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The effect of project-based learning integrated with interactive camera simulator learning media on students' learning outcomes in photography techniques

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ABSTRACT

Photography Techniques requires students to connect visual concepts with practical decisions involving camera angles, shot sizes, and composition. Preliminary classroom observation at SMKN 1 Sampang recorded difficulties among 14 of 25 students (56%). This study was designed to examine the effect of Project-Based Learning (PjBL) integrated with interactive multimedia on tenth-grade students' cognitive learning outcomes using a quasi-experimental pretest–posttest control-group design. The draft describes 40 students in an experimental group and a control group (20 students each), with a cognitive test administered before and after instruction. The proposed analysis includes descriptive statistics, assumption checks, within-group and between-group comparisons, normalized gain, and effect size. However, the numerical results currently included in the manuscript have not been verified against the original participant-level dataset. Therefore, reported means, significance tests, and effect sizes should be treated as provisional and must not be interpreted as confirmed empirical findings until the original data, instrument quality evidence, and analysis output have been checked. The study's intended contribution is to examine how interactive visual explanations and questions can prepare students for the planning, production, presentation, and evaluation stages of a photography project.

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Introduction

Vocational education plays a strategic role in preparing students with competencies that are relevant to the demands of the workplace and the development of contemporary industries. Unlike general education, vocational education places greater emphasis on the integration of theoretical knowledge, practical skills, problem-solving abilities, and the application of competencies in authentic contexts. Therefore, the learning process in vocational high schools should not only enable students to understand concepts but also provide opportunities for them to apply, practice, evaluate, and produce work related to their field of expertise. This orientation is particularly important in vocational programs associated with the creative industry, including broadcasting, multimedia, photography, and audiovisual production, where students are expected to demonstrate both conceptual understanding and technical competence.

The development of the creative and digital industries has further increased the need for students to possess practical competencies in visual communication and audiovisual production. Students in vocational programs are expected to understand not only how technical equipment is operated but also why particular techniques are selected and how those techniques influence the quality and meaning of a visual product. Consequently, learning activities need to provide meaningful experiences that connect theoretical concepts with practical situations. Learning that is dominated by verbal explanations and memorization may be insufficient for competencies that are inherently visual, procedural, and performance-oriented.

One of the competencies that reflects these characteristics is Photography Techniques (*Teknik Pengambilan Gambar*). This competency includes various concepts and practical skills, such as camera angles, shot sizes, composition, perspective, camera positioning, and the selection of appropriate techniques according to visual objectives. Understanding these concepts requires students to recognize visual differences and understand the relationship between technical decisions and the resulting image. Students therefore need opportunities to observe examples, compare different visual techniques, identify the characteristics of each technique, understand its function, and subsequently apply the knowledge through practical activities. The learning process should move beyond the ability to recall terminology toward the ability to use technical knowledge in an authentic production context.

The need for such learning experiences is also reflected in the preliminary observation conducted in Photography Techniques learning among tenth-grade students at SMKN 1 Sampang. Of the 25 students observed, 14 students (56%) experienced difficulties in understanding and appropriately applying photography techniques, while 11 students (44%) were relatively able to follow the learning activities and understand the basic concepts. The difficulties were particularly apparent when students were required to identify camera angles, determine appropriate composition, distinguish different shot types, and select suitable techniques during practical activities. Some students were able to mention technical terms but had difficulty connecting those terms with actual visual situations and practical applications. This condition indicates that students' conceptual knowledge does not necessarily translate automatically into practical competence.

The gap between conceptual understanding and practical application can be framed through experiential learning: learners need opportunities to encounter examples, interpret them, test decisions in practice, and reflect on the results. For Photography Techniques, visual demonstrations may make differences among camera angles, shot sizes, and composition easier to inspect, while a structured project gives students a context in which to apply those distinctions. This rationale supports testing an integrated approach; it does not, by itself, establish that the intervention is effective.

Project-Based Learning (PjBL) is one instructional model that has characteristics compatible with the needs of vocational education. PjBL positions a project or product as an important component of the learning process and requires students to engage in a series of activities involving planning, investigation, implementation, problem solving, production, presentation, and evaluation. Through this process, students can experience a learning environment in which theoretical knowledge is used as a basis for completing a meaningful task. The project-oriented nature of PjBL is particularly relevant to vocational competencies because students are required to demonstrate what they know through tangible products or performances rather than through theoretical understanding alone.

Previous studies have provided evidence regarding the potential of PjBL in vocational education. (Akhyar et al., 2024), for example, developed problem-based and project-based learning syntax for vocational education and highlighted the relevance of project-oriented learning for improving student learning outcomes. (Dewangga & Ahmad, 2023) also reviewed the implementation of PjBL in practical learning among vocational students and emphasized its potential for supporting students' practical competencies. Similarly, (Herlambang et al., 2023) examined the implementation of PjBL among vocational high school students majoring in information technology by considering both cognitive and psychomotor learning outcomes. Their findings indicate that PjBL can influence different dimensions of competency, although the magnitude of its effect may vary according to the learning outcomes being assessed.

The effectiveness of PjBL in vocational contexts has also been reported in more recent studies. (Hidayat & Widiyanti, 2025) examined the effect of PjBL on cognitive and psychomotor competencies among vocational high school students in CAD learning. (Desmira et al., 2026) investigated PjBL supported by e-learning in vocational education courses and reported its relevance to student learning outcomes. (Liawati et al., 2025) likewise examined the effectiveness of PjBL in accounting education at the vocational high school level. These studies collectively suggest that project-based approaches can create opportunities for students to apply knowledge through structured activities and products. Nevertheless, the implementation of PjBL still requires

instructional resources that can help students acquire and process the knowledge needed before and during project completion.

In addition to selecting an appropriate instructional model, the selection of learning media is an important consideration, particularly for competencies that involve visual and procedural knowledge. Interactive multimedia represents one potential medium because it combines visual demonstrations, narration, and interactive elements within a single learning experience. Through multimedia, students can observe how a particular technique is performed rather than relying solely on verbal descriptions or static illustrations. In Photography Techniques learning, for example, students can observe differences between high-angle, eye-level, and low-angle shots; compare various shot sizes; and examine how changes in composition influence the visual presentation of an object.

The addition of interactive elements can further distinguish interactive multimedia from conventional instructional multimedia. Interactive multimedia can incorporate questions, pauses, response activities, embedded tasks, or formative feedback that require students to process information while watching. Consequently, students are not positioned merely as passive viewers. They are encouraged to pay attention to important concepts, respond to questions, check their understanding, and reflect on the information presented. This characteristic is particularly relevant to learning materials in which students need to distinguish visual characteristics and make decisions based on examples.

Several studies have reported the potential of interactive multimedia for supporting learning outcomes. (Ramadani & Nurharini, 2024) investigated Edpuzzle-based interactive multimedia and reported its use in supporting students' learning outcomes. (Fithriyani et al., 2026) developed Edpuzzle-based interactive multimedia containing embedded questions and formative feedback, demonstrating the potential of interactive multimedia to transform multimedia viewing into a more active learning experience. (Prastya et al., 2025) also examined the use of H5P interactive multimedia as a learning medium for vocational high school students and reported its relevance to improving learning outcomes. Furthermore, (Sucipto et al., 2026) investigated interactive multimedia-based learning and its relationship with students' learning outcomes. These studies indicate that interactive multimedia can function not merely as a presentation medium but also as an instructional environment that encourages students to engage with learning content.

Interactive multimedia has also been recognized as relevant to vocational learning because it can provide simulations and concrete representations of technical procedures. (Wibawanto et al., 2022), for example, examined simulation-based interactive multimedia to support vocational students' learning outcomes. Such findings are relevant to Photography Techniques because students need to understand visual procedures and technical decisions that are difficult to fully represent through textual explanations. Visual demonstrations can reduce the abstraction of technical concepts by presenting examples that students can directly observe and analyze.

Although PjBL and interactive multimedia each offer important advantages, using either one independently may not fully address the learning needs of Photography Techniques. PjBL provides students with opportunities to conduct authentic projects, but students may still require adequate conceptual and visual preparation before beginning the project. Conversely, interactive multimedia can facilitate students' understanding of concepts and provide concrete examples, but watching instructional content alone does not necessarily guarantee that students will be able to apply the knowledge in an authentic production activity. Therefore, integrating the two approaches may provide a more coherent learning experience.

The integration of PjBL with interactive multimedia can create a learning sequence that connects conceptual understanding, visual observation, active processing, practical application, and product creation. Interactive multimedia can initially function as a stimulus and learning resource through which students explore examples of camera angles, shot sizes, composition, and other photography techniques. Embedded questions or activities can encourage students to identify and analyze the techniques presented. After acquiring the necessary conceptual foundation, students can proceed to the project phase by determining the project objectives, planning the shots, selecting appropriate techniques, carrying out the photography process, and producing a visual product. The resulting product can then be presented, discussed, evaluated, and revised.

This integration is consistent with the characteristics of vocational learning, which emphasizes the relationship between knowledge and performance. Students are not only expected to know what a particular technique is but also to demonstrate when, why, and how the technique should be applied. For example, after observing an interactive multimedia demonstrating different camera angles, students can be asked to identify the visual effect of each angle and subsequently apply the appropriate angle when producing their own photographs. Similarly, after learning about shot sizes through interactive examples, students can use that

knowledge to plan a sequence of photographs as part of their project. In this way, learning content is directly connected to an observable product.

From a pedagogical perspective, the integration of PjBL and interactive multimedia also has the potential to support more active student participation. The interactive multimedia provides structured learning support during the knowledge acquisition stage, while PjBL provides opportunities for students to make decisions, collaborate, solve problems, and create products. The two components therefore serve complementary functions. Interactive multimedia supports the acquisition and processing of information, whereas PjBL provides a context for applying and demonstrating the acquired knowledge.

Nevertheless, the implementation of PjBL is not without challenges. Project-based learning requires adequate time, learning resources, classroom management, and teacher facilitation. Students may also demonstrate different levels of readiness when working on projects. In addition, technical competencies such as Photography Techniques require appropriate equipment and opportunities for repeated practice. The quality and relevance of instructional media are therefore important factors in ensuring that students have sufficient conceptual preparation before undertaking practical projects. Interactive multimedia can potentially address part of this challenge by providing students with accessible visual demonstrations that can be reviewed before and during project activities.

The preliminary condition at SMKN 1 Sampang further strengthens the relevance of integrating these approaches. The finding that 56% of the observed students experienced difficulties indicates that the problem is not simply related to students' ability to memorize photography terminology. Rather, the difficulty concerns the process of connecting conceptual knowledge with practical situations. Students need learning experiences that make abstract concepts visible and provide opportunities to apply those concepts through meaningful activities. A combination of interactive visual media and project-based learning therefore provides a logical instructional alternative for addressing this learning problem.

Prior studies cited in this manuscript examine PjBL in vocational settings and interactive multimedia in several subject areas. However, the references currently assembled provide limited direct evidence about the combined intervention in vocational photography learning. The present study addresses this contextual gap by comparing a class receiving PjBL supported by interactive multimedia with a class receiving conventional instruction. Because the design uses existing groups and a single school context, the study should be interpreted as a context-specific quasi-experiment rather than evidence of universal generalizability.

The present study examines the effect of Project-Based Learning integrated with interactive multimedia on cognitive learning outcomes in Photography Techniques among tenth-grade students at SMKN 1 Sampang. The proposed mechanism is complementary: interactive multimedia supplies visual examples, simulations, and embedded questions to support initial processing, whereas PjBL structures the application of that knowledge through planning, production, presentation, feedback, and reflection.

The research question is whether posttest learning outcomes differ between students who receive PjBL integrated with interactive multimedia and students who receive conventional instruction, after considering their pretest performance. The contribution sought is practical and context-bound: clarifying whether the integrated sequence is associated with better cognitive outcomes in vocational photography learning. Claims about causality depend on transparent reporting of group assignment, instrument quality, baseline comparability, and verified statistical results.

Method

Research Design

This study employed a quantitative approach using a quasi-experimental method. A pretest-posttest control group design was used to examine the effect of Project-Based Learning (PjBL) integrated with interactive multimedia on students' learning outcomes in Photography Techniques. This design was selected because the study involved existing student groups and aimed to compare changes in learning outcomes between students who received the integrated learning treatment and those who received conventional instruction.

The research design consisted of two groups: an experimental group and a control group. Both groups were administered a pretest before the learning intervention and a posttest after the intervention. The experimental group received Project-Based Learning integrated with interactive multimedia, while the control group received conventional learning. The comparison between pretest and posttest scores was used to identify changes in students' learning outcomes, while the comparison between the two groups was used to determine whether the learning treatment resulted in different learning outcomes. The research design can be represented as follows:

Tabel 1. Design Research Metods

Group	Pretest	Treatment	Posttest
Experimental	O_1	X_1	O_2
Control	O_3	X_2	O_4

Note: O_1 and O_3 = pretest; O_2 and O_4 = posttest; X_1 = Project-Based Learning integrated with interactive multimedia; X_2 = conventional learning.

Participants

The draft reports 40 tenth-grade students at SMKN 1 Sampang, with 20 students in the experimental group and 20 in the control group. The sampling technique and allocation procedure must be specified from the actual study records (for example, whether intact classes were used and whether any random assignment occurred); these details cannot be inferred from the current manuscript. If intact classes were assigned to conditions, this should be reported explicitly and acknowledged as a possible source of selection bias.

Participants were eligible because they were studying Photography Techniques during the period of the intervention. The final manuscript should state the sampling method, class identifiers or selection rationale, inclusion criteria, study dates, and any withdrawals or missing scores. The sample size should be described as the available study sample unless an a priori power analysis was actually conducted; no power estimate should be added retrospectively without a documented analysis.

Learning Treatment

The learning treatment in the experimental group integrated the syntax of Project-Based Learning with the use of interactive multimedia. The learning activities were designed to connect conceptual understanding with practical photography activities. Interactive multimedia was used primarily to provide students with visual examples and opportunities to respond to questions or short activities, while PjBL provided the structure for students to apply the acquired knowledge through a project.

The learning process began with project orientation. At this stage, the teacher introduced the learning objectives, the project context, and the expected product. Students were introduced to the photography problem or task that would become the focus of their project. This stage was intended to establish an understanding of the relationship between the learning material and the practical product that students were expected to produce.

The second stage involved exploration of learning materials through interactive multimedia. Students watched instructional multimedias containing examples of camera angles, shot types, composition, and related photography techniques. The interactive multimedia was not used merely as a conventional presentation medium. Questions and short activities were incorporated into the multimedia so that students were required to respond to the information presented. Through this activity, students could observe visual examples and examine differences among photography techniques before beginning the practical project.

The third stage involved project planning. After exploring the learning material, students developed a plan for their photography project. The planning process required students to determine the subject or object to be photographed, select appropriate techniques, and organize the stages of the photography activity. At this stage, students were encouraged to use the concepts obtained from the interactive multimedia as a basis for making decisions related to their project.

The fourth stage was project implementation. Students carried out the photography activities according to the plans they had developed. They applied concepts related to camera angles, shot sizes, composition, and other techniques while producing their visual work. The practical activity provided students with an opportunity to transform conceptual knowledge into an observable product.

The fifth stage involved presentation and product evaluation. Students presented or displayed their photography products and discussed the techniques used in producing them. Evaluation focused on how well the students applied the concepts and techniques learned during the learning process. The teacher provided feedback regarding the strengths and weaknesses of the students' work.

The final stage was reflection. Students reflected on the learning process and the results of their projects. Reflection allowed students to identify difficulties encountered during the photography process, consider the appropriateness of the techniques they had selected, and recognize aspects that could be improved in future practical activities.

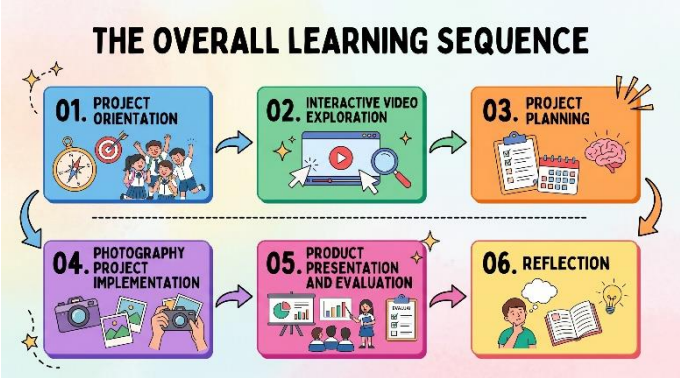


Figure 1. Learning Sequence Flowchart

This sequence was designed to create continuity between the acquisition of conceptual knowledge and its application in a practical project. The interactive multimedia functioned as visual and interactive learning support, while PjBL provided opportunities for students to apply, develop, and evaluate their knowledge through project activities.

Learning Activities in the Control Group

The control group received conventional instruction. The learning activities primarily focused on teacher explanations, presentation of the Photography Techniques material, discussion, and conventional learning exercises. Students were introduced to concepts related to camera angles, shot types, composition, and other relevant techniques through the regular learning process.

The distinction between the two groups was therefore primarily related to the instructional treatment. The experimental group experienced an integrated learning process involving interactive visual materials and project-based activities, whereas the control group participated in conventional instruction. Both groups were assessed using the same learning outcome measurement before and after the learning process.

Research Instrument

The instrument is described as a cognitive learning-outcome test covering camera angles, shot types, composition, and application of photography techniques. To make the method reproducible, the authors must report the number and format of items, score range, test blueprint, scoring procedure, expert-review process for content validity, pilot testing, and item analysis. Reliability (such as KR-20 for dichotomously scored items or Cronbach's alpha where appropriate) must be calculated from the actual instrument data and reported with its sample and value. These properties are not documented in the files currently available and should not be invented.

The pretest was intended to measure students' initial understanding before instruction, and the posttest to measure outcomes after the intervention. The manuscript should clarify whether the same items or parallel forms were used, the interval between tests, and steps taken to reduce testing effects. Any scoring rubric or assessor procedure should also be reported if performance-based outcomes were collected; the current draft specifically describes a cognitive test.

The instrument scores were subsequently used for descriptive and inferential analyses. The pretest and posttest data were analyzed separately for the experimental and control groups to determine changes within each group and differences between the groups.

Data Collection Procedure

Data collection was conducted through three principal stages. The first stage was the administration of the pretest to both the experimental and control groups. The purpose of the pretest was to establish the students' initial learning outcomes before the instructional treatment.

The second stage was the implementation of the learning treatment. The experimental group participated in PjBL activities supported by interactive multimedia, including visual exploration, project planning, practical photography activities, product presentation, evaluation, and reflection. The control group participated in conventional learning activities.

The third stage was the administration of the posttest to both groups. The posttest results were then compared with the pretest results to determine the improvement in students' learning outcomes. Differences between the experimental and control groups were subsequently examined using inferential statistical analysis.

Data Analysis

Descriptive statistics should report the mean, standard deviation, and sample size for each group at pretest and posttest. The final analysis must be rerun from the original student-level dataset, and the reported values should match the statistical output. Missing data, exclusions, and any deviations from the planned analysis should be documented.

Normality and homogeneity checks may inform the choice of parametric tests, but they do not establish that all design assumptions have been met. The final report should identify the exact test statistics, degrees of freedom, p-values, and confidence intervals. Because the groups may be non-equivalent at baseline, an ANCOVA comparing posttest scores while adjusting for pretest scores may be considered if its assumptions are met; the authors should state and justify the analysis actually used rather than selecting a test solely because it produces significance.

A paired-sample *t*-test was used to examine whether there was a significant difference between pretest and posttest scores within each group. This analysis was conducted to determine whether students' learning outcomes changed significantly following the learning process.

For the between-group comparison, the authors should prespecify and justify the method. An independent-samples t-test compares posttest means but does not adjust for baseline differences. If ANCOVA is used, report the adjusted group effect, confidence interval, p-value, and effect size. The final manuscript must present only analyses actually performed on verified data. In addition to significance testing, learning improvement was analyzed using the normalized gain (N-Gain). The N-Gain was calculated using the following formula:

$$\boldsymbol{N - Gain} = (\boldsymbol{Posttest} - \boldsymbol{Pretest}) / (\boldsymbol{Maximum\ Score} - \boldsymbol{Pretest})$$

The N-Gain value was used to describe the relative improvement in students' learning outcomes from the pretest to the posttest. A higher N-Gain value indicated a greater improvement in learning outcomes.

Effect size should be reported with a clear definition and, where possible, a confidence interval. Cohen's d should be calculated from the verified data using the stated comparison and appropriate pooled standard deviation. Avoid interpreting an effect as large until the calculation and underlying data have been checked.

The combination of descriptive statistics, assumption testing, paired-sample *t*-test, independent-sample *t*-test, N-Gain analysis, and effect size was intended to provide a comprehensive analysis of the effect of PjBL integrated with interactive multimedia on students' learning outcomes in Photography Techniques.

Results and Discussions

Preliminary Learning Conditions

The preliminary observation was conducted to identify the learning conditions of tenth-grade students before the implementation of the Project-Based Learning (PjBL) model integrated with interactive multimedia. The observation focused on students' initial understanding of Photography Techniques and their ability to follow practical learning activities. The results indicated that several students experienced difficulties in understanding the material, particularly when the learning content required them to distinguish and apply photography concepts such as camera angles, shot sizes, composition, and perspective.

During preliminary observation, 14 of 25 students (56%) were recorded as experiencing difficulties and 11 (44%) as relatively able to follow the material. These figures are descriptive observations, not a validated diagnostic measure. The manuscript should define the observable indicators and decision rule used to classify difficulty, identify who conducted the observation, and report inter-rater agreement if more than one observer participated. Without this information, the percentages should be interpreted cautiously and should not be treated as a standardized baseline.

Table 2. Preliminary Observation of Students' Learning Conditions

Learning Condition	Number of Students	Percentage
Students experiencing difficulties	14	56%
Students relatively able to understand the material	11	44%
Total	25	100%

The relatively high proportion of students experiencing difficulties provides an important basis for the implementation of a more contextual and practice-oriented learning strategy. Photography Techniques is not only concerned with remembering definitions but also requires students to recognize visual differences and apply concepts appropriately in practical situations. Therefore, students need learning resources that can provide

concrete examples before they perform the photography activities themselves. The classroom learning documentation also illustrates the learning environment in which the treatment was implemented.



Figure 2. Classroom implementation of the learning process

The classroom documentation can be used to demonstrate the actual learning context rather than as additional quantitative evidence. It complements the statistical findings by illustrating how the learning process was conducted in the classroom.

Implementation of Interactive Multimedia in Project-Based Learning

The treatment group received learning through Project-Based Learning integrated with interactive multimedia. The integration was designed to connect the characteristics of project-based learning with the visual and interactive characteristics of the learning media. Students were not only exposed to explanations of Photography Techniques but were also provided with visual examples, simulations, and questions through the media before and during the practical learning process. The interactive multimedia was developed as a supporting learning resource for the Photography Techniques material. Its initial interface provides students with an entry point to the learning content and helps establish the structure of the learning experience.



Figure 3. Initial interface of the interactive multimedia learning media

The initial interface functions as the opening component of the media. From a pedagogical perspective, an organized interface can help students understand the sequence of the learning content and prepare them to engage with the subsequent material. This is particularly relevant in vocational learning, where students need to move between conceptual explanations and practical activities. The media also explicitly presents the learning objectives. The inclusion of learning objectives allows students to understand the competencies expected after completing the learning activities.

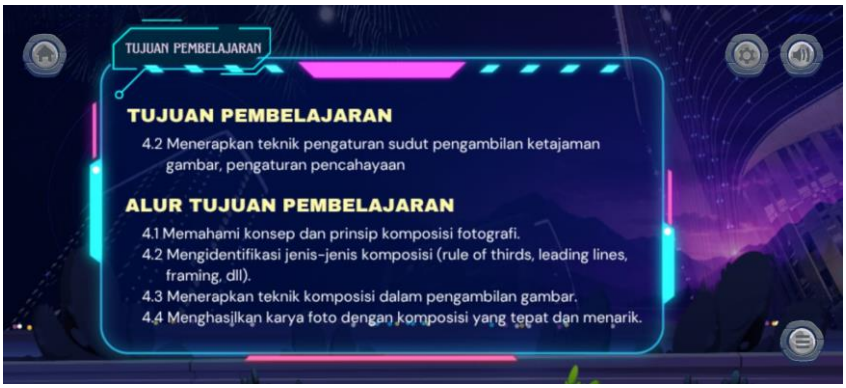


Figure 4. Learning objectives presented in the interactive multimedia media

The presentation of learning objectives provides students with an orientation regarding what they are expected to understand and accomplish. In this study, the objectives were connected to the Photography Techniques material and the practical application of photography concepts. This supports the principle that learning activities should be directed toward clearly defined competencies rather than merely completing media content. The main content of the media contains explanations related to Photography Techniques. The content was presented through a visual learning environment to make abstract or difficult-to-observe concepts easier to understand.



Figure 5. Main content interface of the interactive multimedia learning media

The use of visual content is particularly relevant to Photography Techniques because many concepts are directly related to differences in visual appearance. Camera angle, shot size, composition, and perspective, for example, are more readily demonstrated through visual examples than through verbal descriptions alone. Interactive multimedia therefore functions not simply as a presentation medium but as a bridge between conceptual understanding and practical application. The media also provides simulations that demonstrate the application of photography techniques. These simulations allow students to observe how a particular technique is represented in practice before attempting to apply it themselves.

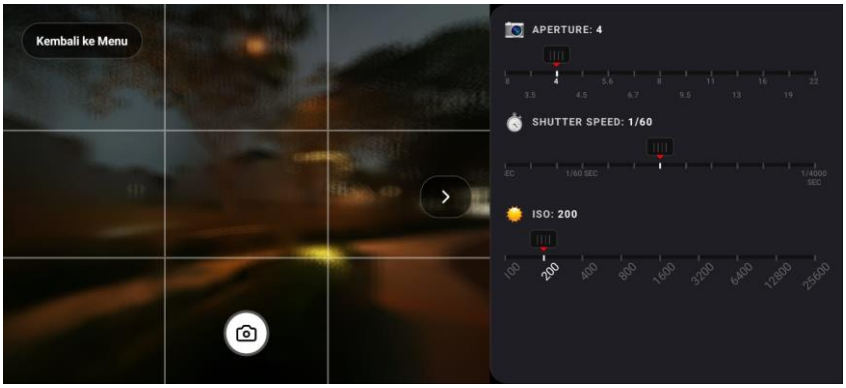


Figure 6. Simulation of Photography Techniques presented in the interactive multimedia

The simulation component is important because vocational learning requires students to understand not only *what* a technique is but also *how* it can be applied. Through visual demonstrations, students can observe examples repeatedly and compare the displayed technique with their own practical work. This characteristic is consistent with the findings of Wibawanto et al. (2022), who emphasized the potential of interactive and simulation-based multimedia to support vocational students' learning outcomes. In addition to explanations and simulations, the media includes questions or exercises that provide opportunities for students to check their understanding.



Figure 7. Questions and exercises provided in the interactive multimedia learning media

The inclusion of questions makes the media more interactive than a conventional multimedia because students are encouraged to respond to the learning content rather than only watch it passively. Interactive multimedia can provide opportunities for students to receive learning prompts, process information, and evaluate their understanding. Similar findings have been reported by Ramadani and Nurharini (2024), Fithriyani et al. (2026), and Prastya et al. (2025), who reported positive effects of interactive multimedia-based learning media on students' learning outcomes.

Student Use of the Interactive Multimedia Media

During the treatment, students were given opportunities to use the interactive multimedia as part of the learning activities. The media was positioned as a learning resource within the PjBL process rather than as a replacement for teacher instruction. Students accessed the material, observed examples and simulations, responded to questions, and subsequently applied the concepts during practical activities.



Figure 8. Students using the interactive multimedia media during the learning process

The documentation shows the utilization of the media during classroom learning. The use of the media provided students with an opportunity to revisit explanations and visual examples while participating in the learning process. This feature is relevant to vocational education because students may require repeated observation before they are able to translate theoretical information into practical performance.

The use of interactive multimedia was integrated with project-based learning. In this context, the multimedia served primarily as an instructional scaffold, while the project provided opportunities for students to apply the knowledge gained from the media. The combination therefore involved two complementary learning functions: the interactive multimedia supported understanding and visualization, whereas PjBL provided opportunities for application through project activities.

Descriptive Analysis of Learning Outcomes

The learning outcomes of the experimental and control groups were compared using pretest and posttest scores. The descriptive results are presented in Table 3.

Table 3. Descriptive Statistics of Pretest and Posttest Scores

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean Gain
Experimental	20	59.15	4.88	85.15	4.88	26.00
Control	20	58.50	4.39	70.90	4.04	12.40

The current draft lists an experimental-group mean increasing from 59.15 to 85.15 and a control-group mean increasing from 58.50 to 70.90. These figures are retained here only as values appearing in the supplied draft; they have not been independently verified against raw data. Before submission, recalculate the descriptive statistics from the original dataset and replace this paragraph and its associated table if any value differs. These descriptive results show that both groups demonstrated improvement after the learning process. However, the increase in the experimental group was substantially greater than that of the control group. The difference suggests that the combination of PjBL and interactive multimedia may provide additional learning support compared with conventional instruction.

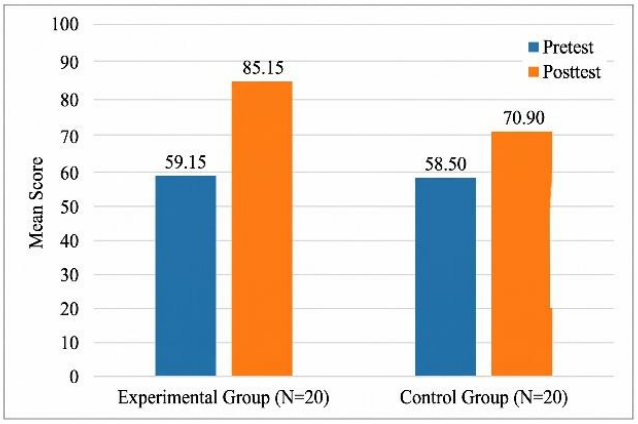


Figure 9. Comparison of pretest and posttest mean scores between the experimental and control groups

The increase in the experimental group is consistent with previous research concerning PjBL in vocational education. Akhyar et al. (2024) reported that project-based learning can be structured to support improvements in vocational students' learning outcomes. Similarly, Herlambang et al. (2023) found that PjBL implementation can contribute to students' cognitive and psychomotor learning outcomes in vocational education. The N-Gain analysis further illustrates the improvement achieved by each group.

Table 4. N-Gain Scores of the Experimental and Control Groups

Group	N	N-Gain	Category
Experimental	20	0.645	Medium
Control	20	0.301	Low

The draft reports N-Gain values of 0.645 for the experimental group and 0.301 for the control group. These values must be recalculated from the verified pretest and posttest data, with the maximum score and categorization criteria explicitly stated. Do not report them as final findings until checked.

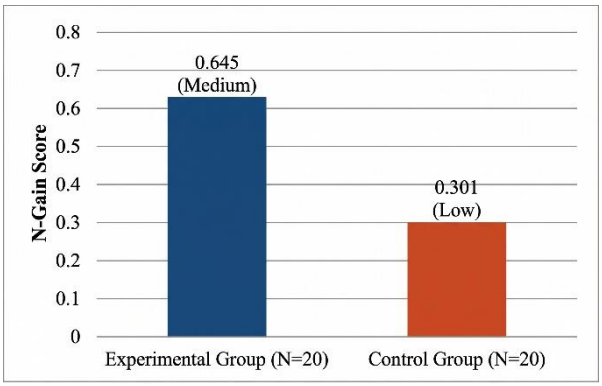


Figure 10. Comparison of N-Gain scores between the experimental and control groups

The higher gain in the experimental group can be interpreted in relation to the characteristics of the treatment. Interactive multimedia provided students with visual explanations and simulations, while PjBL created opportunities to apply the information through practical project activities. The two components therefore provided complementary learning experiences.

Inferential Analysis

The manuscript currently reports normality significance values of 0.951 and 0.958–0.963, a Levene significance value of 0.362, and several t-test results. These figures require verification against the original analysis output. The table should include the appropriate test statistic, degrees of freedom where applicable, exact p-value (or $p < .001$), confidence interval, and the number of observations used in each analysis.

Table 5. Results of Prerequisite and Hypothesis Testing

Analysis	Statistic	Sig.	Interpretation
Experimental pretest normality	W = 0.951	> .05	Normal
Experimental posttest normality	W = 0.951	> .05	Normal
Control pretest normality	W = 0.958	> .05	Normal
Control posttest normality	W = 0.963	> .05	Normal
Homogeneity	Levene = 0.851	0.362	Homogeneous
Paired t-test – Experimental	t = -126.708	< .001	Significant
Paired t-test – Control	t = -53.001	< .001	Significant
Independent t-test	t = 10.061	< .001	Significant
Cohen's d	3.181	—	Large effect

The supplied draft reports statistically significant pretest–posttest differences in both groups. These claims cannot be treated as confirmed until the tests are rerun using the original student-level data and the instrument and analysis procedures are documented. Report the paired-test statistic, degrees of freedom, p-value, mean difference, and confidence interval from the verified output.

The draft also reports an independent-samples result of $t = 10.061$ and Cohen's $d = 3.181$. Because these are currently unverified values, no definitive treatment-effect claim should be based on them. Reanalyse the data, consider baseline-adjusted analysis where appropriate, and report the final effect estimate with its confidence interval.

The interpretation of this study should distinguish the instructional rationale from the evidence actually established by the data. Interactive multimedia may help students inspect visual examples and respond to embedded questions; PjBL may then provide a structured setting for applying those concepts in a tangible product. Together, these elements form a plausible instructional mechanism linking observation, active processing, practical application, feedback, and reflection. Whether this mechanism produced a statistically reliable advantage in this sample must be established from verified analyses.

The interactive multimedia addressed this characteristic by presenting explanations, visual examples, simulations, and questions in a single learning environment. Students could observe the representation of photography techniques before applying them in practical activities. This feature potentially reduced the conceptual distance between theoretical explanations and practical application.

The findings are in line with Ramadani and Nurharini (2024), who reported that interactive multimedia media can improve student learning outcomes. Fithriyani et al. (2026) likewise found that Edpuzzle-based interactive multimedia could support learning outcomes, while Prastya et al. (2025) specifically examined H5P

interactive multimedia in vocational high school learning and reported its usefulness for supporting student outcomes. These studies reinforce the argument that interactive multimedia can be particularly useful when learning content requires students to observe processes or examples.

The contribution of PjBL is reflected in the opportunity for students to apply the information obtained from the media through project-oriented learning activities. Instead of stopping at the stage of observing examples, students were encouraged to use the concepts in practical learning. This characteristic is consistent with the nature of vocational education, which requires the integration of conceptual knowledge and practical competence.

Previous studies have also demonstrated the relevance of PjBL to vocational education. Akhyar et al. (2024) emphasized the importance of project-based and problem-based learning syntax for improving vocational learning outcomes. Herlambang et al. (2023) found that PjBL could influence both cognitive and psychomotor outcomes among vocational high school students. Dewangga and Ahmad (2023) likewise highlighted the relevance of PjBL for improving practical learning competence in vocational education.

The integrated approach should not be interpreted as proving that the combination is superior to each component used independently, because the described design compares the combined intervention with conventional instruction and does not include separate PjBL-only and interactive-multimedia-only groups. Therefore, any observed difference would estimate the effect of the combined package relative to the comparison condition, not the independent contribution or interaction effect of each component.

Nevertheless, implementation should consider several practical factors. Interactive media requires appropriate technological facilities, sufficient access to devices, and adequate teacher preparation. The quality of the instructional multimedia and the clarity of its interactive components are also important because poorly designed media may increase rather than reduce students' cognitive burden. In addition, project-based activities require sufficient classroom time and teacher management to ensure that students remain focused on the intended learning objectives.

From the perspective of vocational education, these findings are important because learning outcomes should ideally be developed through meaningful relationships between knowledge, practice, and authentic tasks. (Hadi, 2020) identified challenges in improving learning outcomes in vocational schools, emphasizing the importance of instructional conditions that support students' learning needs. Therefore, the integration of technology with an appropriate pedagogical model may provide one possible approach for addressing these challenges.

The study may contribute context-specific evidence about combining interactive multimedia with PjBL in vocational photography education. The strength of that contribution depends on verification of the dataset, transparent instrument reporting, and a design-aware interpretation. Until these checks are complete, conclusions should remain provisional rather than presenting the reported statistical values as established findings.

Study Limitations

Important limitations must be acknowledged. First, use of existing classes or non-random allocation may introduce selection bias. Second, maturation, history, and pretest sensitization may contribute to score changes, although the control group helps address some shared influences. Third, the sample comes from one school and may not represent other vocational settings. Fourth, the draft does not yet document test validity, reliability, item analysis, or a power analysis. Finally, because the comparison condition does not isolate PjBL and interactive multimedia separately, the design cannot determine the unique effect of either component. These limitations should be retained in the final report and revised only when supported by study records

Conclusions

This study examines a combined instructional approach in which interactive multimedia supports students' observation and initial processing of photography concepts, while Project-Based Learning organizes their application through project planning, production, presentation, evaluation, and reflection. The preliminary classroom observation recorded difficulties among 14 of 25 students (56%); however, the observation categories require clearer operational definitions before they can be interpreted as a validated baseline. The draft contains provisional score summaries and inferential statistics, but these values have not been verified against the original dataset. Accordingly, this version does not make a definitive claim that the intervention produced a particular effect size or statistically significant advantage. The final conclusion must be updated after the raw scores, instrument quality evidence, and statistical output have been checked and reported transparently. The proposed pedagogical contribution is the alignment of visual demonstration and embedded questions with authentic project work. This design may offer a useful structure for teaching competencies that require students to interpret

visual examples and apply technical decisions. Future studies should use transparent sampling procedures, validated and reliable instruments, baseline-adjusted analysis where appropriate, and multiple schools or comparison conditions to test the robustness and mechanism of the approach. However, the statistical values reported in this draft are illustrative and must be replaced with the final statistical outputs from the actual research data before manuscript submission. Further research may examine the implementation of this integrated approach with larger samples, different vocational subjects, and additional measures of practical or psychomotor competence.

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