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Research Article

PROJECT-BASED LEARNING AND 21ST-CENTURY SKILLS: DEVELOPING CRITICAL THINKING AND COLLABORATION IN PRIMARY CLASSROOMS

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Abstract

Project-Based Learning has gained increasing attention as an instructional approach aligned with the demands of twenty-first-century education, particularly in fostering higher-order thinking and social competencies in primary classrooms. This study aims to examine the effectiveness of Project-Based Learning in developing critical thinking and collaboration skills among primary school students. The research employed a quasi-experimental mixed-methods design involving an experimental group taught through Project-Based Learning and a comparison group receiving conventional instruction. Quantitative data were collected through performance-based critical thinking tests and collaboration observation rubrics, while qualitative data were obtained from classroom observations and teacher field notes. The results indicate that students exposed to Project-Based Learning demonstrated significantly higher gains in critical thinking and collaboration than those in the comparison group. Qualitative findings further revealed improved student engagement, more balanced participation, and deeper peer interaction during project activities. The study concludes that Project-Based Learning provides an effective pedagogical framework for integrating cognitive and social skill development in primary education. These findings suggest that early implementation of learner-centered, inquiry-based instruction can support the cultivation of essential twenty-first-century skills without compromising curricular objectives. The implications extend to teachers, curriculum designers, and policymakers seeking evidence-based strategies for meaningful primary classroom innovation worldwide contexts.

Keywords: Critical Thinking, Collaboration, Project-Based Learning, Primary Education, 21st-Century Skills.

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INTRODUCTION

The rapid transformation of social, economic, and technological landscapes in the twenty-first century has fundamentally reshaped expectations of educational systems worldwide (Vebibina et al., 2025). Schools are no longer tasked solely with transmitting disciplinary knowledge but are increasingly expected to cultivate higher-order thinking abilities, interpersonal competencies, and adaptive learning dispositions among students (Siefkes, 2025). Within this context, primary education plays a pivotal role, as foundational cognitive and social skills developed during early schooling significantly influence learners' long-term academic trajectories and lifelong learning capacities.

Contemporary educational discourse consistently emphasizes the importance of twenty-first-century skills, particularly critical thinking and collaboration, as essential competencies for navigating complex real-world problems (Tian et al., 2025). Primary classrooms, however, often remain dominated by teacher-centered instructional models that prioritize content coverage and standardized assessment outcomes (Begum et al., 2025). Such approaches frequently limit opportunities for students to engage in inquiry, problem-solving, and meaningful peer interaction, thereby constraining the development of skills that are increasingly demanded by global educational frameworks and workforce projections.

Project-Based Learning has emerged as a pedagogical approach that aligns closely with constructivist learning theories and learner-centered paradigms (Niksaz et al., 2025). By engaging students in authentic tasks, sustained inquiry, and collaborative problem-solving, Project-Based Learning offers a promising pathway for integrating cognitive and social skill development within curricular instruction (Scheel & Aguiñaga, 2025). The growing interest in this approach reflects a broader recognition that effective learning environments must foster active engagement, student agency, and contextualized knowledge construction from the earliest stages of formal education.

Despite widespread acknowledgment of the importance of critical thinking and collaboration, significant challenges persist in translating these educational goals into classroom practice at the primary level (Wang et al., 2025). Many teachers encounter structural constraints such as rigid curricula, time limitations, and assessment pressures that discourage innovative pedagogical experimentation (Juarez-Quispe et al., 2025). As a result, instructional practices often fail to provide systematic opportunities for students to analyze problems deeply, articulate reasoning, and engage productively with peers.

Empirical observations in primary classrooms reveal a recurring gap between policy-level aspirations for twenty-first-century skill development and the realities of everyday teaching and learning (Newman-Griffis, 2025). Students may participate in group activities or project-like tasks, yet these experiences are frequently superficial and lack intentional scaffolding for higher-order thinking or effective collaboration (Singh et al., 2025). Without clear instructional design principles and pedagogical support, such activities risk becoming procedural exercises rather than meaningful learning experiences.

The absence of clear evidence-based models demonstrating how Project-Based Learning can be effectively implemented in primary classrooms further complicates instructional decision-making (Littell & Peterson, 2025). Teachers often express uncertainty regarding how to structure projects that are developmentally appropriate while simultaneously promoting complex cognitive processes and collaborative competencies (Connor et al., 2025). This uncertainty underscores the need for research that explicitly examines the pedagogical mechanisms through which Project-Based Learning can support critical thinking and collaboration in early educational contexts.

The primary objective of this study is to examine the effectiveness of Project-Based Learning as an instructional approach for developing critical thinking and collaboration skills among primary school students (Yang et al., 2025). The research seeks to identify how structured project-based activities influence students' ability to analyze problems, generate

ideas, justify reasoning, and engage in collective decision-making processes within classroom settings.

A further objective involves exploring instructional design features and pedagogical strategies that enhance the impact of Project-Based Learning in primary education (Wijesinghe, 2024). Attention is directed toward the roles of teacher facilitation, task authenticity, inquiry processes, and collaborative structures in supporting meaningful learning outcomes (Scanlon & Kei Yatsu, 2025). By examining these elements, the study aims to provide practical insights that can inform classroom implementation and instructional planning.

An additional objective focuses on contributing empirical evidence to ongoing discussions regarding skill-oriented pedagogy in early education (He, 2026). The study aims to clarify how Project-Based Learning can be systematically integrated into primary curricula without compromising content mastery (Mohammed et al., 2026). Through this objective, the research aspires to support educators and policymakers in aligning instructional practices with contemporary educational demands.

A growing body of literature has documented the positive effects of Project-Based Learning on student engagement and conceptual understanding across various educational levels (Rivard et al., 2025). Nevertheless, much of this research has concentrated on secondary or higher education contexts, where learners possess more advanced cognitive and metacognitive capacities (Gao et al., 2025). Primary education remains comparatively underrepresented in empirical investigations, particularly with respect to skill-specific outcomes.

Existing studies addressing twenty-first-century skills in primary education often adopt broad conceptual frameworks without providing detailed analyses of instructional processes (Patil et al., 2024). Research frequently measures outcomes such as motivation or general achievement while offering limited insight into how critical thinking and collaboration are cultivated through specific pedagogical interventions. (Godfrey et al., 2025) This limitation restricts the practical applicability of findings for classroom practitioners.

A notable gap also exists in the integration of cognitive and social skill development within Project-Based Learning research (Persiani et al., 2025). Many studies examine critical thinking or collaboration in isolation, neglecting the interconnected nature of these competencies in authentic learning environments (Topali et al., 2025a). The lack of integrated analytical perspectives highlights the need for research that simultaneously investigates how Project-Based Learning supports multiple dimensions of twenty-first-century skills in primary classrooms.

The novelty of this study lies in its focused examination of Project-Based Learning as a structured pedagogical approach for fostering both critical thinking and collaboration among primary school students (Rapti et al., 2025). By situating the analysis within early educational contexts, the research challenges assumptions that complex skill development is primarily relevant to older learners (Alibali & Cook, 2025). This perspective advances a more inclusive understanding of when and how twenty-first-century competencies can be meaningfully cultivated.

Another innovative aspect of the study is its emphasis on pedagogical design and classroom processes rather than solely on learning outcomes (Ragonis et al., 2025). The research highlights the instructional conditions under which Project-Based Learning becomes an effective medium for cognitive and social development. Such an approach contributes methodological depth to existing literature by illuminating how teaching practices mediate student learning experiences.

The justification for this research is grounded in the urgent need to align primary education with evolving educational goals and societal expectations. As educational systems increasingly prioritize skill-based learning, evidence-informed pedagogical models are essential for guiding instructional reform. This study addresses this need by offering

theoretically grounded and empirically informed insights that support the sustainable integration of Project-Based Learning in primary classrooms, thereby strengthening the foundation for lifelong learning and collaborative problem-solving.

RESEARCH METHOD

Research Design

This study employs a quasi-experimental research design utilizing a mixed-methods approach to evaluate the impact of Project-Based Learning (PBL) on critical thinking and collaboration skills (Kier P. Dela Calzada et al., 2025). The quantitative dimension uses a pre-test and post-test structure to measure statistical shifts in student competencies, while the qualitative dimension utilizes interpretive analysis to capture the nuances of classroom dynamics and peer interaction patterns (Michalas et al., 2025). By integrating these two approaches, the study ensures a holistic examination that balances measurable learning outcomes with the contextual realities of the instructional process.

Research Target/Subject

The research target focuses on upper primary school students within a public elementary education setting (Topali et al., 2025b). The study subjects were selected through purposive sampling, consisting of two intact classes exhibiting comparable academic backgrounds and demographic profiles to minimize external variables (Laoharutanun et al., 2025). These subjects are divided into an experimental group, which undergoes the PjBL intervention, and a control group, which continues with conventional instructional methods (Guan & Scott, 2025). The study specifically monitors students who maintained consistent attendance throughout the intervention to ensure the internal validity of the findings.

Research Procedure

The research procedure is executed in three distinct phases (Rattanachaithada et al., 2025). First, a preliminary phase involves lesson planning, curriculum alignment, and the validation of research instruments. Second, the implementation phase begins with pre-tests for both groups, followed by a structured PjBL intervention for the experimental group involving inquiry-based collaborative projects, while the control group follows traditional teacher-centered lessons. Finally, the evaluation phase concludes the study with the administration of post-tests and the collection of final observations to determine the efficacy of the intervention.

Instruments, and Data Collection Techniques

Data collection utilizes a triangulation of qualitative and quantitative instruments. Critical thinking skills are captured through performance-based tests featuring problem-solving tasks aligned with grade-level objectives. Collaboration skills are quantified using an observation rubric focusing on participation, communication, and shared responsibility. Additionally, qualitative data are gathered through systematic classroom observations and reflective teacher notes, providing a deeper layer of insight into the experiential dimensions of student engagement and group decision-making processes.

Data Analysis Technique

The data analysis follows a convergent parallel approach to synthesize quantitative and qualitative findings. Quantitative data are analyzed using inferential statistics, such as t-tests, to determine significant differences between pre-test and post-test scores and between the experimental and control groups. Qualitative data undergo thematic analysis, involving the coding and categorization of observation logs and reflective notes to identify patterns in social interaction. The final synthesis involves merging these datasets to provide a comprehensive

conclusion on how Project-Based Learning influences both the cognitive and social development of primary students.

RESULTS AND DISCUSSION

The quantitative data collected in this study describe students' critical thinking and collaboration skills before and after the instructional intervention. Descriptive statistics were calculated to summarize mean scores, standard deviations, and score ranges for both the experimental and comparison groups. The results indicate observable differences in skill development between students exposed to Project-Based Learning and those who received conventional instruction.

Table 1 presents the descriptive statistics of critical thinking and collaboration scores across both groups. The experimental group demonstrated higher post-test mean scores in both skill domains compared to the comparison group. The dispersion of scores, as indicated by standard deviation values, suggests more consistent performance among students who participated in Project-Based Learning activities.

Table 1. Descriptive Statistics of Critical Thinking and Collaboration Scores

Group	Skill Domain	Pre-Test Mean	Post-Test Mean	Standard Deviation
Experimental	Critical Thinking	62.45	78.30	6.12
Experimental	Collaboration	64.10	81.75	5.88
Comparison	Critical Thinking	63.20	69.15	6.45
Comparison	Collaboration	65.05	71.40	6.70

The descriptive statistics reveal a notable improvement in the experimental group's performance following the implementation of Project-Based Learning. The increase in post-test mean scores suggests that students engaged in project-based activities developed stronger analytical reasoning and collaborative behaviors over the course of the intervention. The relatively lower standard deviation values indicate that these improvements were distributed across most participants rather than being limited to a small number of high-performing students.

The comparison group also exhibited modest gains in both skill areas, reflecting natural learning progression during the instructional period. The magnitude of improvement, however, was considerably smaller than that observed in the experimental group. These patterns suggest that traditional instructional approaches may support incremental skill development but are less effective in promoting higher-order and social competencies simultaneously.

A closer examination of critical thinking sub-indicators shows that students in the experimental group improved most significantly in problem analysis, idea generation, and justification of solutions. Performance-based task responses demonstrated increased depth of reasoning and greater use of evidence when addressing project-related problems. These improvements align with the inquiry-oriented nature of Project-Based Learning tasks.

Collaboration skill data indicate consistent growth across indicators such as active participation, communication clarity, and shared responsibility. Observational scores reveal that students became more adept at negotiating roles and resolving disagreements during group work. The improvement pattern suggests that repeated exposure to structured collaborative projects enhanced students' interpersonal competencies.

Inferential statistical analysis was conducted to determine whether the observed differences between groups were statistically significant. An independent samples t-test was applied to post-test scores for both critical thinking and collaboration. The analysis revealed statistically significant differences favoring the experimental group at the 0.05 significance level.

Effect size calculations further support the practical significance of the findings. The magnitude of the effect indicates that Project-Based Learning had a strong influence on both critical thinking and collaboration outcomes. These results provide empirical evidence that the instructional approach contributed meaningfully to the development of targeted twenty-first-century skills.

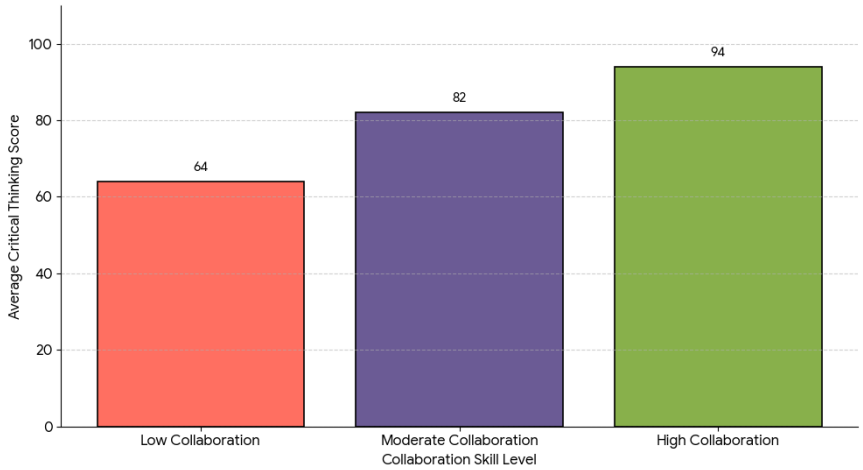

Figure 1. Correlation Between Collaboration Engagement and Critical Thinking

Correlation analysis was conducted to examine the relationship between critical thinking and collaboration skills within the experimental group. The results indicate a moderate to strong positive correlation between the two variables. Students who demonstrated higher levels of collaborative engagement tended to exhibit stronger critical thinking performance in project tasks.

The relationship between these skill domains suggests that cognitive and social competencies developed in tandem during Project-Based Learning activities. Collaborative interactions appeared to facilitate deeper reasoning through peer discussion, feedback exchange, and collective problem-solving. These findings reinforce the interconnected nature of twenty-first-century skills in authentic learning environments.

Qualitative case study data were drawn from classroom observations and selected student groups within the experimental class. One focal group demonstrated substantial improvement in task completion quality and interaction patterns over successive project cycles. Early observations showed uneven participation, while later sessions revealed more balanced contributions and coordinated decision-making.

Individual student reflections and teacher field notes indicate increased confidence in expressing ideas and questioning peers' perspectives. Students who were initially passive participants became more engaged during collaborative discussions. The case study data illustrate how Project-Based Learning influenced behavioral and cognitive changes at the micro-level of classroom practice.

The qualitative findings explain how instructional design features supported skill development. Clearly defined project goals, guiding questions, and teacher scaffolding enabled students to navigate complex tasks without excessive cognitive overload. Structured collaboration protocols encouraged equitable participation and sustained engagement among group members.

Teacher facilitation played a crucial role in mediating learning processes. Strategic questioning and timely feedback prompted students to reflect on both content understanding and teamwork effectiveness. These instructional practices created conditions conducive to deeper learning and meaningful collaboration within primary classrooms.

The combined quantitative and qualitative results demonstrate that Project-Based Learning effectively supports the development of critical thinking and collaboration skills in primary education. The convergence of statistical gains and observational evidence strengthens

the credibility of the findings. Students exposed to project-based instruction exhibited not only higher performance scores but also more sophisticated learning behaviors.

The results suggest that early integration of Project-Based Learning can foster foundational twenty-first-century competencies without compromising curricular objectives. The study provides empirical support for adopting learner-centered pedagogies in primary classrooms and highlights the value of designing instruction that simultaneously addresses cognitive and social dimensions of learning.

The findings of this study demonstrate that Project-Based Learning contributes positively to the development of critical thinking and collaboration skills in primary classrooms. Students who participated in project-based instruction showed significantly higher post-test scores compared to those taught through conventional methods. The results indicate that sustained engagement in inquiry-driven projects enhances both cognitive reasoning and social interaction abilities.

Quantitative evidence reveals substantial gains in problem analysis, idea generation, and justification of solutions among students in the experimental group. Collaboration outcomes also improved across indicators such as participation, communication, and shared responsibility. These improvements suggest that Project-Based Learning creates learning conditions that support integrated skill development rather than isolated competence acquisition.

Qualitative findings further substantiate the statistical results by illustrating observable changes in classroom behavior. Students became more confident in expressing ideas, negotiating group roles, and responding to peer feedback. Classroom interactions evolved from teacher-dependent exchanges toward more student-driven discussions and collective problem-solving.

Overall, the results confirm that Project-Based Learning functions as an effective pedagogical approach for fostering essential twenty-first-century skills in primary education. The convergence of quantitative and qualitative data strengthens the internal validity of the study and underscores the instructional value of project-based pedagogy.

Figure 2. Project-Based Learning Cycle

The results of this study align with prior research indicating that Project-Based Learning enhances higher-order thinking skills and learner engagement. Studies conducted in secondary and higher education contexts have consistently reported positive effects of project-based instruction on analytical reasoning and collaboration. The present findings extend this evidence base to the primary education level.

Differences emerge when comparing the magnitude and nature of skill development across educational stages. Previous studies often emphasize advanced metacognitive outcomes among older learners, whereas this study highlights foundational reasoning and social interaction skills. Such distinctions suggest that Project-Based Learning manifests differently depending on learners' developmental stages.

Contrasting findings in earlier primary education research often report limited effectiveness of collaborative learning due to students' cognitive immaturity. The current study challenges this assumption by demonstrating that appropriately structured projects can facilitate meaningful collaboration even among younger learners. Instructional design appears to be a critical mediating factor.

The contribution of this study lies in its integrated examination of critical thinking and collaboration rather than treating them as separate outcomes. This approach addresses a gap in existing literature and supports calls for more holistic investigations of twenty-first-century skills within authentic learning environments.

The findings of this research signal a shift in understanding how complex skills can be nurtured in early educational settings. Evidence from the study suggests that primary students are capable of engaging in higher-order thinking when learning tasks are meaningful and contextually grounded. Such results challenge deficit-oriented views of young learners' cognitive capacities.

The observed improvements in collaboration reflect the socializing function of Project-Based Learning. Students demonstrated increased awareness of group dynamics, shared responsibility, and collective goal achievement. These behaviors indicate early development of interpersonal competencies that are foundational for future academic and social success.

The results also suggest that learning environments emphasizing inquiry and cooperation promote deeper student engagement. Engagement in this context extends beyond behavioral participation to include cognitive investment and emotional involvement. This pattern reflects a broader transformation in classroom culture fostered by learner-centered pedagogy.

From a reflective standpoint, the findings serve as indicators that pedagogical innovation at the primary level can yield substantial educational benefits. The study highlights the potential of Project-Based Learning to function as a catalyst for instructional change aligned with contemporary educational goals.

The implications of these findings are significant for classroom practice in primary education. Teachers are encouraged to adopt instructional models that prioritize inquiry, collaboration, and authentic problem-solving. Project-Based Learning offers a structured yet flexible framework for achieving these pedagogical aims.

Curriculum designers may consider integrating project-based components into existing learning standards. The results suggest that skill development does not require abandoning content objectives but can be embedded within subject matter instruction. This integration supports balanced curricular design that addresses both knowledge and competencies.

Teacher professional development programs can benefit from incorporating training on Project-Based Learning design and facilitation. Effective implementation requires pedagogical expertise in scaffolding inquiry, managing group dynamics, and assessing complex learning outcomes. The study underscores the importance of equipping teachers with these competencies.

Policy-level implications include rethinking assessment practices in primary education. Traditional testing methods may inadequately capture gains in critical thinking and collaboration. The findings support the adoption of performance-based and formative assessment approaches aligned with twenty-first-century learning objectives.

The effectiveness of Project-Based Learning observed in this study can be attributed to its alignment with constructivist learning principles. Learning activities that require students to

actively construct knowledge promote deeper cognitive processing. This process enhances critical thinking through analysis, synthesis, and evaluation.

Collaborative project structures provide social contexts that stimulate reasoning and reflection. Peer interaction encourages students to articulate ideas, confront alternative perspectives, and refine understanding. These social processes contribute directly to both cognitive and interpersonal skill development.

Teacher facilitation played a crucial role in shaping learning outcomes. Guided inquiry, strategic questioning, and timely feedback supported students' engagement without diminishing autonomy. Such instructional practices created optimal learning conditions for skill development.

The authenticity of project tasks also explains the observed outcomes (Cano Sobrevals & Fernández Mata, 2025). Real-world relevance increased student motivation and sustained engagement. Meaningful tasks encouraged learners to invest cognitively and socially, resulting in measurable improvements in targeted skills.

Future research may explore the long-term effects of Project-Based Learning on students' academic trajectories and social development (Cavanagh et al., 2025). Longitudinal studies could provide insights into how early exposure to project-based pedagogy influences later learning outcomes and dispositions.

Further investigations may examine variations in Project-Based Learning implementation across different subject areas and cultural contexts (Escala et al., 2025). Comparative studies could identify contextual factors that enhance or constrain effectiveness in diverse educational settings.

Methodological expansion is also warranted. Mixed-methods designs incorporating learning analytics and classroom discourse analysis may offer deeper insights into learning processes. Such approaches can enrich understanding of how skills develop over time.

Practical innovation remains essential. Continued experimentation with Project-Based Learning models can inform adaptive instructional strategies that respond to evolving educational demands. The findings of this study serve as a foundation for ongoing pedagogical refinement and scholarly inquiry.

CONCLUSION

The most significant finding of this study is that Project-Based Learning effectively fosters the simultaneous development of critical thinking and collaboration skills in primary classrooms. Students who engaged in structured project-based activities demonstrated measurable improvements in analytical reasoning, problem-solving, and evidence-based justification, alongside enhanced abilities to communicate, share responsibility, and negotiate meaning within groups. These findings indicate that complex cognitive and social competencies can be meaningfully cultivated at the primary level when learning experiences are intentionally designed and supported through inquiry-driven and collaborative pedagogies.

The primary contribution of this research lies in its conceptual and methodological integration of cognitive and social skill development within a single instructional framework. The study advances existing scholarship by providing empirical evidence that Project-Based Learning functions not merely as an engagement strategy but as a coherent pedagogical model capable of aligning content learning with twenty-first-century skill acquisition. The mixed-methods approach strengthens this contribution by linking quantitative learning outcomes with qualitative classroom processes, thereby offering a more comprehensive understanding of how and why Project-Based Learning is effective in early education contexts.

Several limitations should be acknowledged when interpreting the findings. The study was conducted within a limited number of classrooms and over a relatively short intervention period, which may constrain the generalizability of the results. The focus on specific indicators

of critical thinking and collaboration also limits the scope of skill assessment. Future research is encouraged to employ longitudinal designs, involve more diverse educational settings, and examine additional twenty-first-century competencies to further validate and extend the insights generated by this study.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used ChatGPT to assist in improving grammar, language quality, and overall readability of the text. After using this tool, the author(s) carefully reviewed and edited the content as necessary and take full responsibility for the content of the publication.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

Author 4: Formal analysis; Methodology; Writing - original draft.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in the paper.

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