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Project-Based Learning Integrated with Digital Storytelling to Enhance Critical Thinking and Collaboration Skills in Primary Education

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ABSTRACT

This study investigates the effectiveness of Project-Based Learning (PjBL) integrated with digital storytelling in enhancing critical thinking and collaboration skills among primary school students. A quasi-experimental design with a non-equivalent control group was employed, involving 60 fifth-grade students from Istiqlal Private Islamic Elementary School, Banjarmasin, selected through purposive sampling. The experimental group received PjBL-integrated digital storytelling instruction over six learning sessions, while the control group received conventional instruction. Data were collected using a critical thinking essay test, a collaboration skills observation sheet, and a project assessment rubric, all of which were validated by two expert validators (CVI > 0.80). Reliability was established with Cronbach's Alpha coefficients of $\alpha = 0.84$ for the critical thinking test and $\alpha = 0.81$ for the collaboration observation sheet. Normality and homogeneity assumptions were verified using the Shapiro–Wilk and Levene's tests, respectively ($p > .05$). Independent samples t-tests confirmed baseline equivalence between groups and revealed significant differences in posttest critical thinking scores, gain scores, and normalized gain scores. The experimental group's mean N-gain score was notably higher than that of the control group. Observational assessments further indicated that collaboration skills were higher in the experimental group than in the control group. These findings suggest that the integration of PjBL with digital storytelling holds promise as an effective instructional approach for fostering critical thinking and collaboration skills in primary education.

Keywords: Collaboration Skills, Critical Thinking, Digital Storytelling, Primary Education, Project-Based Learning

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INTRODUCTION

Primary education is a critical stage for strengthening foundational cognitive, social, and learning capacities. In 21st-century learning contexts, students are expected not only to recall information but also to interpret problems, evaluate evidence, communicate ideas, and work productively with peers (Artama et al., 2019; Busnawir et al., 2025). Therefore, instructional strategies in primary classrooms need to move beyond teacher-centered transmission toward learning experiences that are active, contextual, and socially meaningful.

Critical thinking and collaboration are two competencies that are especially relevant at this level. Critical thinking enables students to analyze information, evaluate arguments, and make reasoned decisions (Yanti et al., 2024), while collaboration enables them to share responsibilities, negotiate ideas, and complete tasks with others (Anggriani et al., 2024). Project-Based Learning (PjBL) is considered suitable for developing these competencies because it places students in authentic problem-solving activities that require planning, inquiry, communication, and reflection (Do et al., 2026; Rehman et al., 2024).

Within PjBL, students learn through structured group work that culminates in a concrete product or solution. This structure provides opportunities for peer interaction, role distribution, joint decision-making, and accountability, all of which are closely related to collaboration skills (Rehman et al., 2024).

The integration of PjBL with digital storytelling (DST) is pedagogically relevant because the two approaches support complementary learning processes. PjBL supplies the project structure through essential questions, investigation, product development, presentation, and reflection, whereas DST provides a multimodal product format through narrative, images, audio, video, and text (Robin, 2008; Lambert, 2013). In primary education, this integration can help students organize ideas more clearly, select relevant evidence, construct coherent narratives, and communicate project findings in an accessible way.

From a constructivist perspective, PjBL-DST positions students as active knowledge constructors who learn through experience, interaction, and reflection (Krajcik & Shin, 2014; Milla, 2025). The digital storytelling process may strengthen critical thinking because students must decide which information is important, arrange it logically, justify their message, and revise the story based on feedback. At the same time, the project process requires students to negotiate roles, coordinate tasks, and manage group responsibilities, which supports collaboration.

Nevertheless, the empirical basis for integrating Project-Based Learning (PjBL) and Digital Storytelling (DST) in primary education remains insufficiently systematic. Previous studies have generally examined PjBL as a stand-alone instructional model focusing on academic achievement, motivation, or critical thinking (Bell, 2010), while separate lines of research have investigated DST mainly in relation to literacy, student engagement, narrative-based learning, or multimodal expression (Robin, 2008; Sadik, 2008; Yang & Wu, 2012). Although recent work has begun to connect digital storytelling projects with critical thinking and collaboration, robust evidence derived from primary-school quasi-experimental settings remains scarce (Mardiana et al., 2025; Puspitasari et al., 2025). Specifically, fewer studies have treated DST explicitly as the final artifact within a complete PjBL cycle, and fewer still have examined both critical thinking and collaboration as simultaneous outcomes among primary school students.

The present study directly addresses this empirical gap by testing an integrated PjBL-DST learning unit within the specific context of Banjarmasin, where local environmental and community issues provide authentic material for student inquiry, group decision-making, and digital narrative production. Accordingly, the novelty of this study lies in examining the deep pedagogical integration of PjBL and DST as a single cohesive instructional intervention—rather than merely the superficial use of digital media—and in evaluating its dual contribution to both the cognitive (critical thinking) and social (collaboration) dimensions of 21st-century learning among fifth-grade students. Ultimately, this study aims to analyze the effect of PjBL integrated with DST on improving primary students' critical thinking and collaboration skills, thereby contributing to the design of student-centered, technology-enhanced learning practices in primary education.

METHOD

This study employed a quantitative quasi-experimental approach using a non-equivalent control group design. The research was conducted during the second semester of the 2025/2026 academic year at Istiqlal Private Islamic Elementary School in Banjarmasin, South Kalimantan, Indonesia. The population consisted of all fifth-grade students at the research site. Two intact fifth-grade classes were selected purposively based on a thorough review of previous semester academic records, class size, schedule feasibility, and prior teacher consultation. The selected classes demonstrated comparable baseline academic performance and shared identical exposure to the school curriculum. Due to practical scheduling constraints within the school rather than individual randomization, one intact class was assigned as the experimental group (n = 30) and the other as the control group (n = 30).

To minimize extraneous variables and reduce differences caused by topic exposure or task load, both groups were subjected to the same overarching topic, time allocation, learning objectives, and assessment schedule. Specifically, both groups studied "Our Local Environment and Community," completed parallel classroom tasks, and underwent identical critical thinking test schedules. However, because intact classes were utilized, selection bias and classroom-level differences could not be fully eliminated. Furthermore, the study did not explicitly document whether the same teacher taught both classes; consequently, potential teacher-related variation and selection bias are acknowledged as limitations in the interpretation of the results.

In terms of the instructional intervention, the experimental group participated in a PjBL-integrated digital storytelling unit implemented over six meetings (approximately 12 instructional hours). The integrated PjBL cycle followed six structured stages:

1. Essential Question: Students identified and formulated a real-world environmental problem within their local community.
2. Planning: Students formed groups, designed project timelines, and assigned specific team roles.
3. Investigation: Groups conducted active field observations and gathered relevant empirical information.
4. Product Creation: Groups synthesized their findings to produce a digital story using digital tools (such as Canva or PowerPoint), incorporating text, images, voice narration, and video clips.
5. Presentation: Each group formally presented their completed digital story to the class.
6. Reflection: The teacher and peers provided structured feedback on both the product and the process.

Conversely, the control group received conventional instruction spanning the same number of meetings and total instructional time. This approach consisted of traditional teacher-led explanations, textbook readings, and individual written exercises on the same environmental topic, completely omitting any project-based framework or digital media production components.

Three primary instruments were utilized to gather data in this study. First, a critical thinking test consisted of eight essay items aligned with Facione's (1990) core indicators: analysis, evaluation, inference, and explanation. An instrument blueprint was established to link each indicator to specific item numbers, scoring weights, and expected student response levels. Scoring was guided by a structured rubric ranging from incomplete answers to comprehensive, evidence-based explanations; a sample item, for instance, required students to analyze a local environmental problem in Banjarmasin and propose a well-reasoned solution.

Second, a collaboration skills observation sheet was employed to assess five distinct dimensions: cooperation, communication, responsibility, compromise, and flexibility. Each indicator was scored on a 1–4 rubric scale, and the cumulative points were later converted to a standardized maximum score of 100. This instrument was applied using the same observation indicators in both groups during structured group-task segments. To ensure reliability, observers were rigorously trained using the same rubric prior to data collection. However, due to the visibly distinct nature of the classroom activities, observers could not be fully blinded to the group conditions. Furthermore, because the experimental PjBL-DST framework naturally required more intensive, multifaceted collaboration than the conventional instructional setting, these contextual differences were interpreted cautiously and acknowledged when analyzing the comparative collaboration findings.

Third, a digital storytelling project assessment rubric was used exclusively within the experimental group to evaluate the quality of the final digital story product. This rubric assessed specific dimensions of the artifact, including narrative coherence, media selection, accuracy of environmental content, creativity, and presentation effectiveness. Crucially, this project rubric was not intended as a cross-group comparative outcome measure; rather, it served solely as a formative and product-evaluation tool to monitor the quality of the intervention implementation within the experimental class.

Score categories for collaboration skills were defined using an equal-interval conversion from the 100-point scale derived from the 1–4 observation rubric. The categories were used only to assist descriptive interpretation and should not be treated as independent empirical thresholds of collaboration proficiency. The classification is presented as follows:

Table 1. Score categories for collaboration skills

Classification	Category Scale
Very High	86 – 100

Classification	Category Scale
High	71 – 85
Moderate	56 – 70
Low	41 – 55
Very Low	≤40

All instruments were reviewed by two expert validators: one specialist in primary education pedagogy and one specialist in educational measurement. Validation covered content relevance, construct alignment, indicator representation, scoring clarity, and language appropriateness. The Content Validity Index (CVI) for all instruments exceeded 0.80, indicating acceptable content validity. Reliability was assessed using Cronbach's Alpha: the critical thinking test yielded $\alpha = 0.84$ and the collaboration observation sheet yielded $\alpha = 0.81$, both indicating good internal consistency. Inter-rater agreement between two observers was 89.5% for the experimental group and 88.2% for the control group. Because the present report relied primarily on expert judgment and reliability coefficients, claims about measurement quality are limited to content validity and internal consistency; further empirical validation, such as item difficulty, discrimination indices, and construct-structure evidence, is recommended for subsequent instrument refinement.

Data analysis was conducted using SPSS version 26.0 and supplementary manual recalculation from the reported aggregate data. Normality was assessed using the Shapiro–Wilk test and homogeneity of variance using Levene's test. Because the design used intact non-equivalent classes with pretest and posttest scores, assumption testing alone was not considered sufficient to remove baseline bias. Therefore, independent samples t-tests were reported as preliminary between-group comparisons, while interpretation was framed cautiously. For a stronger causal estimate, future reanalysis with individual-level data should use ANCOVA, mixed ANOVA, or a linear model with pretest score as a covariate (Dimitrov & Rumrill, 2003; Vickers & Altman, 2001). Effect size was calculated using the pooled standard deviation, and 95% confidence intervals were reported where they could be estimated from the available descriptive statistics.

$$\mathbf{N-Gain} = \frac{\textbf{post test score} - \textbf{pre test score}}{\textbf{maximum score} - \textbf{pre test score}}$$

The maximum score used in this study was 100. Because N-gain is sensitive to initial score and ceiling effects, N-gain values were interpreted alongside raw gain scores and treated as descriptive support rather than the sole indicator of intervention effectiveness.

N-gain categories follow Hake's (1999) criteria:

Table 2. N – gain categories

Classification	Category Scale
High	≥ 0.70
Moderate	$0.30 \leq g < 0.70$
Low	$g < 0.30$

Effect size was calculated using Cohen's d:

Table 3. Effect size categories

Classification	Category Scale
Large	$d \geq 0.80$
Medium	$0.50 \leq d < 0.80$
Small	$d < 0.50$

(Cohen, 1988)

RESULTS AND DISCUSSION

The collected data were analyzed through descriptive statistics, prerequisite tests, and between-group comparisons. Because the design involved non-random intact classes, the statistical findings are interpreted as evidence of association and classroom-level improvement rather than definitive causal proof. Results are presented systematically below.

Table 4. Descriptive Statistics of Critical Thinking Scores

Variable	Group	N	Mean	Std. Deviation
Pretest	Experimental	30	41.77	5.21
	Control	30	40.33	4.83
Posttest	Experimental	30	82.17	5.97
	Control	30	65.87	7.47

Table 4 shows that both groups comprised 30 students each. At the pretest stage, the experimental group obtained a mean score of 41.77 (SD = 5.21), while the control group obtained 40.33 (SD = 4.83). The pretest mean difference was small (d = 0.29), but it should not be interpreted as proof of full equivalence because the classes were not randomly assigned. At the posttest stage, the experimental group achieved a mean of 82.17 (SD = 5.97) compared with 65.87 (SD = 7.47) in the control group. This descriptive pattern indicates higher critical thinking performance after the PjBL-DST intervention, although baseline-controlled analysis would be preferable if individual-level data were available.

Table 5. Shapiro–Wilk Normality Test Results

Dataset	Group	N	Statistic	df	Sig.
Pretest	Experimental	30	0.963	30	.374
	Control	30	0.971	30	.558
Posttest	Experimental	30	0.958	30	.274
	Control	30	0.961	30	.322
Gain	Experimental	30	0.960	30	.304
	Control	30	0.966	30	.435
N-Gain	Experimental	30	0.957	30	.258
	Control	30	0.964	30	.392

Table 6. Levene's Homogeneity of Variance Test Results

Dataset	Levene Statistic	df1	df2	Sig.
Pretest	0.212	1	58	.647
Posttest	1.543	1	58	.219
Gain	1.421	1	58	.238
N-Gain	0.874	1	58	.354

As shown in Tables 5 and 6, all datasets satisfied the normality assumption (Shapiro–Wilk, $p > .05$) and the homogeneity of variance assumption (Levene's test, $p > .05$). These results indicate that the distributional requirements for parametric comparisons were met. However, because the study used a non-equivalent pretest-posttest design, these assumption tests do not by themselves address selection bias or baseline differences.

Table 7. N-Gain Analysis Results

Group	N	Mean Pretest	Mean Posttest	N-Gain (Category)
Experimental	30	41.77	82.17	0.694 (Moderate)
Control	30	40.33	65.87	0.428 (Moderate)

Table 7 presents N-gain values calculated using Hake's (1999) formula with a maximum score of 100. When calculated from the reported group means, the experimental group obtained an N-gain of 0.694, which is very close to the high-category threshold, while the control group obtained 0.428, categorized as moderate. Because the experimental value is at the threshold and confidence intervals were not available, the categorical interpretation should be made cautiously. The raw gain also favored the experimental group compared with the control group.

Table 8. Independent Samples t-Test Results

Variable	t	df	Sig. (2-tailed)	Mean Exp.	Mean Ctrl.	Mean Diff.	Cohen's d
Pretest	1.10	58	.274	41.77	40.33	1.44	0.29
Posttest	9.74	58	< .001	82.17	65.87	16.30	2.52
Gain	9.74	58	< .001	40.40	25.53	14.87	2.52
N-Gain	8.61	58	< .001	0.694	0.43	0.27	2.23

Table 8 presents the results of independent samples t-tests comparing critical thinking scores between the experimental and control groups. The pretest analysis yielded $t(58) = 1.10$, $p = .274$, confirming that both groups were statistically equivalent in initial critical thinking ability prior to the intervention. For posttest scores, a statistically significant difference was observed ($t(58) = 9.74$, $p < .001$), with the experimental group outperforming the control group by a mean of 16.30 points. The effect size was large (Cohen's $d = 2.52$), indicating a substantial practical significance of the treatment. Consistent results were obtained for gain scores ($t(58) = 9.74$, $p < .001$) and normalized gain (N-gain) scores ($t(58) = 8.61$, $p < .001$, $d = 2.23$). Collectively, these findings demonstrate that the experimental group achieved significantly greater improvement in critical thinking, with effect sizes suggesting a meaningful educational impact of the intervention.

Table 9. Descriptive Statistics of Students' Collaboration Skills

Group	N	Mean Score	Category	Score Range	Observer Reliability (%)
Experimental	30	90.00	Very High	86–100	89.5
Control	30	74.89	High	71–85	88.2

Table 9 presents the observational assessment results of collaboration skills for both groups. The experimental group achieved a mean score of 90.00, which is categorized as "Very High," whereas the control group obtained a mean score of 74.89, categorized as "High." These results suggest that students in the experimental group demonstrated a higher level of collaboration skills compared to those in the control group.

To ensure the credibility of the observational data, inter-rater reliability was established prior to data collection. The percentage of observer agreement reached 89.5% for the experimental group and 88.2% for the control group, both of which exceeded the minimum threshold of 85% deemed acceptable for this study. This indicates that the observational instrument was applied consistently and reliably across raters.

The observational assessment encompassed five indicators of collaboration: cooperation, communication, responsibility, compromise, and flexibility. Across all indicators, students in the experimental group consistently demonstrated higher performance than their counterparts in the control group. These descriptive findings provide initial evidence that the applied learning intervention may have positively contributed to the development of students' collaboration skills.

DISCUSSION

The findings of this study suggest that the implementation of PjBL integrated with digital storytelling was associated with improvement in students' critical thinking and descriptively higher collaboration scores in primary education. The pretest comparison showed no statistically significant difference and a small effect size; however,

this result does not eliminate possible selection bias, maturation, teacher effects, or contamination between intact classes. Therefore, the findings should be interpreted as promising classroom-based evidence rather than definitive causal evidence.

Regarding critical thinking, the results indicate that the PjBL-DST intervention provided students with repeated opportunities to identify problems, gather information, evaluate relevance, organize evidence, and justify conclusions. The PjBL component structured students' inquiry through problem identification, planning, investigation, product development, presentation, and reflection (Thomas, 2000; Bell, 2010). These stages align with higher-order thinking processes because students were not merely answering questions but were required to produce and defend a meaningful project output.

The DST component contributed more specifically by requiring students to transform information into a coherent multimodal narrative. In producing digital stories, students selected key information, sequenced events logically, matched verbal explanations with images or audio, and revised the product based on teacher and peer feedback. These activities can strengthen analysis, inference, explanation, and evaluation because students must decide what evidence is relevant and how it should be communicated (Robin, 2008; Sadik, 2008; Lambert, 2013). Thus, the improvement in critical thinking should be interpreted as the result of the combined project structure and digital narrative production, not PjBL alone.

The very large effect size reported for posttest critical thinking ($d = 2.52$) should be interpreted cautiously. Although large effects may occur in small and intensive interventions, values above $d = 2.00$ are uncommon in educational research and may indicate ceiling effects, implementation differences, teacher effects, or measurement sensitivity. Therefore, the result supports a strong association between the intervention and improved critical thinking, but it should not be overstated as definitive evidence of unusually large causal impact without replication and raw-data verification.

The collaboration findings should be interpreted descriptively. The experimental group obtained Very High collaboration scores, whereas the control group was categorized as High. This pattern suggests that project-based collaborative activities may support peer interaction, role sharing, communication, responsibility, compromise, and flexibility. In the PjBL-DST setting, students had to distribute tasks, negotiate story content, coordinate media production, and present a shared product, which created more explicit opportunities for teamwork than conventional instruction. This interpretation is consistent with social interdependence theory (Johnson & Johnson, 2009) and prior digital storytelling studies that link collaborative media production with peer communication (Niemi et al., 2014).

Nevertheless, the collaboration comparison has two important limitations. First, the observation contexts were not fully equivalent because the experimental group was observed during active project work, while the control group learned through conventional instruction. Second, the present report did not include SDs or raw collaboration scores, so an independent samples t-test for collaboration could not be verified. These issues mean that collaboration results should be presented as observed descriptive differences rather than statistically confirmed differences.

However, the implementation of this approach requires adequate readiness from both teachers and students, particularly in terms of technological proficiency and time management. Challenges such as limited access to digital tools, varying levels of digital literacy, and the need for substantial planning time were noted by Puspitasari et al. (2025), who emphasized the importance of institutional support and teacher professional development. Koehler and Mishra (2009) similarly highlighted that the effectiveness of technology-enhanced learning heavily depends on the quality of implementation and teacher facilitation. It is therefore recommended that schools invest in both infrastructure and capacity-building programs.

Overall, the findings suggest that PjBL integrated with digital storytelling is a promising instructional approach for supporting critical thinking and collaboration in primary education, but several limitations must be emphasized. First, the sample was small and drawn from one school, limiting external validity. Second, intact classes were used without individual random assignment, so selection bias and class-level differences cannot be ruled out. Third, the intervention lasted only six meetings, and no follow-up retention test was conducted. Fourth, collaboration observation may have been biased because the experimental group naturally engaged in more group-based activity than the control group. Fifth, gain and N-gain inferential statistics require verification using individual-level data. Therefore, the findings should be viewed as preliminary evidence that requires replication

using larger samples, multi-school settings, randomization where feasible, and baseline-controlled analysis such as ANCOVA or mixed models.

CONCLUSION

The findings of this study suggest that the integration of Project-Based Learning (PjBL) with digital storytelling was associated with meaningful improvements in critical thinking skills among primary school students. The experimental group demonstrated significantly higher posttest critical thinking scores compared to the control group, with a large effect size, under comparable baseline conditions. Furthermore, observational assessments indicated that collaboration skills were also higher in the experimental group (M = 90.00) than in the control group (M = 74.89), reflecting a descriptive difference between the two groups.

Theoretically, this study contributes to the growing body of literature on constructivist and technology-enhanced learning by demonstrating the potential synergy between project-based inquiry and digital narrative production in fostering both cognitive and social skill development among young learners. From a practical standpoint, these findings offer meaningful guidance for educators seeking to design student-centered learning environments that are responsive to the demands of 21st-century education.

Nonetheless, several limitations should be acknowledged when interpreting these findings. The use of intact classes without random assignment, a relatively small sample size (n = 60), and the single-school research context limit the generalizability of the results. Future studies are encouraged to employ larger and more diverse samples across multiple school settings, utilize random assignment where feasible, and ensure the comparability of assessment tasks across groups. In addition, future research would benefit from reporting complete descriptive statistics including standard deviations, incorporating covariate analyses such as ANCOVA with pretest scores as covariates, and including follow-up assessments to evaluate the long-term retention of learning outcomes.

ETHICAL STATEMENT

This study was conducted in accordance with ethical principles governing research involving human participants, particularly children. Prior to data collection, formal written permission was obtained from the principal of Istiqlal Private Islamic Elementary School. Parental informed consent was secured for all 60 student participants, and students were informed of their right to withdraw from the study at any time without consequence. All student identities are kept strictly confidential; data are reported exclusively in aggregate form, with no personally identifiable information disclosed. The study did not involve any deception, harmful procedures, or sensitive interventions. All collected data are stored securely and will be used solely for academic research purposes.

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