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Nurturing Critical Thinking through Design-Based Learning

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Abstract

This paper examines how Design-Based Learning (DBL) nurtures critical thinking by identifying key approaches and contextual factors that promote critical thinking among students. The study employed a thematic synthesis approach in a five-stage process, including data sources, search strategy, purpose, and output to analyze how DBL promotes critical thinking. Data were collected over three months from multiple academic databases using specific keywords and thematically analyzed for patterns. Findings show that DBL is a powerful pedagogy that enhances critical thinking, creativity, problem-solving, and engagement across diverse contexts, including low-resource settings. Its success, however, relies on teacher readiness, integration with complementary methods, and the development of standardized assessment tools to measure higher-order thinking skills effectively. The study concluded that DBL is a transformative pedagogy that enhances critical thinking, creativity, problem-solving, and engagement across disciplines, including low-resource settings. Its success depends on integration with complementary methods, teacher readiness, and the development of standardized assessment tools to ensure sustainable impact in 21st-century education.

Keywords: Design-Based Learning, Critical thinking, Problem solving, Creativity, Student engagement.

Introduction

Design-Based Learning (DBL) is a pedagogical strategy that actively engages students in solving authentic problems through iterative design processes. It promotes critical thinking by requiring learners to analyze problems, explore alternatives, make reasoned decisions, and reflect on their outcomes (Kolodner et al., 2003; Doppelt, 2009). Nurturing critical thinking through design-based learning (DBL) is increasingly recognized as an effective educational strategy. This approach integrates hands-on projects with structured methodologies, such as design thinking, to enhance students' cognitive skills. By engaging in authentic problem-solving tasks, students develop critical thinking abilities that are essential for the 21st century. The DBL approach complements project-based learning by providing a structured framework that guides students from project conception to completion, fostering critical thinking throughout the process (Maknuunah et al., n.d. This integration encourages students to analyze and evaluate problems, brainstorm solutions, and iterate designs, which enhances their ability to think critically and solve complex issues. Much research indicates that students engaged in technology and engineering design-based learning demonstrate significantly improved critical thinking and problem-solving skills compared to those in conventional learning environments (Shanta & Wells, 2020; Maganga & Srivastava, 2025). The DBL approach has been shown to stimulate student motivation and engagement, leading to deeper learning experiences (Weng et al., 2022). Students report higher satisfaction and increased participation, which correlates with improved higher-order thinking skills, including critical thinking (Weng et al., 2022). While design-based learning offers substantial benefits for nurturing critical thinking, it is essential to consider that not all students may thrive in such environments. Some may prefer conventional methods that provide clearer structures and guidance, highlighting the need for a balanced approach in educational settings. This paper examines how Design-Based Learning (DBL) nurtures critical thinking by identifying key approaches and contextual factors that promote critical thinking among students through a review of relevant literature and case studies; the discussion highlights the potential of DBL as an effective framework for cultivating higher-order thinking skills in diverse educational settings.

Literature Review

Cin & Cifti (2025) conducted the study called Effects of design-based research approach on 4th-grade students' critical thinking problem-solving skills. Their studies find that DBL improved critical thinking, computational thinking, and creativity, self-efficacy in rural students under low resource conditions.

Alvarado et al (2025). The study was called Design Thinking as an Active Teaching Methodology in higher education. The report concluded that design thinking, interdisciplinary collaboration, and iterative innovation

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Ananda et al (2025) the study was critical thinking skills of chemistry students by integrating DT of Chemistry students by integrating DT with STEAM-PJBL. The findings show that in Chemistry learning, combining design thinking with STEAM project-based learning significantly boosted critical thinking.

Blay & Espartinez (2024) conducted a study called improved digital learning using design thinking in the Philippines. The study involved undergraduates who regarded design thinking as transformative, promoting critical thinking, problem solving, empathy, and creativity

Subramaniam et al (2024). The study was called the STEM Ways of Thinking Framework: Engineering Design-Based Physics problem. They introduced WoT4EPD, combining reflection and computation to foster deeper critical thinking in engineering design projects

Jiang & Pang (2023) the study was called Enhancing design thinking in Engineering students' PBL. The findings of the study, Integrated design thinking and DBL, increased students' innovation, user-need focus, motivation, and created problem-solving

Mohamed (2023) in his study called Critical Thinking-Oriented Adoptions of PBL models: A systematic Review. The study finds that adaptations of PBL that incorporate structured CT elements consistently improve learners' critical thinking

Manikutty et al (2022) the study was called Driving Innovation Through project-based learning. A pre-university STEAM for social good initiative in India. The findings showing Indian pre-university students in a STEAM for social good DBL program demonstrated enhanced critical thinking, design reasoning, creativity, and social problem-solving compared to control groups

Frontiers (2022) the study entitled Design-based learning as a pedagogical approach in an online learning environment. The findings of this study show five phases of the DBL model. These are problem identification, solution design, demonstration, reflection, and evaluation, facilitated critical thinking, and solution-oriented learning virtual science course

From the given literature review, the researcher realized that limited papers focus on primary and secondary education. And the majority of studies have been done in developed countries, and a few studies have been done in India. Insufficient attention to teacher training and pedagogical readiness affects the success of DBL in improving critical training. Furthermore, the existing gap in the assessment of critical thinking remains inconsistent, hence the need for a clear assessment tool that accurately measures the growth in critical thinking due to DBL interventions.

Methodology

The study used a thematic synthesis approach to identify patterns of both approaches and contextual factors in the DBL environment that effectively promote critical thinking among students. It included five stages, namely the process stage, in which the author asked what was done. The second stage was recording data sources, where the author had to find the database search engine. Third stage search strategy, the author has to find keywords. Forth stage was to cross-check the purpose; the author has to explain why these sources have to be included. Finally, the Fifth stage outputs what was obtained *from thematic analysis.* The study was conducted for three months, from designing the title until writing the report. Data was obtained only from different databases selected by the researcher. Data was obtained from Google Scholar for its wide coverage; from Scopus, Web of Science, or Social Science Citation Index (SSCI) since they have a high impact factor; The researcher also obtained the data from Education Resources Information Center (ERIC) for the purpose of getting pedagogical approaches; IEEE Xplore or ACM for Technology-enhanced learning. The researcher used keywords to search for data. These keywords were Design-Based Learning; Multidisciplinary approach, problem-based learning; collaborative learning, inquiry-based learning integration, technology-enhanced learning, diverse resources and tools, teachers as facilitators, real-world problem, and failure as a learning opportunity. Finally, the data were thematically analysed as Table 1 indicates;

Table 1: Summary of Methodology for Thematic Synthesis

Stage/Process	Data Source	Search Strategy (Keywords)	Purpose/Focus	Output for Analysis
Study design & planning (3 months duration: from title design to report writing)	—	—	To define the scope and timeline	Structured paper framework

Data retrieval from wide coverage sources	Google Scholar	"Design-Based Learning", "Multidisciplinary approach", "Problem-based learning", "Collaborative learning"	Broad coverage of academic works	Initial pool of diverse literature
Data retrieval from high-impact citation databases	Scopus, Web of Science, Social Science Citation Index	Same keywords	To ensure quality and credibility (high impact factor)	Refined, peer-reviewed studies
Pedagogical approach-focused sources	ERIC	"Inquiry-based learning integration", "Teachers as facilitators"	To capture education-specific approaches	Pedagogical models and teaching strategies

Source: Designed by Author (2025)

Results and Discussion

Table2. Key findings on DBL and critical thinking

Theme	Key Findings	Supporting Studies
Core Strength of DBL	DBL enhances critical thinking, creativity, problem-solving, and motivation through authentic, iterative design tasks. It engages learners in investigating, designing, testing, and evaluating solutions, which fosters analysis, decision-making, and originality rather than rote memorization.	Kolodner et al. (2003); Doppelt (2009); Shanta & Wells (2020); Weng et al. (2022)
Integration with Other Methods	DBL becomes more powerful when integrated with approaches like Design Thinking, PBL, and STEAM. Such combinations create synergy, deepening higher-order skills such as empathy, reflection, reasoning, innovation, and collaboration. This integration has been shown to strengthen creativity, problem-solving, and social innovation.	Blay & Espartinez (2024); Jiang & Pang (2023); Ananda et al. (2025); Subramaniam et al. (2024); Manikutty et al. (2022); Mohamed (2023)
Diverse Application Contexts	DBL has proven adaptable across multiple disciplines and education levels. It has improved digital learning in higher education, enhanced innovation in engineering, boosted critical thinking in chemistry, and supported social good initiatives in pre-university STEAM programs.	Blay & Espartinez (2024); Jiang & Pang (2023); Ananda et al. (2025); Manikutty et al. (2022)
Student Engagement	Compared to traditional lecture-based teaching, DBL increases student engagement, satisfaction, and active participation. Learners report deeper understanding and motivation due to hands-on, authentic design challenges that encourage creativity and collaboration.	Weng et al. (2022); Blay & Espartinez (2024)
Equity and Accessibility	DBL yields positive outcomes even in low-resource or rural settings. It promotes critical thinking, computational thinking, creativity, and self-efficacy among disadvantaged learners, making it a promising tool for reducing educational inequalities.	Cin & Cifti (2025)
Teacher Readiness	The success of DBL depends on teachers' preparedness to act as facilitators rather than knowledge transmitters. However, research on teacher training for DBL is limited, creating gaps in effective implementation. Professional development and pedagogical readiness are needed for sustainable adoption.	Mohamed (2023)
Assessment Challenges	Despite DBL's impact on higher-order thinking, there is no standardized, reliable tool to measure critical thinking gains. Current assessments are inconsistent (self-reports vs. performance tasks), making cross-study comparisons difficult. A universal framework is needed for robust evaluation.	Mohamed (2023)

Source: Designed by Author (2025)

Core strength of DBL: Table 2 analyzes that DBL enhances critical thinking, creativity, problem-solving, and motivation through authentic, iterative design tasks. DBL can develop many or multiple higher-order thinking skills simultaneously, which contributes to having a strong learning-teaching approach. DBL engages students in authentic, practical problem solving in which students must investigate, design, test, and find solutions through repetitive ways. This scenario makes a natural environment for enhancing critical thinking, as learners must evaluate the challenge, analyze alternative solutions, and make informed decisions. Furthermore DBL motivates creativity by permitting students to search diverse ideas, approaches, and design variations. Boosting original thinking rather than memorization. (Kolodner et al., 2003; Doppelt, 2009; Shanta & Wells, 2020; Weng et al., 2022)

Integration with other methods: According to Table 2, Design-Based Learning (DBL) becomes more effective when combined with other pedagogical approaches such as design thinking, project-based learning (PBL), and STEAM frameworks. Studies have shown that such integrations create synergy, enabling students to develop multiple higher-order thinking skills simultaneously. For example, combining DBL with design thinking has been found to enhance creativity, empathy, and problem-solving (Blay & Espartinez, 2024; Jiang & Pang, 2023). Integrating DBL with STEAM-PJBL significantly boosted critical thinking in Chemistry (Ananda et al., 2025), while frameworks like WoT4EPD linked reflection and computation to deepen reasoning in engineering design projects (Subramaniam et al., 2024). Similarly, STEAM for social good initiatives in India demonstrated improved critical thinking, innovation, and social problem-solving (Manikutty et al., 2022). Mohamed (2023) also confirmed that PBL models with structured critical thinking elements consistently strengthen learners' analytical capacity. Altogether, this evidence suggests that DBL is most powerful when used in combination with complementary methods that emphasize interdisciplinary collaboration, reflection, and real-world problem-solving.

Diverse Application Contexts: According to Table 2, Design-Based Learning (DBL) has demonstrated effectiveness across multiple fields and education levels, showing its flexibility as a pedagogy. In higher education, DBL has transformed digital learning environments by fostering empathy, creativity, and critical thinking (Blay & Espartinez, 2024). In engineering education, integrating DBL with design thinking enhanced students' innovation, user-need orientation, and motivation to solve real-world problems (Jiang & Pang, 2023). Similarly, in the sciences, Chemistry students engaging in STEAM project-based DBL tasks significantly improved their critical thinking skills (Ananda et al., 2025). At the pre-university level, STEAM for social good initiatives in India allowed learners to apply DBL in tackling social challenges, which nurtured critical thinking, design reasoning, creativity, and social problem-solving (Manikutty et al., 2022). These diverse examples highlight DBL's adaptability and its proven benefits across disciplines, cultures, and levels of education.

Student Engagement: Furthermore, Table 2 shows that DBL consistently outperforms traditional lecture-based instruction in fostering student engagement and deeper learning. By involving students in authentic design challenges, DBL shifts the learning process from passive knowledge absorption to active exploration and problem-solving. Weng et al. (2022) observed that learners participating in DBL tasks reported higher motivation and satisfaction due to the hands-on and iterative nature of learning. Likewise, in the Philippines, undergraduates considered DBL-driven digital learning transformative because it promoted active participation, creativity, and collaborative inquiry (Blay & Espartinez, 2024). These findings confirm that DBL encourages students to take ownership of their learning, making education more meaningful and impactful.

Equity and Accessibility: One of DBL's strengths is its ability to generate positive outcomes even in low-resource or rural contexts. Table 2 analyses that Cin and Cifti (2025) demonstrated that when rural 4th-grade students engaged in DBL tasks, their critical thinking, creativity, computational thinking, and self-efficacy improved despite limited resources. This suggests that DBL can bridge educational inequalities by offering students authentic problem-solving experiences that do not depend heavily on advanced infrastructure. By focusing on real-world problems and iterative design, DBL provides equitable opportunities for learners from disadvantaged backgrounds to develop higher-order thinking skills.

Teacher Readiness: Although DBL shows strong potential, its effectiveness heavily depends on teacher readiness and pedagogical skills, as Table 2 evaluated. Teachers are expected to shift from being knowledge transmitters to facilitators of inquiry, guiding students through design processes. However, Mohamed (2023) noted that research on teacher training for DBL is limited, and many educators lack systematic preparation to implement this approach effectively. Without sufficient training in facilitation, reflection, and assessment techniques, DBL risks becoming superficial rather than transformative. Addressing this gap requires investment in teacher professional development and pedagogical readiness to ensure successful DBL integration.

Assessment Challenges: Finally, Table 2 indicates that while DBL has shown consistent benefits for critical thinking, measuring these outcomes remains a challenge. Current studies use varied and inconsistent assessment tools, making it difficult to establish clear evidence of growth in critical thinking skills (Mohamed, 2023). Some rely on self-reports, while others use performance tasks, leading

to limited comparability across contexts. This lack of standardized, reliable instruments creates a major gap in DBL research. For DBL to be fully validated as a critical thinking pedagogy, there is a need for robust, universally applicable assessment frameworks that can accurately capture students' development in higher-order thinking skills.

Implications of the study

Core Strength of DBL: The finding that DBL enhances critical thinking, creativity, problem-solving, and motivation implies that it is not merely an instructional strategy but a transformational pedagogy. Its iterative, hands-on nature makes students active participants in knowledge construction rather than passive recipients. This aligns with constructivist learning theory (Kolodner et al., 2003; Shanta & Wells, 2020). For policy and curriculum design, this suggests that embedding DBL across subjects can systemically raise higher-order thinking skills, which are vital for 21st-century education.

Integration with Other Methods: The evidence that DBL becomes more powerful when combined with approaches such as design thinking, PBL, and STEAM underscores the synergistic nature of pedagogy. This suggests that DBL should not be implemented in isolation. For practice, schools should design blended pedagogical models that merge DBL with complementary frameworks to deepen learning. For research, this highlights the importance of interdisciplinary teaching models that cultivate multiple skills simultaneously. Policymakers could support curriculum reforms encouraging hybrid pedagogies that connect design-based, inquiry-driven, and project-focused learning.

Diverse Application Contexts: The fact that DBL has been effective in engineering, chemistry, social good initiatives, and digital learning demonstrates its versatility and transferability. This has important implications: DBL can be adopted across disciplines and education levels, making it a scalable approach for both STEM and non-STEM domains. For educators, this means they can confidently integrate DBL into varied contexts. For policymakers, it validates DBL as a cross-curricular framework adaptable to local needs and resources. For researchers, this opens avenues to test DBL across underexplored disciplines (e.g., humanities, arts-based inquiry).

Student Engagement: The finding that DBL outperforms traditional teaching in engagement shows that it addresses one of the major challenges in contemporary education: low student motivation. By giving learners ownership, DBL enhances participation, creativity, and collaboration. This implies that schools should shift from teacher-centered to learner-centered pedagogies if they aim to sustain motivation and reduce dropout or disinterest. For higher education, it highlights that DBL-driven environments could make courses more experiential and industry-relevant, preparing students for professional realities.

Teacher Readiness: Findings on the dependence of DBL's effectiveness on teacher facilitation highlight a critical implementation challenge. DBL requires teachers to act as guides, mentors, and facilitators, not merely content deliverers. The implication is that professional development programs must prioritize DBL pedagogy. Without systematic training, DBL risks being applied superficially. Education ministries, universities, and teacher-training institutes should embed DBL facilitation skills into teacher education curricula, ensuring that educators are prepared to manage inquiry, reflection, and assessment.

Assessment Challenges: The lack of standardized frameworks for evaluating critical thinking in DBL contexts suggests that although DBL is promising, its credibility as an evidence-based pedagogy is weakened by inconsistent measurement tools. This calls for investment in the development of robust assessment instruments, for example, validated rubrics, performance-based assessments, or digital analytics that capture critical thinking growth reliably. For researchers, this represents an urgent agenda: designing tools that balance comparability with adaptability. For policymakers, it means that scaling DBL must go hand in hand with improving assessment frameworks; otherwise, its impact will remain under-validated.

Recommendation

Based on the findings, this study recommends that Design-Based Learning (DBL) should be systematically integrated into educational curricula across disciplines as a transformative pedagogy for nurturing critical thinking, creativity, and problem-solving. To maximize its impact, DBL should be combined with complementary approaches such as project-based learning, design thinking, and STEAM frameworks, while ensuring its adaptability in both high- and low-resource contexts. Policymakers and education stakeholders are urged to invest in teacher professional development to build facilitation skills essential for DBL implementation, and researchers should prioritize the development of standardized, reliable assessment tools to measure higher-order thinking outcomes. By addressing teacher readiness, assessment gaps, and context-specific adaptations, DBL can serve as a scalable, equitable, and powerful approach to enhance student engagement and 21st-century learning skills.

Conclusion

In conclusion, this study establishes that Design-Based Learning (DBL) is a powerful and adaptable pedagogy that significantly enhances critical thinking, creativity, problem-solving, and learner motivation through authentic, iterative design tasks. The evidence

reviewed demonstrates that DBL not only supports multiple higher-order thinking skills simultaneously but also becomes more impactful when integrated with complementary approaches such as project-based learning, design thinking, and STEAM frameworks. Its successful application across disciplines and education levels, including in resource-limited settings, highlights DBL's versatility and potential to promote equity in education. However, its effectiveness is closely tied to teacher readiness and the availability of robust assessment tools, both of which remain areas requiring focused attention. Overall, DBL offers a transformative pathway for 21st-century education by engaging learners in meaningful, real-world problem-solving, provided that systemic support for teacher training and assessment innovation is prioritized.

Conflict of interest

In this study, there is no conflict of interest to declare. The research was conducted solely for academic purposes, to explore the role of Design-Based Learning (DBL) in nurturing critical thinking and related higher-order skills. The researcher had no financial, institutional, or personal relationships that could have influenced the design, data collection, analysis, or reporting of the findings. All data sources were drawn from reputable academic databases, and the synthesis was carried out objectively to ensure credibility and transparency. Therefore, the study remains independent and free from any competing interests that might compromise its validity.

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