

Narrative Review: Quantum Learning and Gamification Approaches for Engaging Preschool Learners

Izwan Mohamad¹, Romarzila Omar^{2*}, Ainon Nadiah Zainun Mohd Sabri³, Nur Athirah Suhairi⁴

^{1,2}Department of Early Childhood Education, Universiti Pendidikan Sultan Idris, Perak, Malaysia

³Faculty of Education and Humanities, Unitar Kota Bharu, Kelantan, Malaysia

⁴Faculty of Education and General Studies, UCYP University, Pahang, Malaysia

¹<https://orcid.org/0009-0001-0644-5647>

²<https://orcid.org/0000-0001-8591-0756>

³<https://orcid.org/0009-0001-6510-4527>

⁴<https://orcid.org/0009-0008-9609-334X>

DOI: <https://doi.org/10.47772/IJRISS.2026.100900062>

Received: 09 September 2026; Accepted: 14 September 2026; Published: 30 September 2026

ABSTRACT

This narrative review critically synthesizes literature on Quantum Learning and gamification approaches for engaging preschool learners, focusing on their conceptual foundations, effects on engagement and motivation, developmentally appropriate implementation, teacher roles, and potential pedagogical integration. Preschool education increasingly emphasizes playful, active, and learner-centred approaches that promote children's participation and meaningful learning. Quantum Learning and gamification share characteristics such as enjoyable learning, active participation, multimodal experiences, and motivational support. However, their relationship and combined application in preschool education remain insufficiently established. A preliminary literature search was conducted using Consensus AI across a large scholarly corpus incorporating Semantic Scholar, PubMed, and other scholarly sources. Search terms included Quantum Learning, Quantum Teaching, gamification, game-based learning, preschool, early childhood education, engagement, and motivation. Studies addressing relevant pedagogical approaches, preschool contexts, and engagement-related outcomes were considered, while duplicates, conceptually irrelevant studies, and quantum physics or computing education studies were excluded. The synthesis indicates stronger evidence for gamification and game-based learning in supporting preschool engagement and motivation than for Quantum Learning. Quantum Learning nevertheless demonstrates promising educational potential. Both approaches conceptually converge around active, enjoyable, and multimodal learning, but direct empirical evidence supporting their integration remains limited. This review identifies Quantum Learning–gamification integration as a promising pedagogical proposition rather than an established evidence-based preschool model and highlights the need for rigorous preschool-specific comparative and longitudinal research.

Keywords: Quantum Learning; gamification; game-based learning; preschool education; learning engagement

INTRODUCTION

Engagement is a central condition for meaningful learning during early childhood, as young children learn through active participation, exploration, interaction, and developmentally appropriate experiences.

Contemporary approaches to preschool education therefore increasingly emphasize playful and learner-centred pedagogies rather than passive instruction. Evidence synthesized in the Consensus AI document indicates that game-based, inquiry-based, and constructivist learning approaches can promote motivation, participation, persistence, and engagement when learning activities are appropriately designed for young children (Alotaibi, 2024; Behnamnia et al., 2022; Lin et al., 2020; Patrick et al., 2009). In particular, game-based learning has attracted growing attention because it can provide interactive and enjoyable experiences while supporting educational objectives. Nevertheless, the effectiveness of such approaches depends not simply on the presence of games, but on how learning experiences are designed and facilitated.

Within this broader movement toward engaging and active learning, Quantum Learning represents a pedagogical approach that emphasizes an enjoyable, supportive, multimodal, and participatory learning environment. The early childhood literature identified in the Consensus search describes Quantum Learning through activities involving play, storytelling, singing, movement, and other forms of active participation intended to stimulate children's interest and enthusiasm for learning (Fajarini, 2023; Purwanto, 2019; Sofyan & Murdianingsih, 2022).

Although the evidence base remains relatively limited, studies conducted in early childhood contexts have reported promising outcomes involving learning interest, motivation, memory, problem-solving, and participation (Aini & Pradikto, 2025; Hakim et al., 2024; Suryaningsih et al., 2023). A broader meta-analysis of 25 Quantum Learning studies also reported a positive effect on academic achievement, although the evidence was not specific to preschool learners or engagement outcomes (Yiğiter, 2023).

Gamification and game-based learning provide a related but more extensively investigated avenue for enhancing engagement. Gamification generally involves incorporating game-like features into learning experiences, whereas game-based learning places games more directly within the learning process. The literature identified for this review provides comparatively stronger evidence for these approaches than for Quantum Learning in preschool education. Reviews and meta-analyses indicate generally positive effects on motivational and behavioral outcomes, particularly engagement and motivation (Alotaibi, 2024; Sailer & Homner, 2019; Zainuddin et al., 2020).

Preschool-specific evidence similarly suggests that digital game-based learning can support participation and motivation (Behnamnia et al., 2022), while game-based smart-toy activities have been associated with increased engagement, learning interest, and participation among preschool children (Lin et al., 2020). However, positive engagement does not necessarily translate into equally consistent improvements in academic achievement or peer collaboration, highlighting the importance of developmentally appropriate design and teacher support.

Despite their apparent conceptual compatibility, an important gap exists between these two bodies of literature. Quantum Learning and gamification both emphasize active, enjoyable, and engaging learning experiences, yet they have largely developed as partially separate research traditions. The Consensus synthesis found that the evidence supporting preschool gamification and game-based learning is relatively mature, whereas research explicitly labelled as Quantum Learning in early childhood remains smaller, more context-specific, and methodologically heterogeneous.

More importantly, very few empirical studies directly investigate an integrated Quantum Learning–gamification approach in preschool settings. Consequently, existing evidence is insufficient to conclude that combining these approaches constitutes an established or independently validated pedagogical model. Figure 1 illustrates the conceptual convergence between Quantum Learning and gamification/game-based learning in promoting preschool engagement, while highlighting differences in the strength of their respective evidence bases and the current research gap concerning their integration.

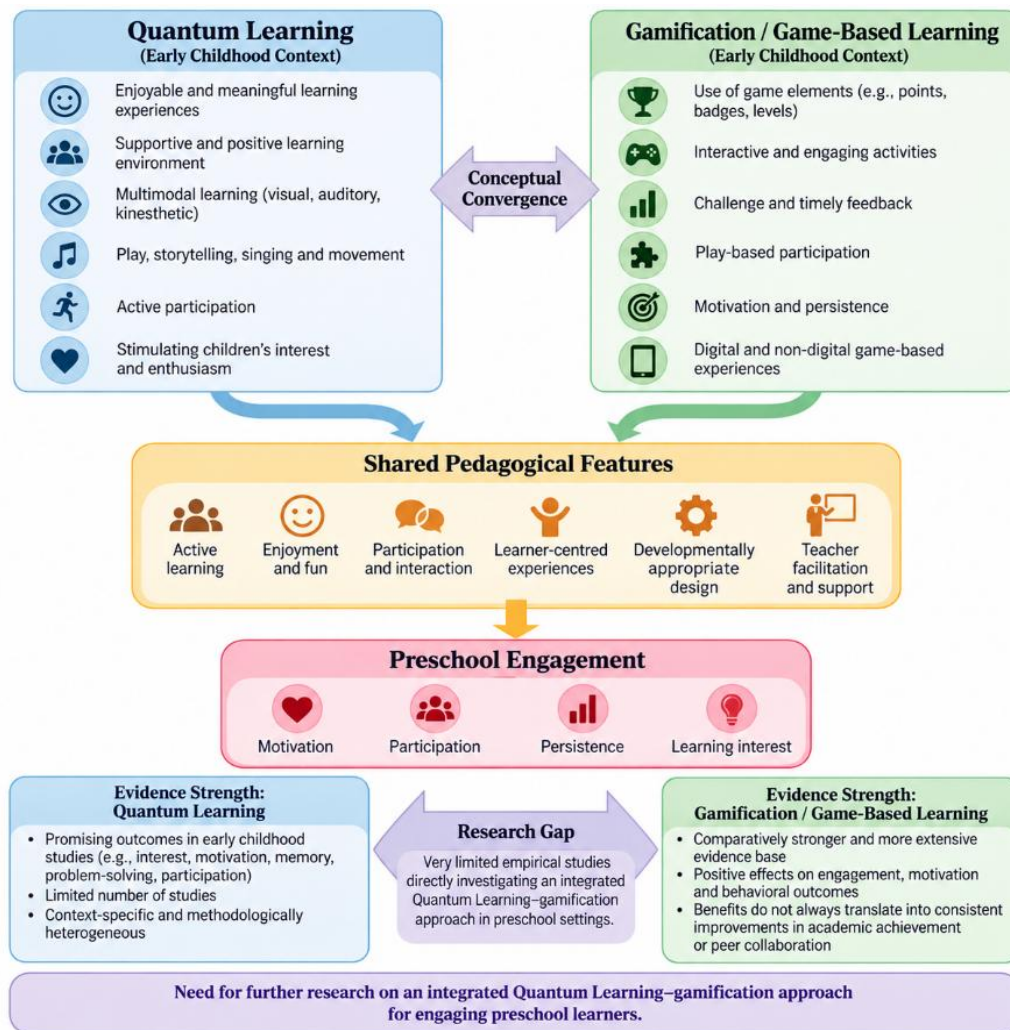


Figure 1. Conceptual Convergence of Quantum Learning and Gamification/Game-Based Learning for Preschool Engagement

Accordingly, this narrative review aims to critically synthesize the literature on Quantum Learning and gamification approaches for engaging preschool learners, with particular attention to their conceptual foundations, effects on engagement and motivation, developmentally appropriate design, and the role of teachers in implementation. The review further examines the conceptual convergence between Quantum Learning and gamification while critically evaluating differences in the strength of their empirical evidence. By bringing these partially separate literatures into dialogue, the review seeks to identify current controversies and methodological limitations, clarify the potential basis for their pedagogical integration, and establish directions for future preschool research. This focus is consistent with the Narrative Review Template, which requires the introduction to establish the current state of knowledge, unresolved issues, review objective, significance, and scope.

Methods

This narrative review was developed to synthesize literature concerning Quantum Learning, Quantum Teaching, gamification, game-based learning, and engagement in preschool and early childhood education. In accordance with the selected Narrative Review Template, the methodological description covers the sources of information, search terms, selection criteria, and document-selection process. The preliminary evidence base was derived from the Consensus AI search document supplied for this review. Because the Consensus search combined two partially overlapping bodies of literature Quantum Learning and gamification/game-based learning the literature was examined as related but conceptually distinct strands rather than assuming that they represent a single established pedagogical model.

Sources of Information

The preliminary literature search was conducted using Consensus AI. According to the supplied Consensus report, the platform searched a large scholarly corpus incorporating research indexed through Semantic Scholar, PubMed, and other scholarly sources. The search process included direct retrieval, citation expansion, alternative terminology searches, adjacent-model searches, and relevance filtering. The Consensus report indicates that 31 papers were directly retrieved from the original Boolean query, after which expanded searching and relevance filtering produced 134 unique papers. The top 100 papers were subsequently included in the Consensus-generated synthesis.

The retrieved literature covered four broad strands: (a) gamification and game-based learning in preschool education, (b) Quantum Learning and Quantum Teaching, (c) related engagement-oriented approaches in early childhood education, including inquiry-based and constructivist learning, and (d) studies retrieved because the term quantum learning was used in relation to quantum physics or quantum computing education. The fourth strand was considered conceptually distinct from the pedagogical Quantum Learning model and therefore should be excluded from the substantive synthesis of the present review unless a study provides directly relevant pedagogical evidence.

For the final manuscript, the Consensus-assisted search should be supplemented and verified through direct database searches in Scopus, Web of Science, ERIC, PsycINFO, and/or Google Scholar. These databases should only be reported as searched after those searches have actually been completed; the supplied Consensus document does not establish that the authors themselves conducted searches in these individual databases.

Search Terms and Keywords

Search terminology was developed around four principal concepts: Quantum Learning/Quantum Teaching, gamification/game-based learning, preschool education, and learning engagement. Alternative terms were incorporated to capture variations in terminology across the two partially overlapping research traditions. The main search concepts included Quantum Learning, Quantum Teaching, gamification, game-based learning, gamified learning, preschool, kindergarten, early childhood education, young children, engagement, motivation, participation, and learning interest. These terms reflect the terminology appearing across the studies identified in the Consensus synthesis.

A Boolean search string developed for the review was:

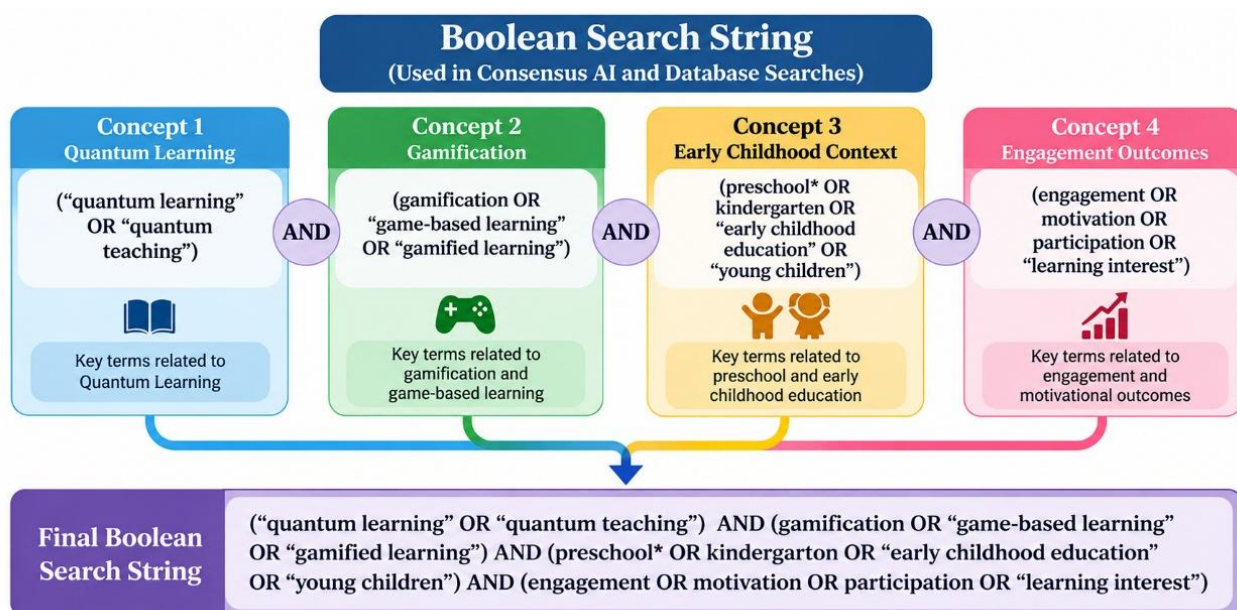


Figure 2. Boolean Search String used for the Literature Search in Consensus AI and Academic Database

Because preliminary searching indicated that direct studies combining Quantum Learning and gamification in

preschool education were limited, separate searches should also be conducted for the two principal bodies of literature. This strategy is important because an excessively restrictive Boolean combination could exclude relevant studies examining either Quantum Learning or gamification independently. The Consensus synthesis similarly concluded that these concepts constitute partially separate literatures and that direct empirical evidence examining their explicit integration remains sparse.

Selection Criteria

Studies were considered relevant when they addressed at least one of the principal pedagogical approaches Quantum Learning, Quantum Teaching, gamification, or game-based learning and provided evidence relevant to preschool or early childhood education. Particular attention was given to studies examining engagement, motivation, participation, learning interest, problem-solving, or related learning experiences. Both empirical studies and evidence syntheses, including systematic reviews and meta-analyses, were considered because the purpose of the narrative review was to critically integrate conceptual and empirical evidence rather than estimate a single pooled intervention effect.

Studies were considered for exclusion when they were unrelated to the pedagogical focus of the review, did not provide relevant evidence concerning early childhood learning or the conceptual development of the review, or represented duplicate records. Particular attention was required when screening the term quantum learning. The Consensus search retrieved studies concerning games for teaching quantum mechanics, quantum science, and quantum computing to older learners. Although these studies use the terms quantum and learning, they represent a different field from the Quantum Learning pedagogical model examined in this review. The Consensus report itself identified this terminological problem and noted that most of these studies involved learners aged eight years or older or secondary-school populations and did not directly address preschool Quantum Learning.

No definitive publication-year or language restriction is documented in the supplied Consensus report. Consequently, such criteria should not be retrospectively invented for the manuscript. A publication period and language criterion may be established for the authors' subsequent Scopus/Web of Science search and reported once that search has been completed.

Document Selection Flow

The preliminary Consensus search involved several stages of evidence identification and filtering. According to the supplied report, the search workflow involved 20 searches and one citation-graph search. The report's screening visualization states that approximately 43.4 million records were initially retrieved by the platform's broad search processes, approximately 2,400 records were considered eligible following relevance and quality filtering and deduplication, and 100 papers were selected for the final Consensus analysis. Elsewhere in the same report, the methodological narrative states that 134 unique papers passed relevance filtering before the top 100 were selected.

These figures should be interpreted cautiously. They describe the Consensus Deep Search workflow rather than a conventional author-conducted database screening process. Therefore, the 43.4 million records should not be presented as though the researchers manually identified and screened that number of records. For a publication-ready narrative review, the final document-selection flow should instead record the results of the researchers' own reproducible database searches using the structure specified in the Narrative Review Template: identification, deduplication, title/abstract screening, full-text eligibility assessment, exclusion with reasons, and final inclusion.

The final selection flow can subsequently be reported as:

Figure 1. PRISMA-Based Flow Diagram - Document Selection Process for Narrative Review		
Stage	Action	n =
Identification	Total documents searched in Scopus, Web of Science, Google Scholar	(n = 43.4m)

Eligibility	Documents evaluated for full-text eligibility	(n = 2.4k)
Inclusion	Documents included in Narrative Review discussion	(n =100)

The selected literature was then organized thematically rather than summarized study by study. The planned synthesis focuses on the conceptual foundations of Quantum Learning, gamification and game-based learning in preschool education, engagement and motivation outcomes, developmentally appropriate design, teacher roles, possible pedagogical convergence between Quantum Learning and gamification, implementation challenges, and unresolved research gaps. This thematic approach is consistent with the Narrative Review Template, which emphasizes comparison and synthesis across studies, identification of controversies and gaps, and consideration of practical implications.

DISCUSSION

The literature synthesized in the Consensus AI document suggests that Quantum Learning and gamification share several pedagogical characteristics relevant to preschool education, particularly their emphasis on active participation, enjoyable learning experiences, multimodal activities, and learner engagement. However, the strength of evidence supporting the two approaches is uneven. Gamification and game-based learning are supported by systematic reviews, meta-analyses, and preschool intervention studies, whereas research explicitly examining Quantum Learning in early childhood settings is smaller, more context-specific, and methodologically heterogeneous. More importantly, only limited evidence directly investigates the integration of Quantum Learning and gamification as a unified preschool pedagogical approach. This distinction is central to the present narrative review because conceptual compatibility should not be interpreted as evidence of empirical equivalence or effectiveness.

Conceptual Foundations of Quantum Learning in Early Childhood Education

Quantum Learning is a pedagogical approach that emphasizes the organization of learning environments, interactions, experiences, and instructional strategies to create meaningful, enjoyable, and engaging learning experiences. The approach promotes active learner participation, positive learning environments, multimodal experiences, and learning through meaningful activities rather than passive transmission of information (Fajarini, 2023; Purwanto, 2019; Sofyan & Murdianingsih, 2022). In early childhood education, these characteristics are particularly relevant because Quantum Learning has been implemented through developmentally appropriate activities involving play, storytelling, singing, movement, and other forms of active participation intended to stimulate children's interest and engagement in learning (Fajarini, 2023; Sofyan & Murdianingsih, 2022). Existing preschool-related studies further suggest that Quantum Learning may support outcomes such as learning interest, participation, problem-solving, and other educational experiences among young children (Aini & Pradikto, 2025; Hakim et al., 2024; Suryaningsih et al., 2023).

Importantly, Quantum Learning as discussed in this review should not be confused with quantum science, quantum mechanics, or quantum computing. The term is used here exclusively to describe a pedagogical approach to teaching and learning rather than the teaching or application of scientific quantum concepts. This conceptual distinction became particularly important during the literature search because the term quantum learning also retrieved studies concerning quantum mechanics, quantum science, and quantum computing education. Such studies represent a conceptually different body of literature and were therefore excluded from the substantive synthesis unless they provided directly relevant evidence concerning the pedagogical Quantum Learning approach. This distinction ensures that the present review remains focused specifically on Quantum Learning as an educational pedagogy within early childhood education.

Quantum Learning has been presented in the retrieved early childhood literature as an approach intended to create enjoyable, meaningful, and participatory learning environments. Rather than positioning children as passive recipients of information, the approach emphasizes learning experiences involving interaction, multiple modes of representation, and positive learning environments. In preschool contexts, activities associated with Quantum Learning include play, singing, storytelling, movement, and other forms of active

participation intended to stimulate children's interest and enthusiasm for learning (Fajarini, 2023; Purwanto, 2019; Sofyan & Murdianingsih, 2022). These characteristics make the approach potentially compatible with the developmental needs of young learners, for whom learning frequently occurs through active engagement and experience.

Available studies provide preliminary evidence of positive educational outcomes. Fajarini (2023) described Quantum Learning as an approach for increasing children's learning interest, while Aini and Pradikto (2025) reported its implementation within an early childhood educational setting. Suryaningsih et al. (2023) examined a STEAM-based Quantum Learning approach and reported a significant effect on young children's problem-solving ability. Hakim et al. (2024) similarly reported that a Quantum Learning model performed better than conventional teaching for the internalization of Islamic values in a kindergarten context. Beyond preschool-specific research, Yiğiter's (2023) meta-analysis of 25 Quantum Learning studies indicated a positive effect on academic achievement. However, the latter evidence was neither specific to preschool populations nor focused primarily on engagement.

These findings require cautious interpretation. The Consensus synthesis characterizes much of the early childhood Quantum Learning literature as descriptive, library-based, or context-specific. Furthermore, outcomes vary considerably across studies, encompassing motivation, learning interest, values, memory, problem-solving, and academic achievement. Consequently, although the literature presents Quantum Learning positively, there is insufficient evidence to conclude that its effects on preschool engagement have been established with the same methodological confidence as those of the broader gamification and game-based learning literature.

A further conceptual issue concerns the distinctiveness of Quantum Learning. Characteristics such as enjoyable learning, active participation, supportive classroom environments, and multimodal experiences also appear in constructivist, inquiry-based, play-based, and edutainment approaches. The critical question is therefore not merely whether Quantum Learning can support preschool learning, but whether it provides mechanisms or outcomes that are distinguishable from other child-centred pedagogies. This issue remains unresolved in the literature identified for this review.

Gamification and Game-Based Learning for Preschool Learners

Compared with Quantum Learning, gamification and game-based learning have a more substantial evidence base. Although related, the two concepts should not be treated as interchangeable. Within the present review, gamification refers broadly to the incorporation of game-like features into educational experiences, whereas game-based learning involves the use of games more directly as part of learning activities. The retrieved literature indicates that both approaches can create interactive environments capable of increasing children's willingness to participate in learning.

At the broader educational level, Sailer and Homner's (2019) meta-analysis reported positive motivational effects of gamification, while Zainuddin et al. (2020) synthesized empirical research concerning the effects of gamification on learning and instruction. More specifically for young children, Alotaibi's (2024) systematic review and meta-analysis identified positive effects of game-based learning in early childhood education. Behnamnia et al. (2022) similarly concluded from their review that digital game-based learning can support preschool children's participation and motivation. The convergence of evidence across different forms of synthesis strengthens the proposition that game-supported approaches have considerable potential for promoting engagement.

Preschool intervention evidence further supports this pattern. Lin, Chien, et al. (2020) investigated game-based smart toys and reported improvements involving preschool children's participation, engagement behaviours, learning interest, and computational thinking. These findings illustrate an important feature of game-based preschool education: game-like experiences can potentially function not simply as entertainment but as pedagogical structures through which children interact with learning tasks.

Nevertheless, positive engagement outcomes should not automatically be equated with improved learning achievement. The Consensus synthesis notes that gamification appears to produce more consistent improvements in affective and behavioural outcomes, particularly motivation and engagement, than in academic achievement. This distinction is particularly important for preschool practice. An activity may be highly enjoyable and maintain children's attention without necessarily producing the intended cognitive, social, or developmental outcomes. Gamification should therefore be evaluated according to its alignment with learning objectives rather than engagement alone.

Engagement and Motivation as Key Preschool Outcomes

Engagement provides an important point of convergence between Quantum Learning and gamification. Across the literature reviewed, engagement is reflected through constructs such as participation, persistence, motivation, interest, enthusiasm, and active involvement. Although these constructs are related, they should not be treated as identical outcomes. The literature suggests that playful and active pedagogies can influence several dimensions of children's engagement simultaneously.

Evidence from game-based learning is particularly persuasive. Alotaibi (2024) reported moderate-to-large effects on motivation and engagement in early childhood education, while Behnamnia et al. (2022) identified participation and motivation as important outcomes of digital game-based learning among preschoolers. Inquiry-oriented research also supports the broader proposition that active learning environments can foster children's engagement. For example, Lin, Yang, et al. (2020) reported positive outcomes from an inquiry-based science and engineering programme involving preschool children's science knowledge, problem-solving skills, and approaches to learning. Earlier kindergarten research likewise demonstrated the relevance of inquiry-oriented instruction to motivation for learning science (Patrick et al., 2009; Samarapungavan et al., 2011).

Quantum Learning appears compatible with these patterns because the approach similarly emphasizes enjoyable, active, and supportive learning experiences. However, the evidential distinction remains important. In the current corpus, game-based learning has stronger synthesis-level support for engagement, whereas claims concerning Quantum Learning rely on fewer preschool-specific empirical investigations. The most defensible conclusion is therefore that both approaches possess characteristics potentially conducive to engagement, but the strength of empirical evidence is substantially greater for game-based and gamified approaches.

This distinction also identifies an important measurement issue for future research. Engagement should be operationalized more precisely rather than represented through broad claims that children are more interested or enjoy learning. Future preschool studies could distinguish behavioural engagement, affective engagement, sustained attention, persistence, participation, and social interaction. Such differentiation would enable stronger conclusions about which aspects of engagement are influenced by particular pedagogical designs.

Developmentally Appropriate Design of Gamified Learning

The effectiveness of gamification depends considerably on how game elements are designed and implemented. The Consensus synthesis identifies developmental appropriateness as a significant consideration in early childhood applications. Game elements need to correspond with children's developmental characteristics, while visual clarity, ease of use, task complexity, and teacher support are particularly important in preschool environments (Behnamnia et al., 2022).

This evidence challenges the assumption that simply adding game elements will make learning effective. Poorly aligned game mechanisms may distract children from the intended learning objective or impose unnecessary cognitive demands. The Consensus report notes evidence of minimal or potentially counterproductive outcomes where game elements increase cognitive load or are inadequately aligned with learning tasks. It also highlights evidence that increased engagement does not necessarily produce stronger collaboration. For example, within smart-toy learning environments, more experienced preschool children could sometimes work independently rather than interact collaboratively with peers (Lin, Chien, et al., 2020).

These findings have direct implications for any proposed integration between Quantum Learning and gamification. The objective should not be to maximize the number of games, rewards, digital elements, or stimulating activities. Instead, game elements should support the broader learning environment and intended educational outcomes. A theoretically coherent integration would therefore require alignment among the learning objective, children's developmental level, game mechanics, multimodal experiences, interaction opportunities, and teacher facilitation.

The Role of Teachers in Engaging and Gamified Preschool Learning

Teachers potentially occupy a central position in translating playful pedagogical principles into developmentally appropriate classroom experiences. Within the literature synthesized by Consensus, teacher support is identified as an important condition in preschool game-based learning, while Quantum Learning literature describes teacher-facilitated environments involving play, storytelling, singing, movement, and other interactive experiences. From this evidence, teachers can reasonably be understood as facilitators of the learning environment rather than merely providers of games or instructional materials.

However, the current evidence base does not provide sufficient direct research to construct a comprehensive model of preschool teachers' roles in integrating Quantum Learning and gamification. This limitation is important because teacher roles were part of the conceptual interest motivating the present review. Claims concerning specific teacher competencies, attitudes, technological skills, scaffolding practices, or assessment strategies would require additional targeted literature.

Consequently, teacher roles represent both an implementation consideration and a research gap. Future investigations could examine how teachers select game elements, scaffold children's engagement, balance individual and collaborative play, monitor cognitive demands, and connect enjoyable activities to intended learning outcomes. Research could also examine whether teachers require specific professional development to translate Quantum Learning principles into gamified preschool environments.

Pedagogical Integration of Quantum Learning and Gamification

The most significant conceptual contribution of this review concerns the potential relationship between Quantum Learning and gamification. At a broad pedagogical level, the approaches appear to converge around several principles. Both can emphasize active participation, enjoyable learning experiences, multimodal stimulation, motivation, and meaningful interaction with learning activities. Such common characteristics provide a plausible conceptual basis for considering how gamification might operate within a broader Quantum Learning environment.

Nevertheless, conceptual convergence is not equivalent to empirical validation. The Consensus document explicitly rates evidence for an integrated "Quantum Learning + gamification" model in preschool as weak because very few direct empirical studies have tested the combined approach. Studies involving Quantum Learning-based digital games have been identified outside the preschool context, including Purba et al. (2024), but evidence from older or different educational populations cannot establish effectiveness for young children.

This represents the central gap emerging from the narrative synthesis. Existing literature can support three propositions with different degrees of confidence: first, playful and game-supported approaches generally promote preschool engagement; second, Quantum Learning studies in early childhood report promising educational outcomes but provide a smaller and less rigorous evidence base; and third, the explicit integration of Quantum Learning and gamification among preschool learners remains insufficiently investigated.

Accordingly, the most productive direction is not to present a combined model as already proven but to treat its integration as a research proposition requiring empirical testing. Future studies could compare Quantum Learning with conventional teaching, gamification alone, and an explicitly integrated Quantum Learning–gamification condition. Such comparative designs would help determine whether Quantum Learning contributes distinctive pedagogical value beyond the effects of playful, multimodal, and game-supported instruction generally.

Challenges and Controversies

Several tensions emerge across the literature. First, the evidence supporting engagement is stronger than the evidence supporting sustained academic achievement. This creates a potential mismatch between children's immediate enjoyment of an activity and its longer-term educational value. Reviews of gamification suggest that affective and behavioural outcomes may improve more consistently than learning outcomes (Dehghanzadeh et al., 2023; Romero-Rodríguez et al., 2024).

Second, methodological differences make direct comparisons difficult. Quantum Learning research identified in the Consensus document includes descriptive, qualitative, library-based, quasi-experimental, and broader meta-analytic evidence. Gamification research similarly encompasses digital games, smart toys, gamified environments, and other interventions. Such heterogeneity makes it inappropriate to assume that all studies are evaluating the same pedagogical mechanisms.

Third, terminology creates an unusual challenge. The term Quantum Learning can retrieve literature about teaching and learning quantum physics or quantum computing. The Consensus search itself retrieved studies involving quantum-science games for older students. Although such research demonstrates how games can make abstract content accessible, it does not directly provide evidence about the pedagogical Quantum Learning model in preschool education. Clear conceptual boundaries are therefore necessary in future reviews.

Research Gaps and Future Directions

Four major gaps can be identified from the current evidence. The first is an empirical integration gap: direct studies combining Quantum Learning and gamification among preschool learners are scarce. The second is a methodological gap: preschool-specific Quantum Learning research requires stronger comparative, experimental, or longitudinal designs. The third is an outcome gap: short-term motivation and engagement are more visible in the literature than sustained learning, retention, collaboration, and longer-term developmental outcomes. The fourth is a conceptual gap concerning whether Quantum Learning produces distinctive benefits beyond those generated by existing child-centred, inquiry-oriented, constructivist, or playful pedagogies. These gaps closely reflect the research questions emerging from the Consensus synthesis.

Future research should therefore examine which combinations of game elements are most developmentally appropriate for preschool learners, whether engagement effects persist beyond the immediate intervention, and whether increased engagement contributes to learning and collaborative outcomes. Particularly valuable would be comparative research examining whether Quantum Learning provides additional benefits when gamification characteristics are held constant. Such evidence would move the field from conceptual compatibility toward empirical evaluation of the proposed integration.

LIMITATIONS

Several limitations should be acknowledged. First, narrative synthesis is inherently more interpretive than a fully systematic review and may therefore be susceptible to selection and synthesis bias. Second, the preliminary evidence base for the present manuscript was generated through Consensus AI, and the final literature set should be independently verified through direct scholarly database searches. Third, the reviewed literature is heterogeneous in population, design, intervention, terminology, and outcomes, limiting direct comparison across studies. Fourth, the Quantum Learning evidence identified for preschool settings is comparatively small and context-specific, whereas the gamification literature includes evidence from broader educational populations. Finally, terminology associated with quantum learning generated irrelevant quantum-physics and quantum-computing education records, requiring careful conceptual screening. These limitations mean that the conclusions should be interpreted as a critical synthesis of the available literature rather than evidence that a unified Quantum Learning–gamification preschool model has already been established.

CONCLUSION

This narrative review examined the literature on Quantum Learning and gamification approaches for engaging

preschool learners, with particular attention to their conceptual foundations, effects on engagement and motivation, developmentally appropriate implementation, and potential pedagogical integration. Overall, the reviewed evidence indicates that playful, active, and game-supported learning approaches generally contribute positively to preschool children's motivation, participation, learning interest, and engagement. The evidence supporting gamification and game-based learning is comparatively stronger, drawing on systematic reviews, meta-analyses, and preschool-specific intervention studies (Alotaibi, 2024; Behnamnia et al., 2022; Sailer & Homner, 2019; Zainuddin et al., 2020). Quantum Learning also demonstrates promising potential in early childhood contexts, particularly for learning interest, motivation, participation, problem-solving, and other educational outcomes (Aini & Pradikto, 2025; Fajarini, 2023; Hakim et al., 2024; Suryaningsih et al., 2023). However, its preschool-specific empirical evidence remains comparatively limited and methodologically heterogeneous.

The principal contribution of this review lies in bringing these partially separate bodies of literature into dialogue without assuming that they constitute an already validated integrated model. Although Quantum Learning and gamification appear to converge around enjoyable learning, active participation, multimodal experiences, and learner engagement, direct empirical evidence examining their combined application among preschool children remains sparse. Consequently, future research should determine whether integrating gamification within Quantum Learning produces benefits beyond those associated with other playful and child-centred pedagogies.

Rigorous preschool-specific comparative and longitudinal studies are particularly needed to identify developmentally appropriate game elements, examine teachers' facilitative roles, and determine whether short-term improvements in engagement translate into sustained learning, retention, problem-solving, and collaborative outcomes. Thus, Quantum Learning–gamification integration should currently be regarded as a promising pedagogical proposition requiring further empirical validation, rather than an established evidence-based preschool model.

ACKNOWLEDGEMENTS

The author would like to express sincere gratitude to Dr. Romarzila binti Omar, supervisor, for her invaluable guidance, encouragement, constructive feedback, and continuous support throughout the research and preparation of this manuscript. Special appreciation is also extended to Dr. Muhd Muslim bin Md Zalli for his valuable academic guidance and insights in strengthening the development of this article.

Heartfelt thanks are conveyed to the author's family for their unwavering encouragement, patience, understanding, and support throughout the postgraduate journey. The author also gratefully acknowledges fellow postgraduate friends for their intellectual companionship, encouragement, exchange of ideas, and mutual support throughout the research and writing process. Their contributions and encouragement have been deeply appreciated.

REFERENCES

1. Aini, K. N., & Pradikto, S. (2025). Implementasi model Quantum Learning pada pendidikan anak usia dini di Raudhatul Athfal An-Nidhomiyah. *Jurnal Kajian Penelitian Pendidikan dan Kebudayaan*. <https://doi.org/10.59031/jkppk.v3i3.562>
2. Alotaibi, M. S. (2024). Game-based learning in early childhood education: A systematic review and meta-analysis. *Frontiers in Psychology*, 15. <https://doi.org/10.3389/fpsyg.2024.1307881>
3. Behnamnia, N., Kamsin, A., Ismail, M., & Hayati, S. (2022). A review of using digital game-based learning for preschoolers. *Journal of Computers in Education*, 1–34. <https://doi.org/10.1007/s40692-022-00240-0>
4. Dehghanzadeh, H., Farrokhnia, M., Dehghanzadeh, H., Taghipour, K., & Noroozi, O. (2023). Using gamification to support learning in K–12 education: A systematic literature review. *British Journal of Educational Technology*, 55, 34–70. <https://doi.org/10.1111/bjet.13335>

5. Fajarini, A. (2023). Quantum Learning model at early children's institutions in an effort to increase children's learning interest. *Proceedings of the 1st International Conference on Early Childhood Education in Multiperspective, ICECEM 2022*. <https://doi.org/10.4108/eai.26-11-2022.2336283>
6. Hakim, S. N., K., & Rahman, A. (2024). Boosting the achievement of internalization of Islamic values with the Quantum Learning model. *Journal of Law and Sustainable Development*. <https://doi.org/10.55908/sdgs.v12i1.2408>
7. Lin, S.-Y., Chien, S.-Y., Hsiao, C.-L., Hsia, C.-H., & Chao, K. (2020). Enhancing computational thinking capability of preschool children by game-based smart toys. *Electronic Commerce Research and Applications*, 44, 101011. <https://doi.org/10.1016/j.elerap.2020.101011>
8. Patrick, H., Mantzicopoulos, P., & Samarapungavan, A. (2009). Motivation for learning science in kindergarten: Is there a gender gap and does integrated inquiry and literacy instruction make a difference. *Journal of Research in Science Teaching*, 46, 166–191. <https://doi.org/10.1002/tea.20276>
9. Purba, S., Hutajulu, O., Mendoza, M., & Fauzani, A. R. (2024). Interactive learning media design: Quantum Learning-based digital game for electrical engineering education. *Proceedings of the 5th International Conference on Innovation in Education, Science, and Culture, ICIESC 2023*. <https://doi.org/10.4108/eai.24-10-2023.2342052>
10. Purwanto, S. (2019). Unsur pembelajaran edutainment dalam Quantum Learning. *Al-Fikri: Jurnal Studi dan Penelitian Pendidikan Islam*. <https://doi.org/10.30659/jspi.v2i2.5149>
11. Romero-Rodríguez, J.-M., Martínez-Menéndez, A., Alonso-García, S., & Victoria-Maldonado, J. (2024). The reality of the gamification methodology in primary education: A systematic review. *International Journal of Educational Research*. <https://doi.org/10.1016/j.ijer.2024.102481>
12. Sailer, M., & Homner, L. (2019). The gamification of learning: A meta-analysis. *Educational Psychology Review*, 32, 77–112. <https://doi.org/10.1007/s10648-019-09498-w>
13. Samarapungavan, A., Patrick, H., & Mantzicopoulos, P. (2011). What kindergarten students learn in inquiry-based science classrooms. *Cognition and Instruction*, 29, 416–470. <https://doi.org/10.1080/07370008.2011.608027>
14. Sofyan, A., & Murdianingsih, S. (2022). Quantum Learning pada pendidikan anak usia dini studi atas buku edutainment pendidikan anak usia dini. *Edusifa: Jurnal Pendidikan Islam*. <https://doi.org/10.56146/edusifa.v7i1.40>
15. Suryaningsih, A., Cahaya, I., & Poerwati, C. E. (2023). Implementasi model pembelajaran Quantum Learning berbasis STEAM terhadap kemampuan pemecahan masalah. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*. <https://doi.org/10.31004/obsesi.v7i2.4299>
16. Yiğiter, M. S. (2023). Kuantum öğrenme modeli akademik başarıyı artırıyor mu?: Bir meta-analiz çalışması. *Cumhuriyet International Journal of Education*. <https://doi.org/10.30703/cije.1216203>
17. Zainuddin, Z., Chu, S., Shujahat, M., & Perera, C. J. (2020). The impact of gamification on learning and instruction: A systematic review of empirical evidence. *Educational Research Review*. <https://doi.org/10.1016/j.edurev.2020.100326>