Using Project-Based Learning for Multidisciplinary Thinking in Teaching Gifted and Talented Learners

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ABSTRACT

Gifted learners require specialized pedagogical frameworks to navigate increasingly complex, interdisciplinary global challenges. This study examines the efficacy of Project-Based Learning (PBL) in fostering multidisciplinary thinking among high-ability students. A systematic literature review synthesized research from major academic databases (ERIC, Scopus, PsycINFO) through thematic analysis to evaluate core design principles and implementation barriers. Findings indicate that PBL's emphasis on autonomy and constructive investigation significantly enhances cognitive depth, while successful multidisciplinary integration necessitates "generalized specialization" roles and authentic, performance-based assessments. However, significant obstacles were identified, including teacher entrenchment in monodisciplinary expertise and systemic infrastructural limitations. This review concludes that fully leveraging PBL's potential requires targeted professional development and adaptive educational policies to cultivate transdisciplinary cognitive capacities in gifted learners, ultimately equipping them to address complex challenges with intellectual breadth and creativity.

Keywords: *Project-Based Learning, Gifted Education, Multidisciplinary Thinking, Thinking Skills, Differentiated Instruction*

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INTRODUCTION

Defining Project-Based Learning

Project-based learning is a student-centered pedagogical approach grounded in constructivist principles, where learning entails the recognition of learning as context-specific, active, and subject to significant enhancement via social interaction and the sharing of knowledge(Zha et al., 2024). This methodology is characterized by its engagement of learners with authentic questions and real-world problems, consequently facilitating profound and substantive educational experiences(Zha et al., 2024). Key characteristics of effective PBL, particularly beneficial for gifted learners, include its centrality as the primary instructional method, not merely an adjunct activity; the organization of learning around ill-structured, open-ended "driving questions" that encourage deeper inquiry; constructive investigations, wherein rigorous, extended inquiry by students facilitates the co-construction of meaning; and the fostering of autonomy and realism through the provision of significant learner control over their work while addressing problems of real-world relevance (Cotton, 2019; Han, 2017; Handa, 2019; Kokotsaki et al., 2016). Furthermore, PBL emphasizes collaborative problem-solving, reflection, redrafting, and presenting findings(Zha et al., 2024). For gifted learners, PBL may offer an ideal environment for the leverage of their creative, critical thinking, and problem-solving abilities, potentially enabling them to tackle complex, advanced content and ill-structured problems, and thereby fostering higher-level thinking skills and creativity beyond traditional instructional models (Cotton, 2019; Handa, 2019). This approach encourages student participation in active inquiry and collaboration, processes which may sharpen their creative and problem-solving skills through real-world scenarios, concurrently motivating interdisciplinary learning via the incorporation of multiple academic subjects into the classroom experience(Zha et al., 2024).

The Concept of Multidisciplinary Thinking

The concept of multidisciplinary thinking entails the capacity for the integration of ideas, research, and theories drawn from various distinct academic fields, thereby facilitating a more complete and nuanced apprehension of complex phenomena. This approach typically encourages individuals to discern connections that may not be immediately apparent, potentially facilitating intuitive problem-solving and generally enabling them to view issues from diverse perspectives. For instance, a student investigating urban sustainability might simultaneously draw upon principles from environmental science to analyze ecological impact, economics to assess cost-benefit ratios, and sociology to understand community behavior, thereby constructing a holistic framework that transcends the limitations of any single discipline (Milakis, 2025; Zha et al., 2024).

For gifted students, cultivating multidisciplinary thinking may be deemed crucial; its cultivation facilitates the synthesis of information through the comprehension of interdisciplinary connections and the integration of knowledge from diverse domains, thereby enabling the assimilation of "big ideas" and overarching themes(Vars & Rakow, 1993). It also promotes "generalized specialization," where they can delve deeply into a specific area while appreciating the philosophical and methodological approaches of other fields (Ambrose, 2000). Moreover, gifted individuals often manifest polymathic tendencies, which may facilitate the assimilation of insights and methodologies from a multitude of domains, thereby potentially enhancing their comprehension and problem-solving capabilities (Alabbasi et al., 2024). Given that giftedness itself is often viewed as interdisciplinary, influenced by multiple developmental factors, the nurturing of multidisciplinary thinking among gifted learners appears not merely an educational enhancement but rather a vital component in the realization of their full potential, thereby equipping them to address complex challenges with both creativity and intellectual breadth (Çeken, 2021).

Characteristics of Multidisciplinary Thinking

As previously delineated, multidisciplinary thinking may be defined by the inherent capacity to synthesize ideas, research, and theories originating from diverse academic fields, with the objective of constructing a more comprehensive and nuanced understanding of complex phenomena (Spelt et al., 2009). This cognitive flexibility reportedly permits individuals to discern interconnections where none previously manifested, thereby facilitating intuitive problem-solving and the cultivation of a diverse range of perspectives (Mönks et al., 2003). Key characteristics include: **Synthesis of Information**: Multidisciplinary thinkers facilitate the integration of knowledge from various domains to form a cohesive understanding of overarching themes and "fundamental constructs." This process entails the discernment of interconnections between different disciplines rather than viewing them in isolation (Lupkowski-Shoplik et al., 2022). **Generalized Specialization**: This concept entails the capacity for profound engagement into a specific area of expertise while simultaneously a comprehensive apprehension of the philosophical underpinnings, conceptual frameworks, and investigative methodologies of other disciplines (Ambrose, 2000). Consequently, such practitioners may assimilate insights and approaches across fields to enrich their problem-solving capabilities (Ambrose, 2000). **Identification of Interconnections**: A core characteristic is the ability to discern the congruence among seemingly disparate phenomena and engage in a contemplation of the interrelationships between bodies of knowledge, and to comprehend the prospective influence one discipline may exert upon another (Gallagher, 1994). For instance, analyzing urban sustainability necessitates the synthesis of perspectives from environmental science, economics, and sociology(Lobo et al., 2021). **Critical Perspective Taking**: Multidisciplinary thinking fosters the cultivation of a flexible, open-minded scholarly disposition, characterized by inquisitiveness, a propensity for rational inquiry, and a deference to diverse epistemic perspectives (Heacox & Cash, 2013). This necessitates the judicious equipoise of specialized knowledge with a cognizant apprehension of alternative epistemological frameworks and the moral-ethical implications of developments in their fields (Ambrose, 2000). **Transdisciplinary Cognitive Capacities**: This form of thinking fosters the development of transdisciplinary cognitive and creative capacities, , thereby enabling the application of newly acquired knowledge by students, to authentic, empirical contexts and facilitate the fluid transition among diverse cognitive modalities (Milakis, 2025).

Research Gap and Novelty

Despite the recognized benefits of multidisciplinary thinking, existing literature, particularly within the Australian context, often focuses on general outcomes like critical thinking and problem-solving without thoroughly exploring specific skills or competencies related to innovation or the long-term impact on career trajectories (Scott & White, 2024). Specifically, there is a paucity of research examining how the specific subskills of interdisciplinary thinking, such as the capacity to integrate disparate knowledge domains for cognitive advancement, can be systematically designed and implemented the fostering of such capacity among learners (Oudenampsen et al., 2023),(Spelt et al., 2009). Furthermore, the "empirical reality" is frequently delineated by substantial implementation barriers which have not been critically addressed by existing reviews. These include teacher resistance due to "monodisciplinary entrenchment," wherein educators often experience discomfort beyond their specific disciplinary expertise (Mönks et al., 2003), and the systemic "fragmentation" of curricula that prevents students from transferring cognitive skills between domains (Guerra & Graaff, 2015). Recent findings suggest that even when PBL is implemented, it often lacks the "integrated viewpoint" necessary to facilitate the transition from rudimentary multidisciplinary tasks to authentic transdisciplinary cognition (Çeken, 2021). This gap, therefore, appears to underscore the urgent necessity for pedagogical frameworks that explicitly address these systemic issues, particularly for gifted learners who stand to benefit immensely from such integrated approaches. This study aims to address these identified lacunae by transcending a merely descriptive review of PBL and multidisciplinary thinking. Its novelty may reside in the rigorous synthesis of design principles for project-based learning units that intentionally cultivate advanced cognitive integration and perspective-taking among gifted K-12 students, alongside a critical examination of implementation strategies to overcome systemic barriers such as teacher training and curriculum silos.

Research Purpose

The purpose of this study aims to critically analyze project-based learning as a strategy for differentiating instruction for the addressment of the unique needs of gifted learners. Specifically, it seeks to synthesize how PBL can be designed and implemented the cultivation of multidisciplinary thinking, thereby facilitating the integration of knowledge across domains by gifted students and the application of their advanced cognitive capabilities to complex, real-world challenges (Cotton, 2019).

METHOD

This study employs a systematic literature review design, conforming to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines to endeavor toward the establishment of a transparent, objective, and replicable synthesis of existing research (Ghamrawi et al., 2025), (Sánchez-Meca, 2022). The systematic identification, evaluation, and synthesis of scholarly work concerning the intersection of project-based learning, multidisciplinary thinking, and gifted education constituted a primary objective.

A comprehensive search was conducted across four primary academic databases: ERIC, Scopus, Web of Science, and PsycINFO. The selection of these databases was predicated upon their extensive coverage of educational psychology and pedagogical innovation (Vanlommel & Boom-Muilenburg, 2024), (Yıldız et al., 2020). The search was limited to peer-reviewed articles and conference proceedings published between 2014 and 2024 to capture the most recent state of the art in digital and interdisciplinary Project-Based Learning (PBL).

The search string's construction involved the utilization of Boolean operators to combine three distinct clusters, which are delineated as follows:

Cluster A: "Project-based learning" OR "PBL" OR "Inquiry-based learning"
Cluster B: "Gifted" OR "Talented" OR ""High-ability"" OR "Advanced learners"
Cluster C: "Multidisciplinary thinking" OR "Interdisciplinary" OR "Transdisciplinary" OR "Cross-curricular"

Table 1. Inclusion and Exclusion Criteria for Study Selection

Criterion	Inclusion Criteria	Exclusion Criteria
Population	Gifted and talented learners (K-12 or Higher Education context)	General education populations without specific gifted focus
Topic	PBL frameworks explicitly targeting multidisciplinary/interdisciplinary thinking	General PBL studies without disciplinary integration
Study Type	Empirical research (qualitative, quantitative, mixed-methods) and high-quality conceptual reviews	Opinion pieces, editorials, or non-peer-reviewed reports
Language	English (to facilitate broader scholarly engagement)	

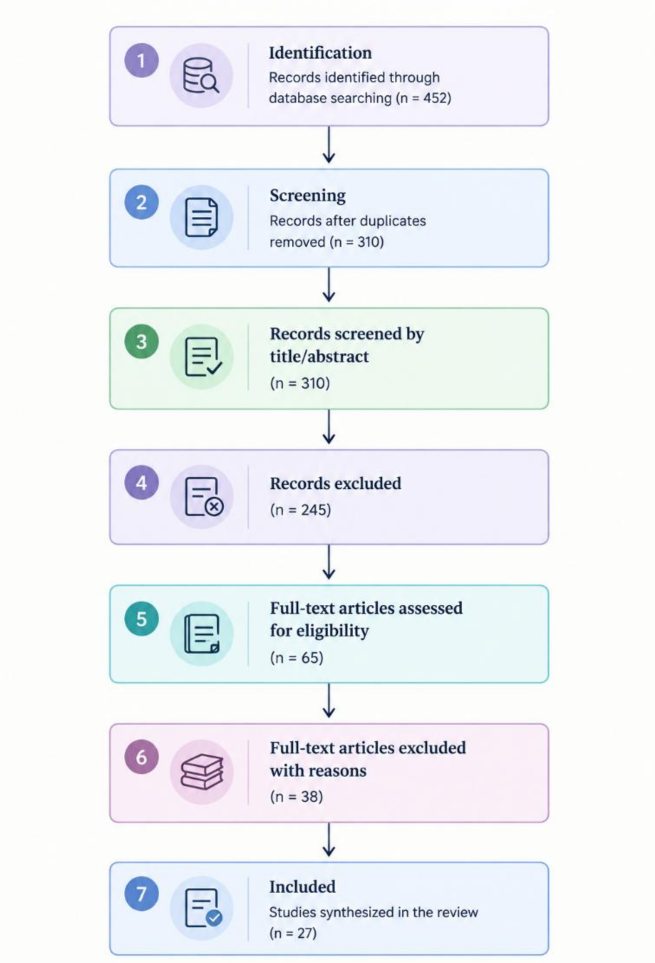

Figure 1. PRISMA Flow Diagram of the Study Selection Process

Data Analysis

Thematic analysis, as conceptualized by Braun & Clarke (2006), provides a systematic six-phase framework that facilitates the identification, analysis, and interpretation of patterns of meaning within qualitative data sets, such as the synthesized literature on Project-Based Learning and multidisciplinary thinking. The process begins with familiarization, where researchers immerse themselves in the full-text articles to document preliminary conceptualizations, succeeded by the generation of initial codes for the designation of significant features such as "differentiation by depth" or specific "pedagogical barriers". These codes are then subjected to collation during the third phase, thereby forming potential themes representative of overarching patterns across the studies. The fourth and fifth phases, which encompass a rigorous reviewing and refining process, frequently leverage a "thematic map" to ensure the precise representation of both the coded extracts and the entire data set, preceding the delineation and nomenclature of each theme's specific essence. Finally, the researcher culminates in the production of the report, a scholarly synthesis employing compelling examples to correlate the identified themes with the pertinent research questions and existing literature, consequently advancing the "state of the art" in the field.

RESULTS AND DISCUSSION

Core Principles of Project-Based Learning

The efficacy of Project-Based Learning (PBL) as a pedagogical strategy appears to be underpinned by several core principles that guide its design and implementation. Thomas, as cited in Kokotsaki et al. and Condliffe, delineated five essential characteristics, as follows(Pena, 2018): 1) **Centrality**: Projects are not subsidiary undertakings but rather integral components of the curricular framework, often functioning as the principal pedagogical instrument rather than a culminating task (Condliffe et al., 2017). 2) **Driving Question**: The organization of learning frequently centers upon complex, open-ended "driving questions" or problems, the characteristic absence of a single correct answer for which typically compels student engagement in profound inquiry and the substantive grappling with foundational concepts (Condliffe, 2017). These problems frequently possess a realistic orientation, resonating intrinsically with the experiential landscapes of learners, and are purposed to maximize the experiential encounter with overarching conceptual frameworks (Condliffe, 2017). 3) **Constructive Investigations**: Student engagement typically involves rigorous, extended investigative processes, wherein the construction of knowledge proceeds via systematic investigation, purposive inquiry, and resolution, thereby facilitating the co-construction of meaning, as opposed to the passive reception of information (Condliffe, 2017). 4) **Autonomy**: Learners are afforded significant autonomy, encompassing decision-making processes, temporal management, and the exercise of individual volition, which may consequently foster the development of self-regulated learning capacities and intrinsic motivational states (Condliffe, 2017),(Kokotsaki et al., 2016). 5) **Realism**: Projects tend to be grounded in real-world relevance, thereby requiring students to apply newly acquired knowledge to authentic situations and potentially facilitating the development of transdisciplinary cognitive and creative capacities (Condliffe, 2017),(Milakis, 2025).

Beyond these foundational tenets, the components of collaboration, reflection, redrafting, and presentations are typically emphasized as pivotal to the facilitation of social learning and the cultivation of self-assessment proficiencies (Kokotsaki et al., 2016). These principles often demonstrate alignment with the pedagogical requirements of gifted learners through the provision of challenging and engaging opportunities that cultivate creative productivity, interdisciplinary understanding, and advanced analytical competencies (Pahrudin et al., 2024),(Reis et al., 2021).

Designing Project-Based Learning Units for Gifted Learners

The design of Project-Based Learning units for gifted learners necessitates a deliberate pedagogical approach that extends beyond conventional differentiation to genuinely challenge and engage their advanced cognitive abilities. Gifted students tend to thrive within educational environments that provide deep, enriched, and complex content, combined with rigorous tasks that actively stimulate critical thinking and foster creativity (Pahrudin et al., 2024). To effectively accommodate the needs of these learners, educators may adhere to several delineated steps for the design of PBL units: 1) **Prioritize Complexity, Open-Endedness, and Realism**: Projects for gifted learners ought to embody intrinsic complex, open-ended, and grounded in real-world scenarios. Such endeavors typically feature multiple potential solutions and diverse avenues for solution attainment, thereby mitigating superficial engagement and fostering profound inquiry (Condliffe, 2017; Condliffe et al., 2017). This design principle can ensure that the project itself presents a sustained intellectual challenge, aligned with the gifted learner's capacity for in-depth inquiry. 2) **Focus on "Big Ideas" and Conceptual Conflict**: Project design ought to maximize the potential for student encounter with fundamental "big ideas" and facilitate the resolution of conceptual conflicts, as opposed to a mere completion of assignments (Condliffe et al., 2017). This may encourage intellectual struggle and conceptual growth, pushing gifted learners to synthesize and evaluate information at a higher level.

3) **Implement Targeted Differentiation Strategies**: In mixed-ability classroom settings, differentiation within PBL units can involve assigning gifted learners more demanding tasks, roles with heightened responsibility, or even leadership positions within group work(Milakis, 2025). For example, a gifted student might undertake the coordination of the group, the distribution of responsibilities, and liaison with the instructor, contingent upon the understanding that they will address more challenging aspects should peers encounter difficulties(Milakis, 2025). 4) **Mitigate the "Tutor" Risk**: While assigning advanced roles, educators must critically address the potential for gifted students to inadvertently assume the role of "tutors" to their non-gifted peers; such an occurrence may dilute their individual learning experience and reinforce hierarchical group dynamics(Milakis, 2025). To counteract this phenomenon, educators ought to endeavor to delineate specific sections or components of projects that carry "more demanding expectations" exclusively for gifted students(Milakis, 2025). Although achieving this precision consistently may prove challenging, it is nonetheless paramount for ensuring sustained intellectual growth for the gifted learner(Milakis, 2025). 5) **Integrate Continuous Assessment and Feedback Cycles**: Effective Project-Based Learning (PBL) unit design necessitates the integration of ongoing assessment and robust feedback mechanisms(Condliffe et al., 2017). These cycles ought to provide ample opportunities for students to revise their work based upon constructive criticism, thereby promoting iterative learning and refinement. 6) **Incorporate Authentic Audiences for Presentations**: Including authentic audiences for project presentations may significantly enhance student motivation and provide a real-world context for their endeavors(Condliffe et al., 2017). Furthermore, this practice facilitates gifted learners' articulation of their complex ideas and findings to a broader, meaningful audience, thus fostering the development of communication and presentation proficiencies.

By the meticulous application of these steps, teachers can craft PBL units that genuinely address the unique intellectual needs of gifted learners, fostering their critical thinking, creativity, and deep conceptual understanding within a challenging and engaging learning environment.

Teacher's Role in Facilitating Project-Based Learning

The teacher's role in PBL, particularly in gifted education, transcends traditional instruction, evolving into that of a facilitator, guide, and scaffolder. Teachers are instrumental in creating an environment where gifted students can thrive by effectively scaffolding learning, motivating, supporting, and guiding, them through complex projects (Kokotsaki et al., 2016). This involves balancing didactic instruction with in-depth inquiry methods and providing timely, effective feedback (Kokotsaki et al., 2016). Expert PBL teachers strategically tend to provide mini-lessons, model inquiry processes, and respond to student questions with further questions to deepen conceptual understanding rather than simply providing answers (Liu et al., 2020). Furthermore, the establishment of checkpoints for progress monitoring, the decomposition of complex problems into manageable components, and the cultivation of student ownership through individual or group goal setting, are often undertaken by these educators (Liu et al., 2020).

In mixed-ability settings, teachers must skillfully manage group dynamics, design projects with cognitive complexity for gifted students, and ensure active engagement from all peers to preserve the collaborative ethos (Milakis, 2025). This may often necessitate proactive planning for role distribution that promotes both accountability and interdependence (Milakis, 2025). The teacher acts as a "more knowledgeable other," the scaffolding of students toward advanced levels of comprehension within their zone of proximal development (Saunders-Stewart et al., 2013). They work collaboratively with learners to construct parts of the curriculum, plan and execute solutions, and share and review results, thereby cultivating a disposition towards scientific inquiry (Mönks et al., 2003; Saunders-Stewart et al., 2013). Effective teacher support is recognized as a crucial facilitating factor in successful PBL implementation (Kokotsaki et al., 2016).

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Assessment in Project-Based Learning Environments

Assessment in Project-Based Learning environments, particularly for gifted learners, necessitates a departure from traditional summative evaluations towards authentic, process-oriented methods that align with the dynamic and complex nature of projects(Tal & Miedijensky, 2005). To effectively assess student learning in PBL, educators may consider the implementation of the following pedagogical strategies and associated steps: 1) **Adopt Authentic and Process-Oriented Assessment Methods:** The imperative entails a redirection of focus from the exclusive evaluation of the final product toward the assessment of the developmental trajectory of learning. Such an approach necessitates the incorporation of tools, including reflection, self-assessment, and peer evaluation, which may empower students in their learning self-monitoring and process ownership (Kokotsaki et al., 2016). These methodologies, moreover, may facilitate the comprehensive documentation of skill development and conceptual understanding throughout the project's duration. 2) **Prioritize Performance-Based Assessments for Gifted Learners:** For gifted learners, performance-based assessments appear particularly well-suited for their educational contexts. These assessments are designed to evaluate complex conceptualizations of giftedness, intellectual behaviors, critical thinking, creative expression, and problem-solving, through tasks situated within authentic, real-world contexts (Cao et al., 2017). Such assessments, furthermore, may permit gifted students the demonstration of advanced capabilities and profound conceptualization within practical application scenarios. 3) **Evaluate Products Against Clear Rubrics:** A significant component of Project-Based Learning (PBL) assessment involves the evaluation of tangible products created by students; these may include, but are not limited to, short stories, computer programs, scientific experiments, or strategic plans (Cao et al., 2017). These products ought to be evaluated against clear, pre-established assessment rubrics, which delineate the criteria for success and the various levels of proficiency. 4) **Strategically Address Assessment of Collaboration and Individual Contributions:** The assessment of collaborative endeavors, particularly within mixed-ability educational settings, may present distinctive challenges, given that individual contributions and effort levels are prone to variation (Milakis, 2025). Educators may, however, mitigate these challenges through the concurrent evaluation of both the final project outcome and the overarching quality of intra-group collaboration. The utilization of presentation performances may also serve as a methodology for the triangulation and inference of individual contributions to the collective endeavor (Milakis, 2025). 5) **Develop Shared and Transparent Assessment Criteria:** To ensure fairness and sustain student motivation, the articulation of shared assessment criteria in advance is deemed essential (Milakis, 2025). These criteria ought to explicitly encompass both the project's procedural aspects and its ultimate tangible product. Addressing methodological vagueness in the evaluation of interpersonal processes and considering potential language barriers within diverse contexts are critical considerations for ensuring equitable assessment within heterogeneous project teams (Milakis, 2025).

Strategies for Integrating Multidisciplinary Thinking in Projects

Project-based learning may afford an optimal framework for the cultivation of multidisciplinary thinking among gifted learners through their engagement in authentic, complex challenges that naturally span multiple subjects (Milakis, 2025; Zha et al., 2024). Teachers can implement several strategies to effectively integrate multidisciplinary thinking within Project-Based Learning (PBL) units: 1) **Design for Interdisciplinary Challenges**: The structuring of projects around real-world problems may intrinsically necessitate the integration of knowledge and skills from disparate disciplines (Trisdiono et al., 2019),(Çeken, 2021). For instance, a project on climate change might necessitate the comprehension of scientific data, economic models, historical context, and ethical considerations. Furthermore, the design of these projects ought to encompass multiple potential solutions, in conjunction with diverse avenues for their resolution (Condliffe et al., 2017). 2) **Emphasize Cross-Disciplinary Exploration and Team Teaching**: The encouragement of cross-disciplinary unit exploration is advisable. Team teaching, involving educators from different subject areas, may effectively elucidate the application of abilities and concepts across various domains, thereby mitigating the fragmentation of skills and knowledge often observed within traditional, siloed curricula (Kokotsaki et al., 2016). 3) **Cultivate Transdisciplinary Problem-Solving**: The design of projects that facilitate the application of knowledge within authentic contexts, fostering experiential learning and the development of transdisciplinary cognitive and creative capacities, is paramount (Milakis, 2025). Such an approach typically entails the linkage of disparate subjects to real-world problems, thereby rendering the learning process contextualized and pertinent (Trisdiono et al., 2019). 4) **Promote "Generalized Specialization" through Project Roles**: Within collaborative projects, the assignment of roles ought to foster deep engagement among gifted learners within a specific aspect of their disciplinary interest, concomitantly necessitating the comprehension and integration of perspectives from other team members and fields. This mechanism subsequently fosters "generalized specialization," wherein individuals function as specialists capable of bridging disciplinary gaps (Ambrose, 2000). 5) **Utilize Technology for Interdisciplinary Connections**: The judicious leveraging of online services and digital tools may substantially facilitate interdisciplinary approaches. Such technological advancements could enable students to access and integrate information from diverse sources, to visualize complex relationships, and to foster collaboration across distinct subject areas (Nikonorova, 2022). 6) **Foster Creative Productivity and Independent Study**: The provision of opportunities for independent study and creative product creation is essential. These endeavors may assist gifted learners in the refinement of their innovative and analytical skills through the pursuit of questions that transcend traditional disciplinary boundaries, thereby preparing them for the complexities of real-world challenges (Pahrudin et al., 2024). 7) **Structure for Equitable and Collaborative Engagement**: It is imperative that projects be meticulously designed for equitable participation and sustained engagement within a socially inclusive environment. This necessitates the integration of disciplinary knowledge into authentic applications, a process which may heighten intrinsic motivation and deepen the learning experience for all students, including those identified as gifted (Milakis, 2025). 8) **Stimulate Cross-Cutting Ability Practice**: The utilization of problem-based learning activities within projects serves to provide a foundational basis for subject-area knowledge application and to actively stimulate the practice of cross-cutting abilities. This approach may facilitate the transference of skills acquired in one domain to another (Senior & Ampofo, 2024).

Through the thoughtful implementation of these strategies, educators may foster the creation of a rich learning environment, one that not only accommodates the advanced intellectual capabilities of gifted learners but also actively cultivates their multidisciplinary cognitive abilities, thereby preparing them for eventual success within an increasingly interconnected global context.

Challenges in The Implementation of Project-Based Learning for the Promotion of Multidisciplinary Thinking

While project-based learning furnishes a robust framework for the cultivation of multidisciplinary thought, particularly among gifted learners; nonetheless, its effective implementation is frequently fraught with considerable impediments. These obstacles span various dimensions, including pedagogical design, teacher preparedness, student dynamics, and broader systemic and infrastructural limitations.

Pedagogical and Design Challenges

One primary challenge lies in the **inherent complexity inherent in the design of projects** that are simultaneously simultaneously stimulating for intellectually advanced students and accessible to all learners within a heterogenous classroom setting (Milakis, 2025). Projects, therefore, must endeavor to offer sufficient cognitive complexity and open-endedness to sustain the interest and engagement of high-ability students, thereby mitigating the potential for disengagement should the assigned tasks prove insufficiently demanding (Milakis, 2025). This endeavor is further complicated by the frequent inadequacy of support within educational systems for both the cultivation of creativity and the holistic development of diverse intellectual strengths (Milakis, 2025).

A further design-related impediment pertains to the architecture of learning objectives and the integration of curricula. Curricula are frequently organized in a discipline-specific manner, a characteristic which may impede students' capacity for navigation across disciplines toward the comprehensive understanding of a theme or the resolution of a complex problem (Zhu, 2022). This fragmentation, therefore, renders the design of projects genuinely fostering interdisciplinary exploration challenging, as opposed to merely combining tasks from disparate subjects. Interdisciplinary learning, in general, is recognized as being more susceptible to failure than conventional teaching methods, underscoring the need for explicit instruction in interdisciplinary competence, particularly for students new to this approach (Braßler & Dettmers, 2017).

Teacher-Related Challenges

Teachers encounter numerous difficulties in the facilitation of multidisciplinary project-based learning (PBL), particularly with intellectually advanced learners, which include the following: Inadequate Professional Preparation: The insufficiency of professional development among numerous educators may impede their capacity for the effective management of mixed-ability collaboration, the fostering of mutual respect, and the navigation of interdisciplinary teaching's inherent complexities (Milakis, 2025); this predicament often engenders sentiments of uncertainty, incompetence, and discomfort upon venturing beyond specialized domains (Zhu, 2022). Entrenchment in Expertise: The predilection of educators to remain within established domains of expertise, wherein they perceive security and control, frequently renders the transition to team-teaching or integrated curricula arduous (Mönks et al., 2003); this orientation may subsequently manifest as an impediment to the introduction of pivotal issues from diverse disciplinary perspectives, thereby precluding the attainment of genuine interdisciplinary understanding (Mönks et al., 2003). Assessment Ambiguity: A significant impediment involves the unresolved challenge of assessment in Problem-Based Learning (PBL) environments designed to achieve multidisciplinary outcomes. Educators frequently articulate uncertainty concerning the effective evaluation of student learning and individual contributions, particularly within collaborative, interdisciplinary projects (Milakis, 2025). This difficulty is demonstrably compounded during the assessment of group dynamics, individual effort, and the integration of knowledge from disparate fields, which may subsequently complicate the assignment of equitable and impactful grades (Milakis, 2025). Coordination and Role Definition in Team-Teaching: In instances where multiple educators are engaged in an interdisciplinary project, an absence of explicit clarity pertaining to roles and responsibilities may engender confusion and consequently undermine the efficacy of co-teaching initiatives (Milakis, 2025).

Student Dynamics and Collaboration Challenges

The collaborative facets of Problem-Based Learning (PBL), although demonstrably advantageous for the cultivation of social competencies, introduce several specific challenges: **Unequal Participation and Dominance:** The achievement of equitable participation in student groups may prove challenging, particularly in instances of member dominance or disengagement (Milakis, 2025). Gifted students, due to their individualistic tendencies or lack of peer challenge, may encounter difficulties in navigating collaborative dynamics or inadvertently exert undue influence upon discussions, potentially diluting their peers' contributions and their own opportunity for growth in collaborative skills (Milakis, 2025). **Social Cohesion and Conflict:** Social dynamics, such as students' preferences to work with friends, may impede the formation of diverse and effective interdisciplinary teams. Furthermore, interpersonal conflicts unrelated to the project task may emerge and consequently impede project progression (Milakis, 2025). **Lack of Metacognitive Competencies:** Students, particularly those inexperienced in self-directed learning, may not possess the necessary metacognitive skills (e.g., critical thinking, self-regulation) to navigate complex problems or reconcile conflicting theoretical and methodological approaches from different disciplines (Zhu, 2022). **Difficulty in Transferring Skills:** Students may encounter difficulties in the transference of cognitive, analytical, and synthetic skills from one scientific domain to another, particularly when opportunities for interdisciplinary projects are infrequent (Guerra & Graaff, 2015). They may also hold preconceived notions about certain scientific disciplines, presenting an epistemological barrier to true multidisciplinary engagement (Guerra & Graaff, 2015).

Systemic and Infrastructural Limitations

Beyond classroom-level considerations, broader systemic and infrastructural challenges may impede the widespread adoption of multidisciplinary PBL: **Monodisciplinary Institutional Structures:** Educational institutions often operate within monodisciplinary structures, characterized by different time schedules, curriculum designs, and examination regulations, across departments. These structures tend to pose significant organizational barriers to the implementation of interdisciplinary programs, which necessitate collaborative engagement across diverse fields (Braßler, 2020). **Lack of Resources and Infrastructure:** Infrastructural limitations, such as suboptimal organization of learning environments and resource inadequacy, can impede the efficacious execution of PBL activities (Milakis, 2025). Specialized centers for gifted education may also face procedural barriers and a lack of access to necessary academic resources such as university libraries and databases, thereby hindering educators' engagement in profound academic endeavors with students (Paşacı, 2024). **Absence of Supportive Educational Policy:** The broader educational system may lack explicit policies or frameworks supportive of creativity or the integration of interdisciplinary methodologies, a circumstance that frequently leaves educators devoid of institutional imprimatur or explicit directives (Milakis, 2025).These multifaceted challenges underscore the critical exigency for the successful implementation of Project-Based Learning (PBL) to promote multidisciplinary thinking, particularly among gifted learners; this necessitates not only the adoption of innovative pedagogical strategies but also substantial investment in educator professional development, adaptive curricular design, and supportive institutional policies designed to actively dismantle traditional monodisciplinary silos.

Discussion

The results indicate that while the core principles of Problem-Based Learning (PBL)—student autonomy, authenticity, and constructive investigation—align theoretically with the needs of gifted learners, its implementation frequently fails to provide, or may not adequately provide, the "differentiation by depth" required for this population (Foo, 2024). A critical ascertainment within this review pertains to the "tutor risk," where gifted students in collaborative PBL environments are frequently relegated to the role of "junior teachers" or peer-assistants rather than receiving commensurate intellectual stimulation (Milakis, 2025). This empirical reality, however, appears to contradict the ideal of Problem-Based Learning (PBL) as a vehicle for individual cognitive growth. To advance beyond this limitation, project design ought to transition from simple multi-disciplinary tasks—wherein subjects remain merely adjacent—to transdisciplinary "ill-structured" problems that force a synthesis of "big ideas" across domains (Çeken, 2021). Only through such complexity can gifted students escape "monodisciplinary entrenchment" and develop the capacity for "generalized specialization" necessary for addressing contemporary global challenges (Ambrose, 2000).

The transition from a traditional didactic role to that of an interdisciplinary facilitator constitutes a formidable pedagogical hurdle. Findings suggest that many educators feel "unsafe" when projects move beyond their specific disciplinary expertise, leading to a "fragmentation" of the curriculum where interdisciplinary connections are superficial at best (Braßler, 2020; Guerra & Graaff, 2015). For gifted education, this is particularly problematic; the "Renaissance" perspective required to guide high-ability students through complex problems is often stifled by systemic "world-view entrapment" within single domains (Ambrose, 2000; Mönks et al., 2003). Effective facilitation in this context necessitates not merely a pedagogical understanding of Problem-Based Learning (PBL), but also a "transdisciplinary mindset" that encourages "youth voice" and allows students to navigate the intersections of STEM, humanities, and ethics (Gül & Ayık, 2024; Zhu, 2022). Without this requisite pedagogical and conceptual shift, Problem-Based Learning (PBL) units may risk becoming "entertainment-based" rather than "inquiry-based," failing to meet the rigorous intellectual standards of gifted programs (Oduro et al., 2024).

A central tension identified in this review appears to be the mismatch between the "ill-structured" nature of multidisciplinary PBL and the "well-structured," standardized assessment models prevalent in many educational systems. Current research suggests that while gifted students are capable of profound cognitive synthesis, their progress is often measured through metrics that prioritize content acquisition over "transdisciplinary cognitive capacities" (Braßler, 2020; Kokotsaki et al., 2016). This "standardization gap" may tend to discourage the implementation of truly innovative PBL, as they are held accountable to monodisciplinary standards that do not capture the "integrated viewpoint" or the development of "innovative practice abilities" (Çeken, 2021; Scott & White, 2024). For the advancement of the field, assessment ought to move toward evidence-based enrichment practices that value the "environmental perceptions" of the students and their ability to transfer skills across diverse contexts (Brigandi et al., 2018).

Critically, the successful implementation of PBL for multidisciplinary thinking may be construed not merely as a pedagogical choice but as a systemic challenge. The results appear to underscore that "infrastructural limitations"—such as rigid school schedules, lack of collaborative planning time, and geographically isolated "islands of excellence"—prevent the scaling of effective interdisciplinary models (Anis et al., 2018; Guerra & Graaff, 2015; Paçacı, 2024).

CONCLUSION

Project-Based Learning may be considered a highly effective pedagogical strategy for the cultivation of multidisciplinary thought and the nurturance of advanced cognitive abilities in gifted learners (Cotton, 2019; Handa, 2019; Zha et al., 2024). This student-centered approach, grounded in constructivist principles, may foster critical thinking, creativity, and problem-solving through the engagement of students in authentic, real-world problems (Kokotsaki et al., 2016; Zha et al., 2024). For gifted students, the successful design of PBL units may necessitate complexity, open-endedness, and a focus upon "big ideas" to ensure sustained engagement and intellectual challenge (Condliffe et al., 2017; Pahrudin et al., 2024). The teacher's role evolves into that of a skilled facilitator, characterized by the provision of strategic scaffolding, the offering of timely feedback, and the adept management of dynamic group interactions (Kokotsaki et al., 2016). Furthermore, authentic, performance-based assessments, complemented by reflective practices and clear rubrics, appear crucial for the evaluation of both the process and product of learning within these rich environments (Cao et al., 2017; King et al., 2011; Kokotsaki et al., 2016; Worrell & Erwin, 2011).

However, the effective implementation of PBL to promote multidisciplinary thinking is not without its significant challenges. Specifically, these may encompass the inherent complexity of designing projects that are simultaneously stimulating for gifted students and accessible to all learners in mixed-ability classrooms (Milakis, 2025). Teacher preparedness is a critical factor, necessitating specialized professional development for the amelioration of disciplinary silos and the adept management of interdisciplinary teaching's inherent intricacies (Milakis, 2025),(Mönks et al., 2003). The challenges in achieving equitable student participation (Milakis, 2025) and navigating assessment ambiguity in collaborative, interdisciplinary contexts further exacerbate these challenges (Milakis, 2025). Moreover, systemic and infrastructural limitations, inclusive of monodisciplinary institutional structures (Braßler, 2020) and inadequate resource allocation (Paçacı, 2024), frequently present considerable impediments to widespread adoption.

Despite these multifaceted obstacles, the cultivation of multidisciplinary thinking in gifted learners through PBL may persist as a vital educational imperative. The strategic amelioration of these complexities, encompassing thoughtful pedagogical design, comprehensive educator support, and adaptable institutional policies capable of dismantling traditional disciplinary boundaries, appears essential for the realization of PBL's full potential. This approach may thus effectively prepare gifted students to critically engage with, and innovate solutions for, the interconnected challenges of our contemporary world (Milakis, 2025).

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