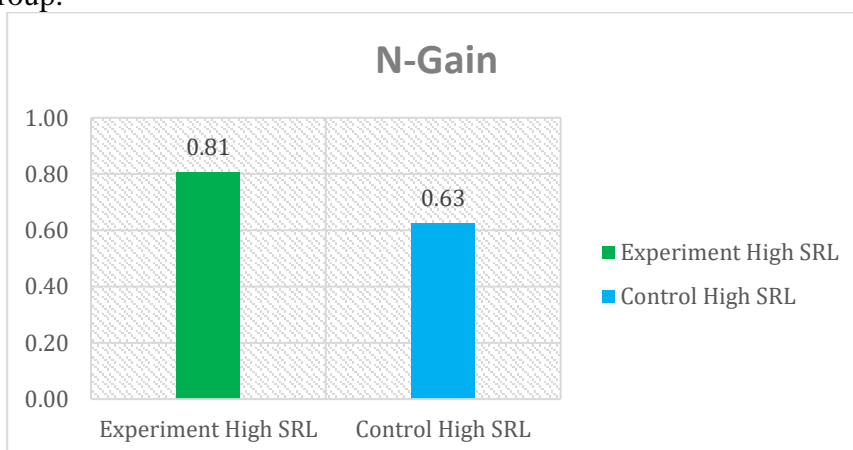


Figure 3. N-Gain Results Viewed from Group of High Self Regulated Learning

Scientifically, students with high self-regulation can maximize the characteristics of Project-Based Learning because they are able to manage learning strategies, construct arguments, and reflect on project outcomes. In ecosystem learning, they are able not only to understand ecological relationships but also to explain causal connections and the consequences of ecological imbalance (Ainullah et al., 2023). Interactive video serves as



visual evidence that strengthens reasoning and supports deeper conceptual understanding (Arum et al., 2024; Hidayat et al., 2025). High self-regulation also enables students to manage group work effectively, leading to more meaningful project outcomes and improved science literacy.

This finding supports Self-Regulated Learning theory, which states that students with strong self-regulation have better control over goals, strategies, and learning evaluation (Abror, 2022; Ghofur, 2022). It also aligns with research indicating that project-based learning yields optimal results among learners who are ready for independent and self-directed learning (Melinda & Zainil, 2020; Setemen et al., 2023; Undari et al., 2023).

Table 4. Pairwise Comparison Viewed from Group of Low Self Regulated Learning

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig. ^d
Experiment Low SRL	Experiment High SRL	-13.231 ^{*,b,c}	.771	.000
	Control High SRL	-4.000 ^{*,b,c}	.771	.000
	Control Low SRL	6.462^{*,b,c}	.771	.000

The fourth scientific finding indicates that among students with low Self-Regulated Learning, Project-Based Learning assisted by interactive video still produces significantly higher science literacy compared with conventional learning. Pairwise comparison analysis shows a significant mean difference between the experimental low Self-Regulated Learning group and the control low Self-Regulated Learning group. Although both groups fall into the moderate N-gain category, the experimental group achieves a higher N-gain score than the control group.

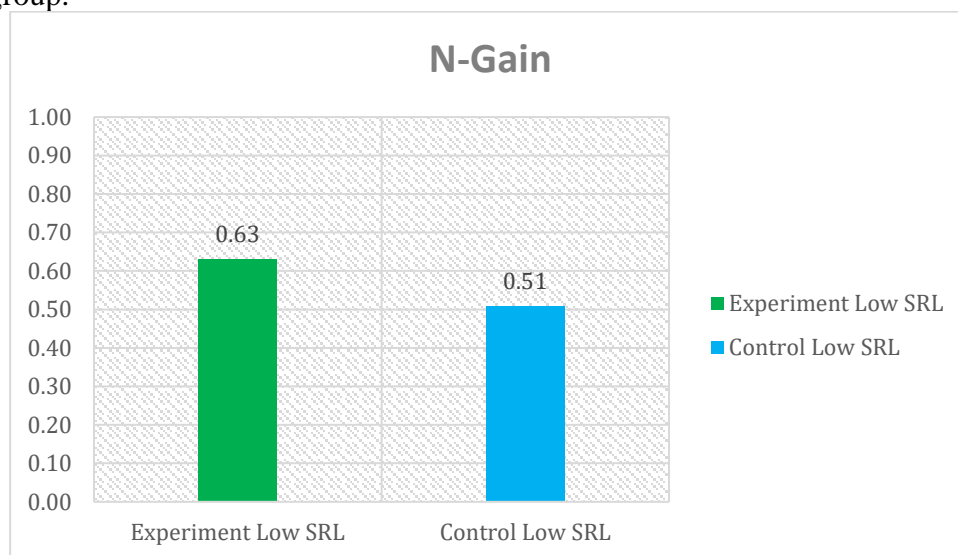


Figure 4. N-Gain Results Viewed from Group of Low Self Regulated Learning

Scientifically, these findings indicate that Project-Based Learning assisted by interactive video provides structured learning support that functions as scaffolding for students with low self-regulation. Clear project stages, collaborative work, and teacher guidance help students follow the learning process more systematically (Kusadi et al., 2020). From the perspective of Cognitive Load Theory proposed by John Sweller, interactive video helps manage students' cognitive load by reducing extraneous load and enhancing germane processing through visual explanations and segmented content. This is particularly beneficial for learners with low self-regulation, as it minimizes cognitive overload while allowing repeated exposure to key concepts (Hidayat et al., 2025; Mayer, 2021). Consequently, even



though low self-regulation limits independent learning management, structured instruction and multimedia support improve conceptual understanding and knowledge application, leading to enhanced science literacy.

Furthermore, this finding aligns with Self-Determination Theory developed by Richard M. Ryan and Edward L. Deci, which emphasizes the importance of external support in fostering autonomy, competence, and relatedness. In structured and media-supported environments, students with low self-regulation can gradually develop their ability to manage learning, as the instructional design supports their sense of competence and engagement. This supports the view that self-regulated learning can be cultivated through supportive learning environments (Ghofur, 2022; Setemen et al., 2023).

In addition, international studies on video-based and immersive learning technologies (e.g., AR and interactive multimedia) demonstrate that well-designed visual media can enhance engagement, reduce cognitive burden, and support diverse learners by presenting information in a clear and interactive manner (Ainullah et al., 2023; Erayani & Jampel, 2022; Singh et al., 2025; Radianti et al., 2020). These technologies provide multimodal representations that help learners integrate abstract scientific concepts more effectively.

Overall, the findings demonstrate that Project-Based Learning assisted by interactive video effectively improves fifth-grade students' science literacy in the IPAS subject, with its effectiveness influenced by the level of self-regulated learning. The model produces optimal outcomes for students with high self-regulation while remaining beneficial for those with lower self-regulation due to structured learning stages and visual scaffolding. This combination not only supports immediate learning outcomes but also contributes to the gradual development of students' self-regulatory capacities through cognitively and motivationally supportive instructional design.

Conclusion

This study concludes that Project-Based Learning assisted by interactive video is an effective instructional approach for improving fifth-grade students' science literacy in the IPAS subject. The findings confirm that the learning model contributes significantly to the development of students' ability to understand scientific concepts, interpret evidence, and apply knowledge in contextual situations. The study also demonstrates that Self-Regulated Learning plays an important moderating role in the effectiveness of the instructional model. The impact of Project-Based Learning assisted by interactive video varies according to students' ability to manage their own learning processes, indicating that instructional strategies and internal learner characteristics jointly influence science literacy development. For students with high Self-Regulated Learning, the implementation of Project-Based Learning assisted by interactive video leads to more optimal science literacy achievement, showing that independent learning readiness strengthens the benefits of project-based environments. For students with low Self-Regulated Learning, the model remains effective in improving science literacy, suggesting that structured project activities and interactive media provide learning support that facilitates conceptual understanding. Overall, the study affirms that integrating Project-Based Learning, interactive video, and Self-Regulated Learning provides a comprehensive and effective approach to enhancing science literacy in elementary education, supporting the development of meaningful, student-centered, and context-based science learning.



Recommendation

Future research is recommended to expand the application of Project-Based Learning assisted by interactive video across different grade levels, subjects, and educational contexts, as well as to include other internal student variables such as motivation, learning interest, and digital literacy to obtain a more comprehensive understanding of science literacy development. Further studies may also explore the use of varied digital media and innovative instructional approaches to strengthen learning effectiveness and examine long-term impacts through longitudinal designs. In terms of practical implications, teachers are recommended to implement Project-Based Learning assisted by interactive video gradually and in a well-planned manner in science learning. The implementation should be adjusted to students' characteristics, particularly their level of Self-Regulated Learning, so that each student receives appropriate learning support. Teachers are also encouraged to provide more intensive guidance for students with low levels of self-regulation, for example by offering more structured project guidelines, clear learning stages, and continuous feedback throughout the learning process. In addition, teachers need to ensure the availability of adequate digital resources and allocate sufficient time for project activities to optimize the learning process and achieve more consistent learning outcomes.

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