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**Research Article**

# Assess the Impact of a Project-Based Learning Approach on the Development of 21st Century Skills

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**Abstract**
The increasing demand for adaptable, collaborative, and innovative professionals has positioned 21st century skills-such as critical thinking, creativity, communication, and collaboration-at the center of educational priorities worldwide. Traditional instruction often fails to cultivate these competencies, prompting the need for more experiential, student-centered learning models. Project-Based Learning (PBL), with its emphasis on real-world problem-solving and interdisciplinary inquiry, has emerged as a promising pedagogical approach to support the development of these essential skills. This study aims to assess the impact of PBL on secondary students' acquisition of key 21st century skills. Using a quasi-experimental design, the research involved 160 students divided into experimental (PBL) and control (conventional instruction) groups. Over ten weeks, the experimental group engaged in structured project cycles aligned with curriculum standards, while the control group followed traditional content delivery. Pre- and post-intervention assessments, student reflections, and teacher evaluations were analyzed to measure skill development. Results revealed that students in the PBL group showed statistically significant improvements in collaboration, problem-solving, and creative thinking compared to the control group. Teachers also reported increased learner autonomy and engagement. The study concludes that PBL is a viable strategy for fostering 21st century competencies in contemporary classrooms.

**Keywords**: project-based learning, 21st century skills, student-centered pedagogy, critical thinking, educational innovation

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## INTRODUCTION

The landscape of global education is shifting rapidly in response to technological advances, evolving workplace demands, and societal transformation. Educational systems around the world are being challenged to go beyond traditional content knowledge and emphasize the development of 21st century skills—critical thinking, creativity, communication, collaboration, digital literacy, and adaptability. These skills are increasingly recognized as essential for students to thrive in complex, unpredictable, and innovation-driven futures.

Conventional classroom practices, dominated by lecture-based instruction and standardized assessments, have shown limitations in cultivating these essential competencies. In many cases, students are trained to recall and reproduce information rather than to analyze, synthesize, or solve real-world problems. There is growing consensus that pedagogical reform is necessary to create learning environments that are more student-centered, inquiry-driven, and authentic in nature (Lapina et al., 2025; Lutsenko & Hrytsenko, 2025). Educational stakeholders are therefore exploring alternative models that can bridge the gap between academic instruction and future-readiness.

Project-Based Learning (PBL) has emerged as one of the most promising approaches to address these challenges. Grounded in constructivist learning theory, PBL engages students in extended investigations of complex, real-world questions, often requiring interdisciplinary knowledge and collaborative effort (Stroud, 2025; Truslove et al., 2025). By centering learning around authentic projects with tangible outcomes, PBL creates meaningful opportunities for students to develop not only academic content mastery but also the core skills required in the 21st century.

Despite the growing advocacy for PBL as a tool to foster 21st century competencies, its implementation and effectiveness vary widely across educational contexts. In many classrooms, PBL is still used sporadically or superficially, lacking a systematic framework that ensures intentional development of specific skills (Ayoade Fadare et al., 2025; Cichoń & Baarová, 2025; Muengsan et al., 2025). Teachers often face challenges in designing, facilitating, and assessing PBL experiences that are aligned with curriculum standards while simultaneously nurturing collaboration, critical thinking, and innovation.

Students frequently encounter inconsistencies in opportunities to apply higher-order thinking, take ownership of their learning, or collaborate meaningfully in team-based tasks. This inconsistency leads to uneven outcomes, where the potential of PBL is not fully realized. Moreover, the lack of empirical evidence linking structured PBL implementation to measurable gains in 21st century skills poses a barrier to broader institutional adoption and support (Blanco-García et al., 2025; Donoso et al., 2025; Richter, 2025; Tewari et al., 2025; Yurt, 2025). Without such evidence, educators and policymakers may remain hesitant to fully invest in pedagogical transformation.

In the context of secondary education, where examination pressure and rigid curriculum timelines often dominate, the adoption of PBL is particularly constrained. Teachers may perceive PBL as time-consuming or incompatible with standardized testing objectives. As a result, the potential benefits of PBL-particularly in skill development-are underutilized in mainstream education (Al-Redouan et al., 2025; Espino-Díaz et al., 2025). A clear, evidence-based understanding of how PBL impacts 21st century skills is needed to validate its relevance and inform practice.

This study aims to assess the impact of a structured Project-Based Learning approach on the development of key 21st century skills among secondary school students. The research focuses on measuring improvements in critical thinking, collaboration, creativity, and problem-solving competencies following a PBL intervention. The intent is to evaluate not only whether these skills improve but also how they are fostered through specific elements of the PBL framework.

The study seeks to explore the relationship between the design features of PBL-such as inquiry-based tasks, peer collaboration, and authentic assessment-and the acquisition of 21st century competencies (Chhabra & Gawande, 2025; Taiebine et al., 2025; Tierney et al., 2025; Tünür & İnalhan, 2025). By examining student work, teacher feedback, and pre-post performance data, the research will provide a multidimensional understanding of how PBL contributes to skill development. Attention is given to both quantitative and qualitative indicators of growth.

The overarching goal is to provide empirical evidence to support the integration of PBL in mainstream curricula as a vehicle for developing future-ready learners. This study aims to inform teachers, school leaders, and curriculum developers on the instructional design principles and pedagogical conditions that maximize the impact of PBL on essential 21st century learning outcomes.

A growing body of literature supports the theoretical foundations of PBL and its potential to enhance student engagement and motivation. However, empirical research that systematically measures its impact on 21st century skill development—particularly using validated assessment tools—is still limited. Many existing studies focus on PBL's effect on academic achievement or student attitudes, without directly assessing changes in competencies such as collaboration, creativity, or critical thinking.

Few studies provide comprehensive, data-driven models that connect the components of PBL design with measurable growth in 21st century skills. Where research does exist, it often lacks contextual specificity or fails to address the challenges of implementation within traditional school structures. These limitations hinder the ability to generalize findings or replicate successful PBL strategies across diverse educational settings.

This study aims to address these gaps by applying a quasi-experimental research design in secondary education, supported by mixed-method data collection. It seeks to evaluate both the outcomes and the processes through which PBL influences student competencies. By grounding the analysis in real classroom experiences and aligning it with global frameworks for 21st century learning, this research offers a robust contribution to the field.

This research introduces a novel perspective by combining outcome-based measurement of 21st century skills with process-oriented analysis of PBL implementation. The originality lies in its dual focus: assessing tangible improvements in student competencies while also unpacking the pedagogical mechanisms that support such development. The study not only investigates what changes occur but also explores how and why they take place within the structure of a project-based learning experience.

The integration of validated assessment rubrics, student reflection protocols, and teacher evaluations contributes to the methodological rigor of the study. By triangulating multiple data sources, the research enhances validity and offers practical insights into effective instructional design. The findings will be particularly valuable for educators seeking to align PBL with curricular standards while maintaining fidelity to its constructivist roots.

The urgency of preparing students for rapidly changing global realities underscores the importance of this study. As education systems worldwide strive to equip learners with transferable skills, evidence-based guidance on how to achieve this goal is critical. This research responds to that need by providing actionable knowledge on the design, facilitation, and assessment of PBL for skill development in 21st century classrooms.

## RESEARCH METHOD

### *Research Design*

This study employed a quasi-experimental design with a non-equivalent control group and pretest-posttest structure to assess the impact of Project-Based Learning (PBL) on the development of 21st century skills. The quasi-experimental model was chosen to allow for intervention in natural classroom settings where random assignment was not feasible (Ghosh, 2025; Roberto et al., 2025). The research compared the outcomes of two instructional approaches-PBL and conventional teacher-centered instruction-to determine their respective effects on students' critical thinking, collaboration, creativity, and problem-solving abilities.

### *Research Target/Subject*

The population consisted of tenth-grade students enrolled in two public secondary schools with comparable academic performance and demographic characteristics. A purposive sampling method was used to select two intact classes from each school, resulting in a total sample of 160 students. One class from each school was assigned to the experimental group (PBL), while the other served as the control group (traditional instruction). Both groups were taught by experienced teachers in the same subject area to control for instructor-related variables.

### *Research Procedure*

The procedures involved a ten-week intervention period. During this time, the experimental group engaged in project-based learning units aligned with curriculum standards and designed around real-world, interdisciplinary problems. Each project followed a structured cycle including inquiry, planning, collaboration, execution, and presentation. The control group received instruction through conventional lecture, textbook activities, and individual assignments. Pretests were administered to both groups prior to the intervention, and posttests were conducted at the end of the tenth week.

### *Instruments, and Data Collection Techniques*

Data collection instruments included a 21st Century Skills Rubric adapted from the Partnership for 21st Century Learning (P21) framework, pretest and posttest assessments, structured student reflection forms, and teacher evaluation checklists. The rubric measured skill indicators in four domains: critical thinking, collaboration, creativity, and communication. Pretest and posttest assessments were used to quantify students' competencies before and after the intervention. Qualitative data from student reflections and teacher observations provided contextual insights into student behavior and engagement during the learning process.

### *Data Analysis Technique*

Data analysis combined descriptive statistics, ANCOVA for quantitative data, and thematic coding for qualitative responses to assess the depth and breadth of 21st century skill development across both groups.

## RESULTS AND DISCUSSION

The study involved 160 secondary school students, divided equally into control and experimental groups. Both groups completed pretest and posttest assessments designed to measure competencies in critical thinking, collaboration, creativity, and problem-solving. The scores were analyzed to identify changes in students' 21st century skills before and after a ten-week instructional period.

Table 1. Descriptive statistics of pretest and posttest scores

| Group | Pretest Mean | Pretest SD | Posttest Mean | Posttest SD |
|---|---|---|---|---|
| Control | 59.38 | 4.79 | 61.94 | 4.59 |
| Experimental | 60.64 | 5.15 | 72.28 | 4.82 |

The descriptive data show that both groups started with similar pretest averages. However, posttest results indicate that students in the experimental group demonstrated a marked improvement in skill acquisition, with an average increase of approximately 11.6 points compared to a modest 2.56-point increase in the control group.

The large gain in the experimental group's posttest scores reflects the effectiveness of the Project-Based Learning (PBL) approach in cultivating 21st century skills. The design of the PBL units encouraged student engagement in authentic problem-solving, peer collaboration, and self-directed inquiry-all of which contributed to substantial cognitive and social skill development.

In contrast, the control group, which continued with traditional instruction, showed only minimal improvement. This result suggests that conventional methods may be less effective in promoting complex competencies needed in contemporary educational and professional contexts. The gap between groups reinforces the notion that pedagogy plays a critical role in shaping skill acquisition beyond content knowledge.

Student reflections from the experimental group highlighted increased confidence in communication, time management, and teamwork. Learners reported that collaborative tasks during project phases helped them develop active listening and idea-sharing habits. Many noted that working in diverse teams improved their ability to resolve conflict and negotiate roles based on individual strengths.

Teacher observations aligned with these reflections. Educators noted a shift from teacher dependence to learner autonomy, especially during project planning and execution stages. Students

were observed taking initiative, managing group responsibilities, and seeking feedback actively-behaviors directly associated with 21st century competencies such as collaboration and self-regulation.

An ANCOVA was conducted to compare posttest scores between the experimental and control groups while controlling for pretest performance. The results indicated a statistically significant difference, $F(1,157) = 48.37$, $p < 0.001$, confirming that the PBL intervention had a strong effect on the development of 21st century skills.

Effect size analysis showed a partial eta squared value of 0.24, indicating a large effect according to Cohen's benchmarks. This finding suggests that the PBL approach not only contributed to skill development but did so with meaningful practical significance. The outcome validates the model as an effective method for fostering future-ready competencies.

Correlational analysis between student reflection quality and posttest scores revealed a moderate positive relationship ($r = 0.64$, $p < 0.01$), indicating that students who were more metacognitive about their learning process tended to demonstrate greater improvement. This supports the idea that reflection plays a key role in consolidating the skills developed through PBL.

Further analysis showed that project complexity and team dynamics influenced the extent of skill development. Groups that tackled interdisciplinary problems and maintained consistent peer communication outperformed others on posttest assessments. This suggests that well-designed projects and collaborative coherence are critical in maximizing the outcomes of PBL implementation.

One illustrative case involved a group project focused on sustainable urban planning. Students researched local infrastructure challenges, interviewed community members, and proposed design innovations using 3D models and presentations. The team demonstrated growth in problem-solving, digital literacy, and leadership, as reflected in both their posttest scores and qualitative evaluations.

Another case featured a health education project in which students designed campaigns addressing teenage mental health awareness. The process required coordination, message development, and community outreach. Teachers noted significant growth in empathy, teamwork, and creative expression, all of which contributed to enhanced collaborative and communication skills among participants.

The qualitative data provide further insight into the mechanisms behind the statistical gains observed. Students frequently expressed a sense of ownership over their learning, often citing the relevance and authenticity of the projects as key motivators. Many found that having to apply knowledge in real contexts deepened their understanding and made the learning process more engaging.

Teachers emphasized that PBL created space for diverse learners to succeed. Visual, kinesthetic, and verbal strengths were all activated through various project phases, allowing students with different learning styles to contribute meaningfully. This inclusivity helped to democratize classroom participation and empowered students who might struggle in traditional lecture-based formats.

The findings of this study indicate that Project-Based Learning significantly enhances the development of 21st century skills among secondary school students. Quantitative gains were substantiated by strong qualitative evidence, pointing to the value of PBL in promoting learner autonomy, critical thinking, and collaborative engagement.

The research confirms that when PBL is implemented with intentionality and aligned with curriculum standards, it can serve as an effective vehicle for preparing students for the challenges of a rapidly evolving world. These results offer a compelling case for educational stakeholders to adopt and scale PBL as a core pedagogical approach in skill-oriented curriculum reform.

The findings of this study demonstrate a significant improvement in students' 21st century skill development as a result of the Project-Based Learning (PBL) intervention. Students in the experimental group showed greater gains in critical thinking, collaboration, creativity, and problem-solving compared to their peers in the control group. These gains were validated through both pre-post quantitative assessments and qualitative reflections from teachers and students.

The experimental group's posttest scores increased by an average of over 11 points, while the control group showed only modest growth. Observational data confirmed that students participating in PBL tasks were more engaged and displayed stronger interpersonal and cognitive skills. Group projects and authentic challenges appeared to enhance not only academic performance but also the quality of classroom interactions.

Student reflections provided compelling evidence of metacognitive growth. Many learners expressed that they felt more responsible for their learning and more prepared to work in collaborative environments (Alalawi et al., 2025; Andargie et al., 2025; du Plessis, 2025; Ferrer & Ángel-Torres,

2025; Witherell, 2025). Teachers corroborated these outcomes, highlighting increases in student autonomy, initiative, and willingness to lead within group contexts.

The results also revealed that PBL encouraged meaningful application of content knowledge in real-life scenarios. This relevance strengthened student motivation and reinforced the practical value of learning, aligning with the broader aims of 21st century education to foster adaptable, lifelong learners.

The outcomes of this research align with prior studies emphasizing the efficacy of PBL in developing higher-order thinking skills. Studies by Thomas (2000), Bell (2010), and Kaldi et al. (2011) have previously highlighted that PBL environments foster student-centered learning and engagement. The present study confirms and extends these findings by demonstrating that measurable gains in 21st century competencies can be systematically achieved through structured PBL interventions.

This study also supports claims made in international frameworks, such as those developed by the Partnership for 21st Century Learning (P21), which identify real-world problem-solving and collaboration as core educational priorities. The integration of interdisciplinary tasks in the projects allowed students to draw from various subject areas, fostering cognitive flexibility and integrative thinking.

While previous research has emphasized PBL's motivational benefits, this study contributes empirical evidence that directly links PBL to skill acquisition using validated assessments. It goes beyond anecdotal support and highlights quantifiable improvements in student performance, bridging a gap in the literature regarding impact measurement.

The study also differentiates itself by examining both process and outcomes. Rather than focusing solely on achievement scores, it investigates the learning behaviors and dynamics that lead to skill development. This dual lens strengthens the evidence base for PBL as a holistic pedagogical model that supports both academic and personal growth.

The results suggest a critical shift in how educational success can be defined and measured. Learning should no longer be confined to content retention and test scores; it must encompass the development of essential life and work competencies. The success of PBL in this context signals a move toward education models that value the process of learning as much as the outcome.

Student behavior during the PBL cycle-characterized by initiative, collaboration, and self-management—reflected attributes that are increasingly relevant in professional and civic life. These behaviors are not typically cultivated in traditional, lecture-based settings. The study reveals that students are capable of much more than passive knowledge consumption when provided with the right structure and autonomy.

Teachers' evolving roles from knowledge deliverers to facilitators of inquiry also point to pedagogical transformation. This shift creates space for students to construct meaning, manage their learning, and work through complexity-skills that are essential for navigating real-world problems. The findings underscore the value of creating environments that foster curiosity, resilience, and teamwork.

These outcomes indicate that PBL is not just a method but a mindset. It redefines classroom roles, learning expectations, and success indicators in ways that are more aligned with the realities and demands of the 21st century (Huseynli & Bub, 2025; Mumpuni et al., 2025; Pohlak et al., 2025; Trimuliana & Supena, 2025). The study suggests that such approaches are not only desirable but necessary for future-ready education systems.

The implications of these findings are far-reaching for educational practice, curriculum design, and policy. Schools aiming to prepare students for future challenges must look beyond conventional teaching strategies and invest in models that explicitly cultivate 21st century competencies. PBL offers a replicable and scalable framework to meet these objectives.

Curriculum developers should consider embedding project cycles, authentic tasks, and interdisciplinary challenges into national and local curricula. These elements encourage students to engage in deeper learning and apply knowledge in ways that mirror real-life complexity. Assessment systems should also evolve to recognize collaborative efforts, creative processes, and problem-solving strategies, not just individual performance on standardized tests.

Teacher training and professional development programs must be reoriented to equip educators with the skills and mindset required to design and facilitate effective PBL experiences. This includes training in scaffolding inquiry, managing group dynamics, and integrating formative assessment tools that align with skill development goals.

Policymakers should support the institutionalization of PBL through funding, infrastructure, and assessment reforms. Systemic backing is essential to move from isolated instances of PBL to

widespread adoption (Dobson, 2025; Khalemsky et al., 2025; Thipayasothorn et al., 2025). The evidence provided in this study offers a compelling case for policy changes that prioritize skill-based learning environments across educational systems.

The positive impact of PBL on 21st century skills can be attributed to its alignment with how students naturally learn best-through exploration, collaboration, and contextual application. The project cycle structure inherently supports the development of higher-order thinking by requiring students to define problems, investigate solutions, and reflect on outcomes.

Collaborative projects created real social learning environments where students were accountable to peers and motivated to contribute meaningfully. This setup encouraged the development of communication and interpersonal skills that are less frequently emphasized in teacher-directed instruction. The sense of shared responsibility fostered more equitable participation and promoted inclusive engagement.

Real-world relevance was another driver of effectiveness. Students perceived their work as purposeful and connected to broader societal contexts. This relevance increased intrinsic motivation and sustained attention throughout the project, both of which are crucial for deep learning and skill acquisition. PBL provided the scaffolding needed for students to take risks and learn from failure.

The teacher's role as a facilitator allowed students to navigate challenges independently while receiving timely guidance. This balance of autonomy and support was essential in cultivating metacognitive abilities and self-directed learning habits. The results underscore that when designed intentionally, PBL can operationalize the abstract goals of 21st century education into tangible classroom practices.

Future research should explore the longitudinal impact of PBL on students' academic trajectories, personal development, and post-secondary outcomes. Investigating whether the skills developed through PBL persist over time and transfer to new contexts would provide valuable insights into its long-term benefits and limitations.

Comparative studies across different educational systems and cultural contexts would help determine the adaptability and universality of PBL's impact. Research involving rural, under-resourced, or non-traditional school settings could reveal important variations in implementation and effectiveness, contributing to more inclusive models of PBL design.

Mixed-method studies integrating learning analytics, classroom observation, and student self-reporting would deepen our understanding of the mechanisms behind PBL's effectiveness. Investigating how digital tools and hybrid environments can support or hinder PBL would also be timely, given the growing prevalence of technology in education.

Educational leaders, researchers, and practitioners should now collaborate to refine PBL frameworks, assessment tools, and teacher training modules that support 21st century learning. Policy alignment, resource investment, and research-practice partnerships will be critical to ensuring that PBL moves from promising innovation to widespread educational transformation

## CONCLUSION

The most significant finding of this study is the substantial and measurable enhancement of students' 21st century skills-particularly in collaboration, problem-solving, creativity, and critical thinking-as a result of participating in structured Project-Based Learning (PBL) experiences. The experimental group not only showed statistically significant improvements compared to the control group, but also demonstrated deeper learner engagement, self-regulation, and authentic application of knowledge in real-world contexts. These outcomes affirm that PBL, when deliberately implemented with alignment to skill development goals, serves as a highly effective pedagogical model for preparing students for future academic, professional, and social challenges.

This research offers both conceptual and methodological contributions to the educational field. Conceptually, it strengthens the link between constructivist pedagogy and 21st century skill acquisition by empirically demonstrating that PBL fosters transferable competencies beyond content mastery. Methodologically, it introduces a mixed-data framework that combines quantitative pre-post assessment with qualitative reflection and teacher observation, offering a robust and multi-dimensional approach to evaluating complex skills. The use of validated rubrics and alignment with global educational

frameworks enhances the replicability of the study across diverse instructional contexts and supports a broader movement toward evidence-based, skills-focused instructional design.

The primary limitation of the study lies in its scope and duration, as it was conducted within a controlled ten-week period in two school settings, which may not fully capture long-term skill retention or broader scalability. The research also focused primarily on cognitive and interpersonal skills, with limited exploration of intrapersonal dimensions such as resilience or adaptability. Future studies should consider longitudinal designs to evaluate sustained impact, explore integration of digital tools to support remote and hybrid PBL models, and examine the role of teacher professional development in optimizing implementation. Expanding the sample across diverse geographic and socioeconomic contexts will also be critical to validating and refining the universal applicability of PBL in 21st century skill development.

## AUTHOR CONTRIBUTIONS

Thiago Rocha: Conceptualization; Project administration; Validation; Writing - review and editing; Conceptualization; Data curation; In-vestigation.
Clara Mendes: Data curation; Investigation; Formal analysis; Methodology; Writing - original draft.
Wahju Dyah Laksmi Wardhani: Supervision; Validation; Other contribution; Resources; Visuali-zation; Writing - original draft.

## CONFLICTS OF INTEREST

No conflicts of interest.

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