

Effects of Kosifacay Media-Assisted Problem-Based Learning on Fifth-Grade Students' Learning Interest and Conceptual Understanding of Light: A Quasi-Experimental Study

Yuan Alfa Yoga Winarta^{1*}, Joko Sulianto², Iin Purnamasari³
^{1,2,3}Universitas PGRI Semarang, Semarang, Indonesia

ARTICLE INFO	ABSTRACT
Article history: Submitted: September 17, 2026 Final Revised: Sept. 22, 2026 Accepted: September 29, 2026 Published: September 30, 2026	Purpose: This study examined the effects of Kosifacay media-assisted Problem-Based Learning (PBL) on fifth-grade students' learning interest and conceptual understanding of the properties of light. Methods: A quasi-experimental study using a Matching Only Pretest–Posttest Control Group Design was conducted with 43 fifth-grade students from two public elementary schools in Blora Regency, Indonesia. The participants consisted of 15 students in the experimental group and 28 students in the control group. The groups were naturally formed classroom groups located in different schools, and random assignment was not feasible. Data were collected using a 20-item learning interest questionnaire and a 30-item conceptual understanding test. Data were analyzed using descriptive statistics, paired-samples <i>t</i> -tests, and MANOVA with Pillai's Trace. Findings: The experimental group showed increases in both learning interest and conceptual understanding following the intervention. MANOVA indicated a statistically significant multivariate difference between the instructional conditions in the combined outcomes (Pillai's Trace = 0.733, $F(2, 40) = 54.870$, $p < .001$). Research Implications: The findings suggest that integrating Kosifacay media with PBL may support affective and cognitive outcomes in elementary science learning. However, the unequal group sizes, lack of random assignment, and implementation across different schools limit causal interpretation and generalizability. Originality: This study provides empirical evidence on the integration of Kosifacay media and PBL to address learning interest and conceptual understanding of the properties of light within an elementary science context.
Keywords: Conceptual Understanding; Elementary Science Education; Kosifacay Media; Learning Interest; Problem-Based Learning; Properties of Light; Quasi-Experimental Study	
	
 	Doi: https://doi.org/10.61255/jupiter.v4i4.2115

INTRODUCTION

Improving the quality of science education is an important component of efforts to achieve Sustainable Development Goal (SDG) 4, which emphasizes inclusive, equitable, and quality education and lifelong learning opportunities. Within this broader agenda, elementary science education plays an important role in developing students' scientific literacy, critical thinking, problem-solving abilities, and capacity to understand natural phenomena. These outcomes require learning approaches that move beyond knowledge transmission toward student-centered experiences in which students actively construct knowledge through inquiry, collaboration, problem solving, and meaningful learning activities. Such approaches can also foster students' learning interest and engagement, which are important for sustained participation in science learning (David & Weinstein, 2024; Howard et al., 2021; Suhelayanti et al., 2023).

Despite the importance of quality science education, elementary students may experience difficulties in understanding scientific concepts that require reasoning, investigation, and the interpretation of observable phenomena. In Indonesia, the Programme for International Student Assessment (PISA, 2023) reported an average science score of 383 for Indonesian students, below the OECD average, reflecting continuing challenges in science learning at the national level (OECD, 2023). At the classroom level, teacher-centered instruction may further limit students' opportunities to investigate phenomena, collaborate, and construct conceptual understanding through direct experiences. Previous research has indicated that inquiry-oriented and student-centered learning can provide greater opportunities for active engagement and conceptual development (Julianto et al., 2023). Similar conditions were identified during preliminary observations and teacher interviews at SDN 1 Jepangrejo and SDN Kauman, Blora Regency. Science learning in the participating classes was primarily conducted through lectures and written assignments, with limited use of student-centered learning models and concrete instructional media. Students also

experienced difficulties in understanding the properties of light and showed limited classroom participation. School assessment records indicated that only 18 of 43 Grade V students (41.86%) had achieved the Minimum Learning Competency Criteria (KKTP) before the intervention. These conditions indicate a local instructional need for learning approaches that provide students with opportunities to investigate scientific phenomena, engage actively in problem solving, and develop conceptual understanding through meaningful experiences.

This need is consistent with the orientation of the Merdeka Curriculum, which emphasizes student-centered learning, inquiry, collaboration, meaningful experiences, and the development of higher-order thinking skills. In elementary Natural and Social Sciences (IPAS), students are expected to investigate natural phenomena and construct knowledge through direct and contextual learning experiences. The properties of light represent a relevant topic for such an approach because concepts such as reflection, refraction, transmission, straight-line propagation, and light dispersion involve phenomena that can be explored through observation and experimentation. Therefore, instructional approaches that combine active problem solving with appropriate concrete learning media may provide opportunities for students to connect scientific concepts with observable phenomena (Asnawi et al., 2023; Halim et al., 2024).

Problem-Based Learning (PBL) provides a pedagogical framework that can support these learning requirements. Grounded in constructivist principles, PBL engages students in authentic problems, collaborative inquiry, investigation, solution development, and reflection. Through these processes, students have opportunities to construct knowledge rather than simply receive information from teachers. Previous research and reviews have reported that PBL can support students' conceptual understanding, critical thinking, motivation, and other learning outcomes, particularly when learning activities require active investigation and problem solving (Anggraeni et al., 2023; Hidayati & Purwaningsih, 2023; Liu & Pásztor, 2022; Rizki & Suprpto, 2024). PBL may therefore be particularly relevant to elementary science topics that require students to connect abstract concepts with observable phenomena.

Instructional media can complement PBL by providing concrete representations and opportunities for direct exploration. In the present study, Kosifacay media is used as a concrete learning medium for investigating the properties of light. Its use is intended to enable students to observe and investigate relevant phenomena directly during the problem-solving process. Concrete and manipulative learning experiences can help elementary students connect theoretical explanations with observable phenomena and may support conceptual development (Dewanti et al., 2025; Putri & Asrori, 2019). However, the existing literature cited in this study primarily examines PBL, instructional media, or concrete learning experiences in broader contexts. The available references do not provide sufficient evidence to claim that previous studies have specifically established the effectiveness of Kosifacay media itself. Therefore, the present study focuses on examining its use in a specific instructional context rather than assuming its effectiveness from studies of other media or PBL implementations.

The research gap is therefore narrowed to the specific combination of Kosifacay media-assisted PBL, the properties-of-light topic, and the simultaneous examination of learning interest and conceptual understanding among fifth-grade elementary students. Although previous studies have investigated PBL and media-assisted learning, the present study addresses these two outcomes together within a specific elementary science topic and instructional setting. The novelty of the study consequently lies not in claiming that the integration of PBL and instructional media is generally new, but in examining the application of Kosifacay media within a PBL framework for learning the properties of light while simultaneously assessing an affective outcome, namely learning interest, and a cognitive outcome, namely conceptual understanding. This focus provides context-specific empirical evidence concerning the potential of this instructional combination in elementary science education.

Based on this research gap, this study aims to examine the effects of Kosifacay media-assisted Problem-Based Learning (PBL) on fifth-grade students' learning interest and conceptual understanding of the properties of light compared with conventional instruction. Specifically, the study investigates changes in students' learning interest following the implementation of Kosifacay media-assisted PBL, changes in students' conceptual understanding of the properties of light following the intervention, and the multivariate difference between the instructional conditions in the combined outcomes of learning interest and conceptual understanding. Because the study was conducted using naturally existing classroom groups from two different schools, the findings are interpreted within the limits of its quasi-experimental design, unequal group sizes, and absence of random assignment.

Accordingly, the hypotheses are formulated as follows. H1: Kosifacay media-assisted Problem-Based Learning produces a significant difference in fifth-grade students' learning interest between pretest and posttest. H2: Kosifacay media-assisted Problem-Based Learning produces a significant difference in fifth-grade students' conceptual understanding of the properties of light between pretest and posttest. H3: There is a significant multivariate difference between students receiving Kosifacay media-assisted Problem-Based Learning and those receiving conventional instruction in the combined outcomes of learning interest and conceptual understanding.

METHOD

Research Design

This study employed a quasi-experimental non-equivalent control group pretest–posttest design to examine the effects of Problem-Based Learning (PBL) assisted by Kosifacay media on fifth-grade students' learning interest and conceptual understanding of the properties of light. A quasi-experimental design was selected because the participating schools had established classroom structures, and students could not be randomly assigned to the instructional conditions. Therefore, the study used intact classroom groups under authentic school conditions (Fraenkel et al., 2024; Creswell & Poth, 2023).

The experimental group received Problem-Based Learning assisted by Kosifacay media, whereas the control group received conventional teacher-centered instruction covering the same curriculum content and learning objectives. The independent variable was the instructional condition, while the dependent variables were students' learning interest and conceptual understanding of the properties of light.

Previous science achievement was considered when selecting the participating classes; however, no individual-level matching procedure was conducted after class selection. Therefore, the study did not claim statistical baseline equivalence through matching. The experimental and control groups were located in different schools and differed in size. The experimental group consisted of 15 students from SDN 1 Jepangrejo, whereas the control group consisted of 28 students from SDN Kauman. Consequently, school-level, teacher-level, classroom, and resource-related characteristics could not be completely separated from the instructional condition. The findings were therefore interpreted within the limits of a non-equivalent quasi-experimental design rather than as definitive evidence of an effect attributable solely to the Kosifacay-assisted PBL intervention.

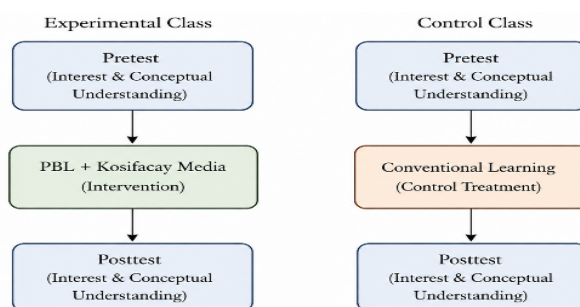


Figure 1. Research Design

Participants

The study was conducted during the second semester of the 2025/2026 academic year at two public elementary schools in Blora Regency, Central Java, Indonesia, namely SDN 1 Jepangrejo and SDN Kauman. Both schools implemented the Merdeka Curriculum in Grade V Natural and Social Sciences (IPAS). A purposive sampling procedure was employed because the existing classroom organization could not be modified during the research period. One intact Grade V classroom from each participating school was included. The experimental group consisted of 15 students from SDN 1 Jepangrejo, while the control group consisted of 28 students from SDN Kauman, resulting in a total sample of 43 students. The unequal group sizes reflected the naturally occurring enrollment of the participating classrooms rather than researcher-assigned group sizes. Previous science achievement was considered when selecting the participating classes. However, because no individual matching procedure was conducted and the groups were drawn from different schools, previous science achievement was not treated as evidence of statistical equivalence. Differences in the learning-interest pretest were retained and considered when interpreting the findings. The final analytical sample consisted of 43 students (Cohen et al., 2024). During the study, the experimental group received Problem-Based Learning assisted by Kosifacay media, whereas the control group received conventional teacher-centered instruction covering the same curriculum content and learning objectives. The demographic characteristics of the participants are presented in Table 1.

Table 1. Characteristics of Research Participants

Group	School	Grade	n	Learning treatment
Experimental	SDN 1 Jepangrejo	V	15	Problem-based learning assisted by Kosifacay media
Control	SDN Kauman	V	28	Conventional teacher-centered learning
Total			43	

Research Procedures

The research procedure consisted of four sequential stages: preparation, pretest, instructional intervention, and posttest. During the preparation stage, permission was obtained from the participating schools, instructional materials and research instruments were prepared, and the implementation procedures were coordinated with the participating teachers. Lesson plans were prepared to ensure that both groups addressed the same curriculum content and learning objectives.

The intervention was implemented over three instructional sessions, with approximately 2×35 minutes per session. Before the intervention, students in both groups completed the conceptual understanding pretest and learning-interest questionnaire. These assessments provided baseline measurements of the two dependent variables.

In the experimental group, the learning process employed Problem-Based Learning assisted by Kosifacay media. The instructional activities followed the five phases of PBL. The first phase involved orienting students to the problem, in which students were introduced to problems related to the properties of light. The second phase involved organizing students for learning by forming groups and explaining the tasks to be completed. The third phase involved guiding individual and group investigation, during which students investigated the problems through observation and hands-on activities using Kosifacay media. The fourth phase involved developing and presenting solutions, in which students discussed their findings and presented the results of their investigations. The fifth phase involved evaluating the problem-solving process and reflecting on the learning outcomes. Through these activities, Kosifacay media was integrated into the learning process to facilitate students' direct observation and hands-on investigation of phenomena related to the properties of light.

In the control group, students received conventional teacher-centered instruction covering the same curriculum topic and learning objectives. The control condition consisted of the routine instructional approach implemented in the participating classroom.

After completion of the three instructional sessions, both groups completed the same conceptual understanding test and learning-interest questionnaire as posttests. Supporting documentation, including lesson plans, instructional materials, classroom observation records, and photographs of learning activities, was collected to document the implementation process. Completion of the intervention was followed by administering the conceptual understanding posttest and the learning interest questionnaire to both groups using the same instruments employed during the pretest. The resulting data were analyzed to determine the effectiveness of Kosifacay media-assisted Problem-Based Learning on students' learning interest and conceptual understanding. Figure 2 summarizes the overall research procedure.

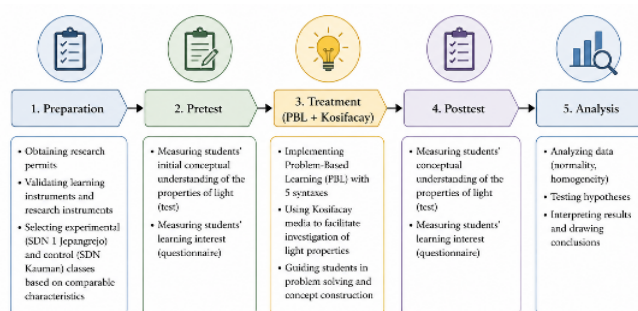


Figure 2. Research Procedure

A summary of the research instruments is presented in Table 2, while the results of the validity and reliability analyses are described in the subsequent subsection.

Table 2. Research Instruments

Instrument	Variable	Indicators	Scale	Items
Learning Interest Questionnaire	Learning Interest	Feeling of enjoyment; interest; attention; involvement	4-point Likert scale	20
Conceptual Understanding Test	Conceptual Understanding	Reflection; refraction; light transmission; straight-line propagation; light dispersion; integrated concepts (C4–C6)	Objective test	30

Research Instruments

Two instruments were used to collect the primary data: a learning-interest questionnaire and a conceptual understanding test. The learning-interest questionnaire consisted of 20 items measured using a four-point Likert scale. The questionnaire assessed four indicators of learning interest: enjoyment, interest, attention, and involvement. The conceptual understanding test consisted of 30 objective items covering reflection, refraction, light transmission, straight-line propagation, light dispersion, and integrated concepts involving higher-order cognitive processes (C4–C6).

Instrument Validation and Reliability

Before the main data collection, the research instruments underwent expert review to assess the relevance, construction, language clarity, and presentation of the items. Two validators were involved in the validation process: a lecturer from Universitas PGRI Semarang (UPGRIS) and the principal of SDN 1 Jepangrejo. The validators reviewed the instruments before their use in the pilot study and main data collection.

A pilot study involving 30 Grade V students was subsequently conducted to examine the psychometric properties of the instruments. Item validity was assessed using the Pearson Product–Moment correlation coefficient at the 5% significance level. With $n = 30$, the reported r value was 0.361. The learning-interest questionnaire produced item correlation coefficients ranging from 0.669 to 0.886, whereas the conceptual understanding test produced coefficients ranging from 0.380 to 0.890. All items exceeded the specified correlation criterion.

Internal consistency was examined using Cronbach's alpha. The learning-interest questionnaire yielded an alpha coefficient of 0.966, while the conceptual understanding test yielded 0.958. These coefficients indicated high internal consistency within the pilot sample. Because the pilot sample consisted of only 30 students, the item-total correlations and internal-consistency coefficients were interpreted as preliminary evidence of instrument quality. Item difficulty and discrimination indices should only be reported if these analyses were actually conducted.

Data Collection

Data collection was conducted before, during, and after the instructional intervention. Before instruction, both groups completed the conceptual understanding pretest and learning-interest questionnaire. The pretest results were used to describe the initial conditions of the two groups.

During the intervention, classroom implementation was observed and documented. The experimental group received PBL assisted by Kosifacay media, while the control group received conventional teacher-centered instruction. Both groups addressed the same curriculum content and learning objectives.

Following completion of the three-session intervention, the same conceptual understanding test and learning-interest questionnaire were administered as posttests. The resulting pretest and posttest data were subsequently analyzed to examine within-group changes and differences between the instructional conditions.

Ethical Considerations

Permission to conduct the research was obtained from the participating schools. Because the participants were elementary school students, research procedures were conducted in accordance with the applicable school requirements for research involving minors. Student identities and individual assessment results were kept confidential. The manuscript should report parental/guardian consent, student assent, and formal ethics approval only according to the procedures actually conducted. If formal ethics committee approval was not obtained, this should not be stated as having been obtained.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 27. Descriptive statistics were first calculated for learning interest and conceptual understanding, including the mean, standard deviation, minimum, and maximum scores for each group.

Before inferential testing, the assumptions relevant to the planned analyses were examined. The Shapiro–Wilk test was used to assess normality, while Levene's test was used to assess the homogeneity of variance. Because the study employed MANOVA, the homogeneity of covariance matrices was assessed using Box's M test, provided that this analysis was included in the actual statistical analysis. The correlation between learning interest and conceptual understanding was also examined to determine whether the dependent variables were sufficiently related without being redundant.

Changes in learning interest and conceptual understanding from pretest to posttest were examined using paired-samples t -tests. These analyses were interpreted as within-group changes and were not treated independently as definitive evidence of causal treatment effects. To examine the combined differences between the experimental and control groups across learning interest and conceptual understanding, a Multivariate Analysis of Variance (MANOVA) was conducted. Pillai's Trace was used as the primary multivariate statistic because it is relatively robust under unequal group sizes and potential deviations from multivariate assumptions.

Following the multivariate analysis, appropriate univariate tests were used to examine differences for each dependent variable separately. Statistical significance was evaluated at $\alpha = .05$.

Effect sizes were reported where appropriate. Cohen's d was used to describe the magnitude of mean differences, with conventional reference values of 0.20, 0.50, and 0.80 corresponding to small, medium, and large effects, respectively. The coefficient of determination (R^2) was also reported where applicable to describe the proportion of variance associated with the instructional condition.

Because the study involved unequal group sizes, intact classrooms, different schools, and no random assignment, the statistical findings were interpreted cautiously. In particular, differences between the experimental and control groups cannot be attributed exclusively to the Kosifacay-assisted PBL intervention because the instructional condition was completely confounded with school membership. The findings therefore provide context-specific evidence regarding the observed outcomes under the two instructional conditions rather than definitive causal evidence generalizable to other schools or populations. A summary of the statistical analyses performed in this study is presented in [Table 3](#).

Table 3. Summary of Data Analysis

Analysis	Purpose
Descriptive Statistics	Summarize the distribution of learning interest and conceptual understanding scores.
Shapiro–Wilk Test	Examine the assumption of normality.
Levene's Test	Examine the assumption of homogeneity of variance.
Paired Sample <i>t</i> -Test	Determine the effect of the instructional treatment by comparing pretest and posttest scores within the experimental group.
MANOVA (Pillai's Trace)	Examine the simultaneous effect of the instructional treatment on learning interest and conceptual understanding between groups.
Cohen's <i>d</i> and <i>R</i> ²	Determine the magnitude and practical significance of the treatment effect.

RESULTS

This study examined differences in students' learning interest and conceptual understanding following instruction using Problem-Based Learning assisted by Kosifacay media. The analysis involved 43 fifth-grade students, consisting of 15 students in the experimental group and 28 students in the control group. Learning interest was measured using a 20-item questionnaire, whereas conceptual understanding was measured using a 30-item test on the properties of light.

The results are presented in accordance with the research objectives. First, descriptive results for learning interest are presented, followed by the distribution of learning-interest categories. The results for conceptual understanding are then presented, followed by the multivariate analysis of the two dependent variables. Because the groups were non-equivalent and differed in their baseline learning-interest scores, the results are interpreted primarily in terms of observed changes and differences between the instructional conditions rather than as definitive causal effects of the intervention.

Learning Interest

The first analysis examined students' learning interest before and after the instructional process. Descriptive statistics were calculated for both groups to describe changes in students' learning-interest scores.

Table 4. Descriptive Statistics of Students' Learning Interest Scores

Group	<i>n</i>	Minimum	Maximum	Mean	SD
Experimental (Pretest)	15	36	52	44.20	4.52
Experimental (Posttest)	15	54	69	61.40	4.01
Control (Pretest)	28	45	57	50.68	3.26
Control (Posttest)	28	43	56	49.07	3.11

As shown in Table 4, the experimental group had a mean learning-interest score of 44.20 at pretest and 61.40 at posttest, representing an observed increase of 17.20 points. In contrast, the control group had a mean score of 50.68 at pretest and 49.07 at posttest, representing an observed decrease of 1.61 points. The two groups therefore showed different patterns of change. The experimental group demonstrated an increase in learning-interest scores, whereas the control group showed a slight decrease. However, the experimental group had a lower baseline mean than the control group. This baseline difference is important when interpreting the posttest results because the observed difference between groups may reflect both changes during the instructional period and pre-existing differences between the groups.

Table 5. Distribution of Students' Learning Interest Categories

Category	Experimental Pretest (<i>n</i> = 15)	Experimental Posttest (<i>n</i> = 15)	Control Pretest (<i>n</i> = 28)	Control Posttest (<i>n</i> = 28)
Very Good	0 (0.0%)	2 (13.3%)	0 (0.0%)	0 (0.0%)
Good	1 (6.7%)	13 (86.7%)	16 (57.1%)	12 (42.9%)
Moderate	14 (93.3%)	0 (0.0%)	12 (42.9%)	16 (57.1%)
Poor	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

Table 5 shows a substantial change in the distribution of learning-interest categories in the experimental group. At pretest, 14 students (93.3%) were classified in the moderate category and one student (6.7%) in the good category. At posttest, 13 students (86.7%) were classified in the good category and two students (13.3%) in the very good category. No students in the experimental group were classified in the moderate or poor categories at posttest.

The control group showed a different pattern. At pretest, 16 students (57.1%) were classified in the good category and 12 students (42.9%) in the moderate category. At posttest, the number of students in the good category decreased to 12 (42.9%), whereas the number classified in the moderate category increased to 16 (57.1%). Taken together, the descriptive findings indicate an increase in learning interest in the experimental group and a slight decrease in the control group. Nevertheless, these descriptive changes should be interpreted together with the baseline difference between the groups.

Inferential Analysis of Learning Interest

The original paired-samples t-test results required re-examination because the reported statistics were not consistent with the group sizes and descriptive statistics. In particular, the previously reported $t = 2.748$, $df = 42$, and mean difference = 4.953 do not represent a paired-samples comparison conducted solely within the experimental group. The experimental group contained 15 students; therefore, a paired-samples t-test for that group would have $df = 14$. Similarly, a paired-samples t-test for the 28-student control group would have $df = 27$.

Furthermore, the experimental-group descriptive statistics indicate an observed pretest–posttest difference of 17.20 points ($61.40 - 44.20$), which is inconsistent with the previously reported mean difference of 4.953. Therefore, the previous inferential statistics were not retained in the final analysis until they could be verified against the original SPSS output. This correction is important because a paired-samples t-test assesses change within a particular group and should not be interpreted as a direct test of differences between the experimental and control conditions. Accordingly, the revised analysis distinguishes between within-group changes and between-group differences.

Conceptual Understanding

Conceptual understanding was assessed using a 30-item objective test covering the properties of light, including reflection, refraction, light transmission, straight-line propagation, light dispersion, and integrated concepts involving higher-order cognitive processes. The descriptive and inferential results for conceptual understanding were examined using the same analytical framework as the learning-interest data. Particular attention was given to the consistency between the stated number of test items, the scoring procedure, and the reported descriptive statistics.

The previous results reported a conceptual-understanding mean difference of 9.93 points for the experimental group and a Cohen's d value of 0.502. However, the effect-size calculation requires verification against the original data because the reported value appears to have been calculated using a denominator based on the total sample rather than the appropriate comparison. Consequently, the previously reported Cohen's d value was not interpreted as evidence of effect magnitude until the calculation was verified.

In addition, the reported maximum score of 35 requires clarification because the instrument is described as containing 30 items. If the items were scored dichotomously with one point per correct response, the maximum raw score should be 30. Therefore, the final manuscript should explicitly state the scoring procedure if the reported score of 35 was obtained through weighted items or conversion to a different scale.

Multivariate Analysis of Learning Interest and Conceptual Understanding

A Multivariate Analysis of Variance (MANOVA) was conducted to examine the combined pattern of differences in learning interest and conceptual understanding between the experimental and control groups. Pillai's Trace was used as the multivariate test statistic.

Table 6. Multivariate Analysis of Learning Interest and Conceptual Understanding

Multivariate Test	Pillai's Trace	F	df	p
Instructional condition	0.733	54.870	2, 40	< .001

The MANOVA indicated a statistically significant multivariate difference between the experimental and control groups across learning interest and conceptual understanding, Pillai's Trace = 0.733, $F(2, 40) = 54.870$, $p < .001$. Thus, the two instructional conditions were associated with different combined patterns of learning interest and conceptual understanding. However, this result should not be interpreted as definitive evidence that the observed difference was caused solely by the Kosifacay-assisted PBL intervention. The experimental and control groups were drawn from different schools, were not randomly assigned, and differed in their baseline learning-interest scores. Therefore, school-level and pre-existing group differences cannot be completely separated from the instructional condition. The MANOVA result consequently indicates a statistically significant difference between the two instructional conditions on the combined dependent variables, but it does not demonstrate that the intervention alone caused the observed difference.

Effect Size Interpretation

Effect sizes were interpreted using conventional reference values, with Cohen's d of approximately 0.20, 0.50, and 0.80 representing small, medium, and large effects, respectively. Accordingly, a value of $d = 0.502$, if confirmed after recalculation, should be described as approximately a medium effect, rather than a moderate-to-large effect. The previously reported $d = 0.419$ should likewise be recalculated from the verified paired-group data before being included in the final manuscript. Because the original calculation was inconsistent with the reported sample structure, no definitive interpretation of this value is made in the revised Results section.

Summary of Findings

Overall, the descriptive results showed a substantial increase in learning-interest scores in the experimental group, from a mean of 44.20 at pretest to 61.40 at posttest, whereas the control group showed a decrease from 50.68 to

49.07. The categorical distribution showed a corresponding shift in the experimental group, with all students classified in the good or very good categories at posttest.

The MANOVA also showed a statistically significant multivariate difference between the instructional conditions across learning interest and conceptual understanding, Pillai's Trace = 0.733, $F(2, 40) = 54.870$, $p < .001$. These findings indicate different observed outcome patterns between the two instructional conditions. However, because the study used non-equivalent intact groups from different schools and the groups differed at baseline, the findings should be interpreted as evidence of differences associated with the instructional conditions rather than definitive causal evidence of the effectiveness of Kosifacay-assisted Problem-Based Learning.

Effect of Problem-Based Learning Assisted by Kosifacay Media on Students' Learning Interest

This section presents the findings related to the first research objective, namely to examine the effect of Problem-Based Learning assisted by Kosifacay media on Grade V students' learning interest in learning the properties of light. The results are presented through descriptive statistics, changes in students' learning interest categories, and inferential statistical analysis to provide comprehensive evidence regarding the effectiveness of the instructional intervention.

Table 4. Descriptive Statistics of Students' Learning Interest Scores

Group	<i>n</i>	Minimum	Maximum	Mean	SD
Experimental (Pretest)	15	36	52	44.20	4.52
Experimental (Posttest)	15	54	69	61.40	4.01
Control (Pretest)	28	45	57	50.68	3.26
Control (Posttest)	28	43	56	49.07	3.11

Table 4 shows that students in the experimental group demonstrated a substantial increase in learning interest after the implementation of Problem-Based Learning assisted by Kosifacay media. The mean score increased from 44.20 on the pretest to 61.40 on the posttest, indicating an improvement of 17.20 points. In contrast, the control group showed a slight decrease in the mean score from 50.68 to 49.07 following conventional instruction. These findings suggest that students receiving the instructional intervention exhibited greater improvement in learning interest than those taught using conventional learning methods.

Table 5. Distribution of Students' Learning Interest Categories

Category	Experimental Pretest (<i>n</i> = 15)	Experimental Posttest (<i>n</i> = 15)	Control Pretest (<i>n</i> = 28)	Control Posttest (<i>n</i> = 28)
Very Good	0 (0.0%)	2 (13.3%)	0 (0.0%)	0 (0.0%)
Good	1 (6.7%)	13 (86.7%)	16 (57.1%)	12 (42.9%)
Moderate	14 (93.3%)	0 (0.0%)	12 (42.9%)	16 (57.1%)
Poor	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

As presented in Table 5, the distribution of learning interest categories in the experimental group changed markedly following the implementation of Problem-Based Learning assisted by Kosifacay media. Before the intervention, 93.3% of students were categorized as having moderate learning interest, while only 6.7% were classified in the good category. After the intervention, the distribution shifted substantially, with 86.7% of students reaching the good category and 13.3% achieving the very good category. No students remained in the moderate or poor categories after the instructional intervention.

In contrast, the control group did not demonstrate comparable improvement following conventional instruction. Before the intervention, 57.1% of students were already classified in the good category and 42.9% in the moderate category. However, after the learning process, the proportion of students in the good category decreased to 42.9%, whereas the percentage of students in the moderate category increased to 57.1%. These findings indicate that conventional learning was less effective in enhancing students' learning interest than Problem-Based Learning assisted by Kosifacay media.

Table 6. Results of the Paired Sample t-Test and Effect Size for Learning Interest

Variable	Mean Difference	<i>T</i>	<i>df</i>	<i>p</i>	Cohen's <i>d</i>	Interpretation
Learning Interest	4.953	2.748	42	.009	0.419	Moderate

The results of the Paired Sample t-test revealed a statistically significant difference between the pretest and posttest learning interest scores ($t = 2.748$, $p = .009$). Because the probability value was lower than 0.05, the first hypothesis was accepted, indicating that Problem-Based Learning assisted by Kosifacay media significantly improved students' learning interest. Furthermore, the calculated Cohen's *d* value of 0.419 indicates a moderate effect size, suggesting that the instructional intervention produced a meaningful improvement in students' learning interest.

Effect of Problem-Based Learning Assisted by Kosifacay Media on Students' Conceptual Understanding

This section presents the findings related to the second research objective, namely to examine the effect of Problem-Based Learning (PBL) assisted by Kosifacay media on Grade V students' conceptual understanding of

the properties of light. The results are presented sequentially through descriptive statistics, the distribution of conceptual understanding categories, hypothesis testing using the Paired Sample t-test, and effect size analysis to provide comprehensive evidence regarding the effectiveness of the instructional intervention.

Table 7. Descriptive Statistics of Students' Conceptual Understanding Scores

Group	<i>n</i>	Minimum	Maximum	Mean	SD
Experimental (Pretest)	15	15	25	19.67	2.80
Experimental (Posttest)	15	25	35	29.60	2.85
Control (Pretest)	28	12	27	19.89	3.77
Control (Posttest)	28	12	28	20.25	4.32

Table 7 shows that students who learned through Problem-Based Learning assisted by Kosifacay media experienced a substantial improvement in conceptual understanding after the instructional intervention. The mean score of the experimental group increased from 19.67 (SD = 2.795) on the pretest to 29.60 (SD = 2.849) on the posttest, representing an average gain of 9.93 points. In addition, the minimum score increased from 15 to 25, while the maximum score increased from 25 to 35, indicating that learning gains occurred across students with different initial achievement levels. Conversely, the control group demonstrated only a marginal improvement, with the mean score increasing from 19.89 (SD = 3.765) to 20.25 (SD = 4.317). The minimum score remained unchanged at 12, whereas the maximum score increased only slightly from 27 to 28. Overall, these descriptive findings indicate that students receiving Problem-Based Learning assisted by Kosifacay media achieved considerably greater conceptual understanding than those who participated in conventional learning.

Table 8. Distribution of Students' Conceptual Understanding Categories

Category	Experimental Pretest (<i>n</i> = 15)	Experimental Posttest (<i>n</i> = 15)	Control Pretest (<i>n</i> = 28)	Control Posttest (<i>n</i> = 28)
Good	0 (0.0%)	15 (100.0%)	16 (57.1%)	12 (42.9%)
Moderate	13 (86.7%)	0 (0.0%)	12 (42.9%)	16 (57.1%)
Poor	2 (13.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

As presented in Table 8, the distribution of conceptual understanding categories in the experimental group improved markedly following the implementation of Problem-Based Learning assisted by Kosifacay media. Prior to the intervention, 86.7% of students were categorized as having moderate conceptual understanding, while 13.3% were classified as poor, indicating that none of the students had achieved the good category. After the intervention, all students (100.0%) reached the good category, demonstrating a complete transition toward higher conceptual understanding.

Simultaneous Effect of Problem-Based Learning Assisted by Kosifacay Media on Students' Learning Interest and Conceptual Understanding

This section presents the findings related to the third research objective, namely to examine the simultaneous effect of Problem-Based Learning (PBL) assisted by Kosifacay media on Grade V students' learning interest and conceptual understanding of the properties of light. The multivariate analysis was conducted using Multivariate Analysis of Variance (MANOVA) to determine whether the instructional intervention simultaneously influenced both dependent variables.

Table 9. Results of Multivariate Analysis of Variance (MANOVA)

Multivariate Test	Value	F	Hypothesis <i>df</i>	Error <i>df</i>	<i>p</i>
Pillai's Trace	0.733	54.870	2	40	< .001
Wilks' Lambda	0.267	54.870	2	40	< .001
Hotelling's Trace	2.743	54.870	2	40	< .001
Roy's Largest Root	2.743	54.870	2	40	< .001

Table 9 presents the results of the multivariate analysis examining the simultaneous effect of Problem-Based Learning assisted by Kosifacay media on students' learning interest and conceptual understanding. Considering the unequal sample sizes between the experimental and control groups, Pillai's Trace was used as the primary multivariate statistic because it provides a robust estimate under such conditions. The analysis yielded a Pillai's Trace value of 0.733, with $F(2, 40) = 54.870$ and $p < .001$, indicating a statistically significant multivariate effect of the instructional treatment on the combined dependent variables. These findings demonstrate that the instructional intervention simultaneously influenced students' learning interest and conceptual understanding.

To determine the practical significance of the multivariate effect, the coefficient of determination (R^2) was examined for each dependent variable. The results showed that the instructional treatment explained 53.4% of the variance in learning interest ($R^2 = 0.534$) and 58.1% of the variance in conceptual understanding ($R^2 = 0.581$). These coefficients indicate that more than half of the variation in both learning outcomes was attributable to the

implementation of Problem-Based Learning assisted by Kosifacay media, suggesting a substantial educational impact of the intervention.

DISCUSSION

The findings indicate that students in the Problem-Based Learning (PBL) assisted by Kosifacay group showed a greater observed increase in learning interest than students in the comparison group. Constructivist learning theory provides a relevant perspective for interpreting the observed pattern because learning is conceptualized as an active process in which learners construct knowledge through interaction, exploration, and reflection rather than passively receiving information. Student-centered learning environments characterized by active participation, collaborative inquiry, and authentic problem-solving activities may support students' engagement, motivation, and interest in science learning (Safitri et al., 2023; Apriansyah, A. et al., 2024). Classroom activities in the present research involved contextual problem solving, group discussion, observation, and experimentation using Kosifacay media. Active interaction with learning materials and peers may have contributed to the observed increase in learning interest among students in the experimental group (Aripin et al., 2025).

Student-centered learning principles further suggest that motivation and engagement can be supported when instructional activities provide opportunities for autonomy, competence, and social interaction (Irwandi et al., 2024; Pangestu et al., 2024; Auliya et al., 2025). Learning activities in the intervention required students to investigate the properties of light using Kosifacay media, discuss observations with group members, and present solutions to contextual problems. Opportunities for active participation, collaborative interaction, and problem solving characterized the instructional process. Such characteristics are consistent with previous research suggesting that active and collaborative learning environments can support students' interest and engagement in science learning (Gunawan & Al, 2025). However, differences between the instructional groups should be interpreted cautiously because the research used nonequivalent groups from different schools and the initial learning-interest levels were unequal. Consequently, the observed increase cannot be attributed solely to PBL assisted by Kosifacay media.

Previous studies have reported positive relationships between PBL and students' motivation, classroom engagement, and learning interest. Collaborative inquiry, problem investigation, and solution development provide learners with opportunities to participate actively in the learning process (Simanjuntak et al., 2024; Marhami et al., 2024). Concrete instructional media may likewise support enthusiasm and participation by transforming abstract scientific concepts into observable and meaningful learning experiences (Putri et al., 2025; Setianingsih et al., 2024; Anas et al., 2024). The instructional framework examined in the present research combined contextual problem solving with direct interaction with Kosifacay media. Students investigated problems while also examining scientific phenomena through concrete learning activities. Such integration may have increased the meaningfulness and interactivity of classroom experiences. Nevertheless, evidence from the current design cannot establish that the combined approach provides greater benefits than PBL or Kosifacay media implemented independently because separate PBL-only and Kosifacay-only comparison groups were not included. A factorial or multi-group experimental design would be required to examine the independent and combined contributions of the two instructional components.

Conceptual understanding also showed a substantial observed increase among students who participated in PBL assisted by Kosifacay media. Concrete learning experiences provide one possible explanation for the pattern because students were given opportunities to observe phenomena related to light reflection, refraction, transmission, and shadow formation. Direct observation and experimentation allowed students to connect scientific explanations with observable phenomena. Concrete experiences are particularly relevant in elementary science learning because abstract explanations can become more accessible when learners interact directly with objects and phenomena. The Cognitive Theory of Multimedia Learning also provides a complementary theoretical perspective by emphasizing the integration of meaningful verbal and visual representations in knowledge construction (Mayer, 2021). Kosifacay activities incorporated concrete and visual representations alongside discussion, observation, and problem solving, potentially providing multiple opportunities for students to organize conceptual knowledge.

Previous research similarly indicates that PBL can support conceptual understanding through inquiry, evidence-based reasoning, collaborative problem solving, and active knowledge construction (Ilahi et al., 2024). Inquiry-oriented learning can become more meaningful when appropriate instructional media are incorporated into scientific investigations (Doyan et al., 2024). Research concerning PBL and active investigation has also reported improvements in learning outcomes and conceptual understanding, particularly when instructional activities emphasize higher-order thinking (Asmiyunda & Hardeli, 2023). Interactive instructional media have additionally been associated with improved conceptual understanding among elementary students, although several studies have focused primarily on media development rather than integration with inquiry-oriented learning (Tirtawati et al., 2025). Digital instructional media combined with PBL have also been examined in previous research, particularly through game-based learning environments (Ariyanti et al., 2025). Kosifacay extends the existing

discussion by representing a concrete learning medium integrated into PBL activities for investigating scientific phenomena related to light.

The multivariate analysis indicated a statistically significant difference between the instructional conditions when learning interest and conceptual understanding were examined simultaneously, as reflected by the Pillai's Trace statistic. A multivariate perspective is relevant because affective and cognitive outcomes can develop within the same instructional process. Contextual problem solving, group discussion, observation, and experimentation were incorporated into the learning sequence, allowing students to engage with problems while developing conceptual knowledge. Constructivist learning principles provide a theoretical basis for understanding such integration because active engagement with problems and learning materials can support knowledge construction. Nevertheless, school-level confounding represents an important limitation. Experimental and comparison conditions were implemented in different schools, resulting in complete confounding between treatment condition and school. Differences in school characteristics, classroom environments, teacher-related factors, peer interactions, or other contextual conditions may therefore have contributed to the observed group differences.

Baseline imbalance in learning interest represents another important consideration. The experimental group started with a lower mean learning-interest score than the comparison group, creating a potential source of bias in interpreting subsequent changes. Regression toward the mean may also contribute to greater observed change when a group begins with a relatively lower baseline value. Consequently, posttest differences and pretest–posttest changes should be interpreted in conjunction with the initial group characteristics. Inferential statistics should also correspond directly with the actual sample size of each group and the descriptive statistics reported in the manuscript. Any statistical output that does not correspond to the group-specific sample sizes should be rechecked before inclusion in the final interpretation.

The findings have relevance to the principles of the Merdeka Curriculum, particularly the emphasis on student-centered learning, contextual activities, collaboration, investigation, and higher-order thinking through meaningful learning experiences (Azkia et al., 2025; Maharani et al., 2024). PBL assisted by concrete instructional media represents one possible classroom approach for implementing such principles in elementary science education. Connections with Sustainable Development Goal 4 (SDG 4) should nevertheless remain appropriately bounded. The study provides a small-scale example of instructional practices involving participation, contextual investigation, and meaningful learning, but the available evidence cannot establish a direct contribution of the intervention to the broader achievement of SDG 4. Larger studies involving diverse schools, populations, and educational settings would be necessary to support broader conclusions.

Practical implications can be drawn for elementary science teachers who seek to integrate contextual problem solving with concrete instructional media. Kosifacay can function as a supporting medium within PBL by providing opportunities for students to investigate observable scientific phenomena through direct experience. Classroom implementation may therefore combine problem orientation, group investigation, experimentation, discussion, and presentation activities. Context-specific conditions should be considered when applying the approach because the research involved 43 students from two public elementary schools, with 15 students in the experimental group and 28 students in the comparison group. Naturally existing classroom groups and the absence of random assignment further restrict the generalizability of the findings.

Overall, the research contributes empirical evidence concerning the observed differences in learning interest and conceptual understanding between two nonequivalent instructional conditions involving PBL assisted by Kosifacay media and conventional instruction. Constructivist learning theory, concrete experiential learning, and multimedia-learning perspectives provide theoretical explanations for the observed patterns, while previous PBL and instructional-media research provides supporting empirical context. Causal conclusions, however, should remain limited because school and treatment conditions were completely confounded, baseline learning-interest levels were unequal, and the sample size was relatively small. Future research should involve larger samples, multiple schools within each instructional condition, stronger matching or randomization procedures where feasible, and separate comparison groups for PBL and Kosifacay media. Such research would provide stronger evidence regarding the contribution of each instructional component while reducing the influence of school, teacher, classroom, and baseline differences.

CONCLUSION

Findings indicate that students who received Problem-Based Learning (PBL) assisted by Kosifacay media showed larger observed changes in learning interest and conceptual understanding of the properties of light than students in the comparison group. Multivariate analysis also indicated a statistically significant difference between the two instructional conditions when learning interest and conceptual understanding were considered simultaneously. However, interpretation of the findings should be limited to differences between nonequivalent instructional conditions rather than definitive evidence of a causal effect of PBL assisted by Kosifacay media. Experimental and comparison groups were drawn from different schools, resulting in school-level confounding, while baseline learning-interest levels also differed between groups. School, classroom, teacher, and other contextual factors may therefore have contributed to the observed differences.

A principal contribution of the study lies in examining PBL and Kosifacay media within a single instructional framework for elementary science learning. Classroom activities involving contextual problem solving, collaboration, observation, and direct experimentation provided opportunities for students to engage with scientific phenomena while developing conceptual understanding and learning interest. Findings provide preliminary empirical evidence concerning the potential of Kosifacay-assisted PBL as an instructional approach for teaching the properties of light. Practical relevance can be considered within the context of the Merdeka Curriculum, particularly its emphasis on student-centered, contextual, collaborative, and experiential learning. Connections with Sustainable Development Goal 4 (SDG 4) should be understood as potential educational relevance rather than evidence of a direct contribution of the intervention to achieving SDG 4.

Several limitations should be considered when interpreting the findings. The study involved 43 Grade V students from two public elementary schools, comprising 15 students in the experimental group and 28 students in the comparison group. Naturally existing classroom groups, implementation of the two instructional conditions in different schools, unequal baseline learning-interest levels, and focus on a single science topic limit causal inference and generalizability. Future research should involve multiple schools and classes within each instructional condition, employ stronger randomization or matching procedures where feasible, and conduct an appropriate power analysis before data collection. Baseline-adjusted statistical analyses should also be considered to account for initial group differences. Longitudinal research incorporating retention measures would provide further evidence concerning the sustainability of changes in conceptual understanding and learning interest. Additional outcomes, including scientific literacy, critical thinking, and problem-solving skills, could also be examined to provide a broader understanding of the educational potential of Kosifacay-assisted PBL.

REFERENCE

- Anas, N., & Hartono. (2024). Science learning media for elementary school students. *Jurnal Penelitian Pendidikan IPA*, 10(1), 9020–9026. <https://doi.org/10.29303/jppipa.v10i11.9227>
- Anggraeni, D. M., Prahani, B. K., Suprpto, N., Shofiyah, N., & Jatmiko, B. (2023). Systematic review of problem-based learning research in fostering critical thinking skills. *Thinking Skills and Creativity*, 49, 101334. <https://doi.org/10.1016/j.tsc.2023.101334>
- Apriansyah, A., Sari, N., Nizaar, M., & Alaa, S. (2024). Project-based learning model on elementary school students' science process skills and creative thinking skills. *Jurnal Ilmiah Sekolah Dasar*, 8(1), 120–128. <https://doi.org/10.23887/jisd.v8i1.64273>
- Aripin, N., Festiyed, Yermadesi, Alberida, H., Ahda, Y., & Mufit, F. (2025). The impact of Problem-Based Learning on science learning to improve students' critical thinking and problem-solving skills: A meta-analysis. *Jurnal Penelitian Pendidikan IPA*, 11(6), 45–57. <https://doi.org/10.29303/jppipa.v11i6.10051>
- Ariyanti, D., Sulianto, J., & Buchori, A. (2025). Development of EDUMEDIG media with the Problem-Based Learning model to improve science understanding. *Indonesian Journal of Educational Development*, 6(3), 1055–1070. <https://doi.org/10.59672/ijed.v6i3.5614>
- Asmiyunda, & Hardeli. (2023). The effect of problem-based learning (PBL) on learning outcomes: Meta-analysis. *Pedagogia: Jurnal Ilmu Pendidikan*, 21(2), 161–172. <https://doi.org/10.17509/pdgia.v21i2.65061>
- Asnawi, Sahudra, T. M., Ramadhani, D., Kenedi, A. K., Aosi, G., Wardhana, M. R., & Khalil, N. A. (2023). Development of digital diagnostic test instruments for differentiated learning process in elementary schools. *Jurnal Penelitian Pendidikan IPA*, 9(Special Issue), 460–466. <https://doi.org/10.29303/jppipa.v9iSpecialIssue.6125>
- Auliya, R., Adi, S., Rakhmawati, S., Suryani, L., Haliem, D., Pangastuti, & D. (2025). Enhancing third graders' understanding of the water cycle through Problem-Based Learning and Wordwall integration. *Jurnal Prima Edukasia*, 13(2), 324–338. <https://doi.org/10.21831/jpe.v13i2.80657>
- Azkia, S., Maksum, A., & Usman, H. (2025). Improving critical thinking abilities in social studies learning using the Problem Based Learning model assisted by audio-visual media in elementary school students. *Jurnal Cakrawala Pendas*, 11(1), 18–32. <https://doi.org/10.31949/jcp.v11i1.11809>
- Cohen, L., Manion, L., & Morrison, K. (2024). *Research methods in education* (9th ed.). Routledge. <https://doi.org/10.4324/9781315456539>
- Creswell, J. W., & Poth, C. N. (2023). *Qualitative inquiry and research design: Choosing among five approaches* (5th ed.). SAGE Publications.
- David, L., & Weinstein, N. (2024). Using technology to make learning fun: Technology use is best made fun and challenging to optimize intrinsic motivation and engagement. *European Journal of Psychology of Education*, 39, 1441–1463. <https://doi.org/10.1007/s10212-023-00734-0>
- Dewanti, S., Rahmawati, & Sumardi. (2025). Problem-Based Learning with manipulative media: Enhancing elementary students' conceptual understanding in area and volume. *Jurnal Ilmiah Sekolah Dasar*, 8(3), 487–499. <https://doi.org/10.23887/jisd.v8i3.80221>

- Doyan, A., Rahayu, S., Lugi, F., & Annam, S. (2024). Trends research problem-based learning (PBL) model to improve generic science skills in students' science learning (2015–2024): A systematic review. *Jurnal Penelitian Pendidikan IPA*, 10(9), 621–630. <https://doi.org/10.29303/jppipa.v10i9.8370>
- Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2024). *How to design and evaluate research in education* (11th ed.). McGraw-Hill.
- Gunawan, W., Atiqoh, W., Wiyarno, Y., Fatirul, A. N., Sugiarni, & Mastoah, I. (2025). Enhancing students' problem-solving abilities: The role of project-based learning, problem-based learning, and learning motivation. *Jurnal Pendidikan Progresif*, 15(1), 315–330. <https://doi.org/10.23960/jpp.v15i1.pp315-330>
- Halim, A., Iskandar, I., Ansari, A., & Halim, N. M. (2024). A study on how the Merdeka curriculum promotes multilingualism in Indonesian ELT classrooms. *XLinguae*, 17(2), 107–121. <https://doi.org/10.18355/XL.2024.17.02.07>
- Hidayati, T., & Purwaningsih, D. (2023). The effect of applying problem-based learning model on students' critical thinking ability in science subjects. *Jurnal Pendidikan Indonesia*, 12(3), 576–585. <https://doi.org/10.23887/tscj.v6i2.61354>
- Howard, J. L., Bureau, J., Guay, F., Chong, J. X. Y., & Ryan, R. M. (2021). Student motivation and associated outcomes: A meta-analysis from self-determination theory. *Perspectives on Psychological Science*, 16(6), 1300–1323. <https://doi.org/10.1177/1745691620966789>
- Ilahi, D. P., Festiyed, Yerimadesi, Yulkifli, Utami, L., & Ratih, A. (2024). Evaluating the impact of problem-based learning on students' metacognition in science learning: A meta-analysis review. *Jurnal Penelitian Pendidikan IPA*, 10(8), 526–525. <https://doi.org/10.29303/jppipa.v10i8.7892>
- Irwandi, H., Y., H., T., & Fitriani, A. (2024). Impact of problem-based learning-blended learning on students' creativity and learning interest. *Jurnal Penelitian Pendidikan IPA*, 10(1), 37–46. <https://doi.org/10.29303/jppipa.v10i1.5366>
- Julianto, F., Hidayati, F., Rahmawati, J. F., Cahyaningsih, R., & Surrahman, I. (2023). Training students' critical thinking skills through inquiry models to minimize science misconceptions. *Jurnal Penelitian Pendidikan IPA*, 9(11), 1011–1015. <https://doi.org/10.29303/jppipa.v9i11.3757>
- 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, 101069. <https://doi.org/10.1016/j.tsc.2022.101069>
- Maharani, W., Riastini, P. N., & Asril, N. M. (2024). Model pembelajaran Problem Based Learning (PBL) berorientasi gaya belajar siswa terhadap minat belajar IPAS kelas IV sekolah dasar. *Jurnal Penelitian dan Pengembangan Sains dan Humaniora*, 8(1), 77–84.
- Mayer, R. E. (2021). *Multimedia learning* (3rd ed.). Cambridge University Press.
- OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. <https://doi.org/10.1787/53f23881-en>
- Pangestu, K., Malagola, Y., Robbaniyah, I., & Rahajeng, D. (2024). The influence of project-based learning on learning outcomes, creativity and student motivation in science learning at elementary schools. *Jurnal Prima Edukasia*, 12(2), 194–203. <https://doi.org/10.21831/jpe.v12i2.63208>
- PISA. (2023). *PISA 2022 results: Factsheets*. OECD Publishing. <https://doi.org/10.1787/53f23881-en>
- Putri, R., Wibawa, C. I. M., & Astawan, I. G. (2025). The influence of media-assisted Problem Based Learning with concrete media on elementary students' conceptual understanding. *MIMBAR PGSD Undiksha*, 13(3), 433–441. <https://doi.org/10.23887/jppgsd.v13i3.103543>
- Rizki, I. A., & Suprpto, N. (2024). Project-oriented problem-based learning through SR-STEM to foster students' critical thinking skills in renewable energy material. *Journal of Science Education and Technology*, 33(4), 526–541. <https://doi.org/10.1007/s10956-024-10102-2>
- Safitri, R., Hadi, S., & Widiasih, W. (2023). Effect of the problem-based learning model on the students' motivation and learning outcomes. *Jurnal Penelitian Pendidikan IPA*, 9(9), 7310–7316. <https://doi.org/10.29303/jppipa.v9i9.4772>
- Setianingsih, D., Siswono, T. Y. E., & Yumiati. (2024). Development of web-based learning media (Google Sites) to improve critical thinking skills and digital literacy of Grade V elementary school students. *ELSE (Elementary School Education Journal)*, 8(2). <https://doi.org/10.30651/else.v8i2.23179>
- Simanjuntak, Y. I. W., & Purwaningsih, D. (2024). STEM integrated problem-based learning: The implementation and roles in science learning. *Jurnal Pendidikan MIPA*, 25(2), 686–700. <https://doi.org/10.23960/jpmipa.v25i2.pp686-700>
- Suhelayanti, Syamsiah, Z., Rahmawati, I., Tantu, P., Tangio, J. S., & Anzelina, D. (2023). *Pembelajaran ilmu pengetahuan alam dan sosial (IPAS)*. Yayasan Kita Menulis.
- Tabachnick, B. G., & Fidell, L. S. (2019). *Using multivariate statistics* (7th ed.). Pearson.
- Tirtawati, I. G. A., Wibawa, I. M. C., & Dharmayanti, P. A. (2025). Development of problem-solving-based flipbook learning media to improve science learning outcomes of fifth grade elementary school students. *Journal of Education Technology*, 9(2), 353–363. <https://doi.org/10.23887/jet.v9i2.91622>

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to SDN 1 Jepangrejo and SDN Kauman, Blora Regency, for their support and cooperation throughout the implementation of this study. The authors also extend their appreciation to the school principals, Grade V teachers, and all students who participated in the research. Special thanks are addressed to the expert validators for their valuable suggestions in improving the research instruments and to all individuals whose contributions facilitated the successful completion of this study.

AUTHOR CONTRIBUTION STATEMENT

Conceptualization: YAYW and JS; Methodology: YAYW and JS; Formal analysis: YAYW and JS; Investigation: YAYW; Data curation: YAYW; Resources: YAYW; Visualization: YAYW; Writing original draft: YAYW; Writing, review and editing: JS and IP; Supervision: JS and IP. All authors have read and agreed to the published version of the manuscript

AI DISCLOSURE STATEMENT

The authors used ChatGPT by OpenAI during the preparation of this manuscript to assist with language refinement, organization, and clarity of presentation. The tool was not used to generate, modify, or analyze the research data. After using the tool, the authors thoroughly reviewed, verified, and edited the content and take full responsibility for the accuracy and integrity of the publication.

***Yuan Alfa Yoga Winarta (Corresponding Author)**

Master's Program in Elementary Education, Postgraduate Program,
Universitas PGRI Semarang,
Jl. Sidodadi Timur No. 24, Karangtempel, Semarang Timur, Semarang, Central Java 50232, Indonesia
Email: yuan.alfa.yoga@gmail.com

Joko Sulianto (Corresponding Author)

Master's Program in Elementary Education, Postgraduate Program,
Universitas PGRI Semarang,
Jl. Sidodadi Timur No. 24, Karangtempel, Semarang Timur, Semarang, Central Java 50232, Indonesia
Email: jokosulianto@upgris.ac.id

Iin Purnamasari

Master's Program in Elementary Education, Postgraduate Program,
Universitas PGRI Semarang,
Jl. Sidodadi Timur No. 24, Karangtempel, Semarang Timur, Semarang, Central Java 50232, Indonesia
Email: iin.purnamasari@gmail.com
