

**BRIDGING DEPTH AND BREADTH: A CRITICAL ANALYSIS OF CASE STUDY AND SCOPING REVIEW APPROACHES IN EARLY CHILDHOOD STEM EDUCATION****MENGHUBUNGKAN ASPEK SECARA MENDALAM DAN MENYELURUH: ANALISIS KRITIKAL PENDEKATAN KAJIAN KES DAN ULASAN SKOP DALAM PENDIDIKAN STEM AWAL KANAK-KANAK**Ahmad Hazman bin Ali<sup>1\*</sup><sup>1</sup>Fakulti Pengurusan dan Pembangunan Insan, Kolej Universiti Islam Antarabangsa Sultan Ismail Petra (KIAS), Peti Surat 68, Km 12, Jalan Kuala Krai, Nilam Puri, 15730 Kota Bharu, Kelantan

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**Abstract**

*In today's rapidly changing world, early learning experiences play a crucial role in shaping children's curiosity, confidence, and capacity to think creatively. Within this context, STEM education has become a cornerstone for preparing young learners to explore, question, and solve problems in meaningful ways. This paper critically reviews two recent studies: a Malaysian case study that documents classroom-based practices, and a scoping review that synthesizes international insights and recurring challenges. Both emphasize the value of play-based, inquiry-driven approaches and highlight the teacher's pivotal role as a facilitator of exploration. However, they differ notably in scope, methodological design, and analytical depth. The case study provides rich qualitative insights and alignment with developmental and policy frameworks, while the review offers systematic breadth and transparency in reporting. Each nonetheless presents distinct constraints, from limited sampling to narrow contextual representation. Synthesizing both perspectives, this paper proposes the SEEDS framework—Scaffolding, Experiential Play, Equity, Developmental Fit, and Systems Alignment. Grounded in developmental theory, SEEDS offers practical tools for teacher reflection and challenge-to-solution mapping. By bridging local classroom findings with global discourse, this framework contributes to clearer conceptual grounding and practical advancement in early STEM research, policy, and practice.*

**Keywords:** early childhood education; STEM; pedagogy; best practices; Malaysia; SEEDS framework

**Abstrak**

Dalam dunia yang berubah pantas hari ini, pengalaman pembelajaran awal memainkan peranan penting dalam membentuk rasa ingin tahu, keyakinan, dan keupayaan kanak-kanak untuk berfikir secara kreatif. Dalam konteks ini, pendidikan STEM menjadi tunjang utama dalam mempersiapkan pelajar muda untuk meneroka, menyoal, dan menyelesaikan masalah secara bermakna. Kertas ini menilai secara kritikal dua kajian terkini: satu kajian kes di Malaysia yang mendokumentasikan amalan bilik darjah, dan satu kajian tinjauan skop

yang mensintesis pandangan serta cabaran antarabangsa. Kedua-duanya menekankan nilai pendekatan berasaskan permainan dan inkuiri, serta menyerlahkan peranan penting guru sebagai fasilitator penerokaan. Namun begitu, kedua-dua kajian ini berbeza dari segi skop, reka bentuk metodologi dan tahap analisis. Kajian kes memberikan pandangan kualitatif yang kaya serta sejajar dengan kerangka pembangunan dan dasar, manakala kajian tinjauan skop menawarkan keluasan dan ketelusan sistematik dalam pelaporan. Walau bagaimanapun, setiap satu mempunyai kekangan tersendiri seperti sampel terhad dan representasi konteks yang sempit. Dengan menggabungkan kedua-dua perspektif, kertas ini mencadangkan kerangka **SEEDS** — *Scaffolding, Experiential Play, Equity, Developmental Fit*, dan *Systems Alignment*. Berasaskan teori perkembangan, SEEDS menawarkan alat praktikal untuk refleksi guru dan pemetaan cabaran kepada penyelesaian. Dengan menjambatani dapatan bilik darjah tempatan dan wacana global, kerangka ini menyumbang kepada landasan konseptual yang lebih jelas serta kemajuan praktikal dalam penyelidikan, dasar, dan amalan STEM awal kanak-kanak.

**Kata kunci:** pendidikan awal kanak-kanak; STEM; pedagogi; amalan terbaik; Malaysia; kerangka SEEDS

## INTRODUCTION

In recent decades, education systems around the world have placed increasing emphasis on building strong foundations in science, technology, engineering, and mathematics (STEM). This focus is often linked to broader national goals—strengthening competitiveness, driving innovation, and developing the human capital required for a rapidly evolving twenty-first-century economy (Moore et al., 2016). In Malaysia, this aspiration is reflected in the Education Blueprint 2013–2025 and the long-standing 60:40 policy that encourages greater participation in science-related fields. Early exposure to STEM is viewed not only as preparation for future academic success but also as a means of cultivating curiosity, collaboration, and creative problem-solving—skills essential for navigating an unpredictable global landscape.

Yet, despite clear policy intentions, the implementation of STEM at the preschool level remains uneven. Teachers often face limitations in both confidence and competency, compounded by a lack of creative materials, insufficient professional development, and a curriculum already dense with competing priorities (Rahayu et al., 2018; Ghani et al., 2020). These realities suggest that improving early STEM education requires more than new resources or training—it calls for evidence

that connects practical classroom insights with broader theoretical and international perspectives.

Two recent publications offer contrasting yet valuable contributions to this effort. The first, a Malaysian case study by Ghazali et al. (2024), identifies nine best practices across several preschool settings, emphasizing the role of play and exploration in local teaching contexts. The second, a scoping review by Ghazali, Ashari, and Hardman (2024), consolidates findings from 31 international studies across multiple databases, mapping 23 themes of best practice and 10 recurring challenges. While both studies deepen understanding of STEM in early childhood education, their differences in scope and methodological approaches highlight key issues of rigor, relevance, and applicability.

However, despite the expanding literature on early childhood STEM education, a clear gap remains in connecting diverse research approaches into a cohesive understanding. Much of the existing work either captures localized classroom practices or broad international patterns, with limited integration between the two. Addressing this gap is vital to strengthen the bridge between global discourse and local implementation, particularly within the Malaysian context, where early STEM initiatives continue to evolve.

This paper offers a comparative critique of these two works, examining how each contributes to theory and practice, and how their insights can be integrated. From this synthesis emerges the SEEDS framework—Scaffolding, Experiential Play, Equity, Developmental Fit, and Systems Alignment—which unites localized classroom knowledge with global perspectives to guide future research, policy, and practice in early childhood STEM education.

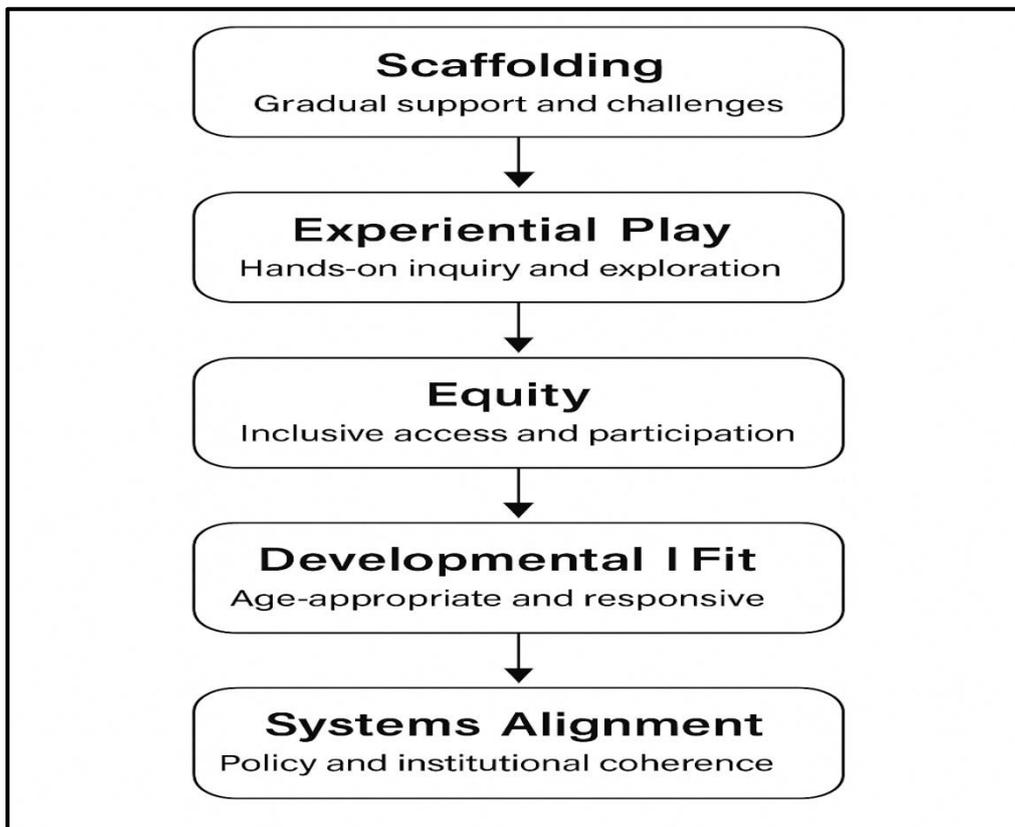


Figure 1. Conceptual alignment of the SEEDS framework across developmental and systemic dimensions in early childhood STEM education.

## LITERATURE REVIEW

### i. STEM in Early Childhood Education

A growing body of research recognizes the value of early exposure to STEM in fostering curiosity, persistence, and cognitive growth among young children (Demir & Kermani, 2017; Pantoya et al., 2015). Developmental theorists also provide strong foundations for integrating STEM learning in preschool settings. Piaget (1962) highlights how play supports children's movement from concrete to abstract thinking. Vygotsky (1978) introduces the idea of scaffolding and the Zone of Proximal Development (ZPD), emphasizing the teacher's role in guiding inquiry and social learning. Dewey (1938) promotes experiential and democratic education, asserting that active engagement helps children connect ideas and develop reasoning skills. Together, these theories affirm that introducing STEM through play-based and inquiry-driven approaches is

consistent with developmentally appropriate practice and contributes to holistic learning in early childhood.

## **ii. Barriers to the Implementation of ECE–STEM**

Although the theoretical foundations for early STEM education are well established, practical challenges often prevent effective implementation. Studies report that many teachers lack confidence and creativity in designing STEM activities (Amran, 2021). Resource shortages, limited parental engagement, and overloaded curricula further constrain opportunities for meaningful integration (Stylianidou et al., 2018; Ghani et al., 2020). These issues suggest that improving STEM in preschool classrooms requires more than creative teaching methods—it also depends on systemic support such as professional training, access to materials, and institutional encouragement that help teachers sustain good practices over time.

## **iii. Case Studies and Scoping Reviews as Research Approaches**

Different research designs contribute distinct insights into how STEM is interpreted and applied in early childhood contexts. Case studies, for instance, provide in-depth understanding and “thick description” of how theory and policy take shape in classroom practice (Yin, 2018; Stake, 2006; Merriam & Tisdell, 2015). Their strength lies in contextual detail, although findings are often limited to small, localized samples. Scoping reviews, on the other hand, map a broad range of studies to identify trends, gaps, and policy-relevant patterns (Arksey & O’Malley, 2005; Tricco et al., 2018). They offer useful overviews but can overlook the nuances of cultural and classroom settings. Recognizing the complementary strengths of both approaches can therefore enrich understanding of STEM in early childhood education by combining empirical depth with broader evidence synthesis.

## **METHOD OF CRITIQUE**

This paper applies a comparative evaluation framework to examine the two selected studies across seven key dimensions: (1) research focus and alignment, (2) design and sampling, (3) data collection and analytic rigor, (4) theoretical coherence, (5) quality of

findings and contribution, (6) reporting transparency, and (7) generalizability. Evaluating both studies through these dimensions allows for a balanced and systematic critique that recognizes their contributions and constraints. The process also informs the formulation of the SEEDS framework—Scaffolding, Experiential Play, Equity, Developmental Fit, and Systems Alignment—which integrates the contextual strengths of the case study with the analytical breadth of the scoping review. This synthesis aims to strengthen both theoretical understanding and practical application in the field of early childhood STEM education.

Although this critique is primarily conceptual and comparative in nature, the analysis moves beyond a simple descriptive review by adopting an interpretive and integrative lens. Each study is considered not merely for its reported findings, but for the way its methodological choices, theoretical grounding, and contextual relevance interact to generate meaning. Through this interpretive synthesis, the discussion shifts from recounting observations to uncovering relationships and contrasts, allowing deeper patterns, tensions, and complementarities between the two methodological traditions to surface more clearly.

### **CRITIQUE OF THE CASE STUDY (MALAYSIA)**

The Malaysian case study conducted by Ghazali et al. (2024) was designed to identify and document best practices in preschool STEM education, focusing particularly on how science, mathematics, technology, and simple engineering concepts are introduced through classroom activities. The study shows a clear connection with Malaysia's educational priorities, especially the emphasis on play-based and inquiry-oriented learning promoted in national policy documents. By situating its observations within the preschool curriculum framework, the research illustrates how local teachers interpret and adapt STEM principles in ways that encourage exploration, experimentation, and meaningful engagement among young learners.

The study employed a multi-site qualitative design, drawing data from classroom observations, teacher interviews, and documentary analysis. Its triangulated methodology is a strength, as it enhances credibility through multiple

data sources. However, the sampling introduces challenges. While the abstract refers to three preschools, the main body of the paper reports data from four sites (labeled A–D). This inconsistency undermines reporting reliability and raises questions about methodological transparency.

The analysis was conducted using ATLAS.ti v8, suggesting systematic coding. Nevertheless, critical aspects of analytic rigor were missing. The study did not report inter-coder reliability, nor did it detail member checking or reflexive practices on the part of researchers. According to Creswell and Poth (2018), such omissions weaken confirmability and raise concerns about potential researcher bias.

The theoretical fit of the study is notable. It explicitly draws on Piaget, Vygotsky, and Dewey, aligning these perspectives with Malaysia’s Learning and Facilitation Process (LFP) framework and broader twenty-first century skills discourse. The findings are framed around nine identified best practices, with play-based learning emerging as the most frequent. While this highlights important classroom insights, the reliance on frequency counts and the absence of detailed micro-level vignettes of teacher–child interactions reduced the richness of the analysis.

Overall, the study provides policy-relevant contributions by documenting how STEM is enacted in Malaysian preschools. However, its limited sample size, inconsistencies in reporting, and insufficient detail on analytic rigor restrict the generalizability of its findings.

### **CRITIQUE OF THE SCOPING REVIEW (INTERNATIONAL)**

The scoping review by Ghazali, Ashari, and Hardman (2024) adopts a markedly different approach, aiming to map international best practices and challenges in ECE-STEM. The research focus is clearly articulated and ambitious, situating the study as a contribution to global discourse on STEM in early childhood education.

The review systematically searched four databases—Scopus, ERIC, Web of Science, and ScienceDirect—using the string “STEM Education” AND “Preschool”

AND “Learning.” While this approach is systematic, it is also narrow. The search excluded synonyms such as “early childhood education,” “kindergarten,” or “pre-primary,” thereby omitting potentially relevant studies. The application of filters further restricted the scope, as only English-language articles published between 2018 and 2022 were included. While these filters enhanced recency and focus, they also excluded foundational studies and valuable contributions from non-English and Global South contexts (Munn et al., 2018).

The review followed PRISMA guidelines, with a transparent flow from 169 records to 31 included studies (Tricco et al., 2018). This adherence to international reporting standards strengthens the credibility of the review. Data extraction was conducted using Excel charting, and thematic synthesis identified 23 best-practice themes and 10 recurring challenges. However, the analysis did not report inter-rater checks, and the handling of heterogeneity across cultural contexts was limited. This reduced the review’s capacity to capture the nuances of how STEM is implemented differently across diverse educational systems.

The findings provided broad insights from countries including Turkey, the United States, Japan, Australia, and Malaysia. The breadth of coverage is a strength, enabling cross-national comparisons and policy benchmarking. Yet, the practices and challenges were presented in parallel without adequate integration. The absence of explicit links between best practices and their potential to mitigate challenges left the synthesis less actionable for practitioners and policymakers.

In terms of contribution, the scoping review is valuable as an agenda-setting piece, drawing attention to the international state of ECE-STEM research. Nonetheless, its conservative search strategy and limited strategies for managing diversity restrict its comprehensiveness.

### **COMPARATIVE ANALYSIS**

Although the two studies differ considerably in their scope and methodological orientation, both contribute important perspectives on STEM learning in early childhood. The Malaysian case study illustrates the significance of contextualized

inquiry by showing how teachers and children co-construct understanding through play and exploration. Its main strengths lie in the detailed narrative of classroom practice, the connection it draws between developmental theory and everyday teaching, and the way it links national policy aims to real preschool settings. Nonetheless, the study is constrained by several methodological issues—limited sample size, uneven site documentation, and restricted analytic explanation—which collectively reduce the generalizability of its findings.

The scoping review takes a contrasting approach by emphasizing breadth rather than depth. Through systematic searches across several databases, adherence to PRISMA reporting standards, and transparent documentation, it succeeds in identifying global patterns in early STEM research. However, its dependence on narrow search terms, the omission of non-English and Global South studies, and minimal attention to contextual variation weaken its inclusiveness and limit the diversity of perspectives represented.

Viewed together, these studies illustrate the persistent tension between depth and breadth in educational research. The case study offers grounded, practice-based insights, whereas the scoping review supports broader agenda-setting at the international level. Their combined value suggests the need for integrative frameworks that balance local specificity with global synthesis—a position reflected in the development of the SEEDS framework, which draws on the complementary strengths of both approaches while addressing their respective limitations.

### **THE SEEDS FRAMEWORK**

The SEEDS framework emerged as an integrative synthesis of two strands of evidence: the grounded insights from the Malaysian case study and the broad international patterns identified in the scoping review. The acronym SEEDS represents Scaffolding, Experiential Play, Equity, Developmental Fit, and Systems Alignment. Collectively, these five components form a holistic structure for strengthening STEM learning in early childhood contexts.

The first component, Scaffolding, builds on Vygotsky's (1978) notion of the Zone of Proximal Development, emphasizing how teachers guide children's inquiry through purposeful questioning, modeling, and graduated support. Experiential Play, the second component, draws from Piaget (1962) and Dewey (1938), both of whom viewed play and hands-on activity as central to how children make sense of the world. The third element, Equity and Access, underscores the need to create inclusive learning environments where every child—irrespective of socioeconomic status, gender, or language background—can meaningfully engage in STEM exploration, echoing priorities highlighted in recent OECD reports (OECD, 2021). Developmental Fit, the fourth component, ensures that learning experiences correspond to children's readiness and developmental stage, supported by studies showing that age-appropriate exposure enhances both cognitive and socio-emotional growth (Pantoya et al., 2015; Demir & Kermani, 2017). Finally, Systems Alignment reflects Bronfenbrenner's (1979) ecological model, recognizing that classroom practices are most effective when aligned with curriculum standards, teacher training systems, policy frameworks, and family participation (Moore et al., 2016).

The SEEDS framework can be viewed in two complementary ways. In a linear sense, it offers a practical sequence for planning, implementing, and evaluating STEM activities. In a cyclical sense, it highlights the ongoing interplay among scaffolding, play, equity, developmental appropriateness, and systemic support—elements that must operate in concert to maintain meaningful learning. Beyond serving as a conceptual model, SEEDS functions as a practical instrument. For educators, a SEEDS-based checklist can support self-reflection and continuous improvement in classroom practice. For policymakers, the framework's challenge-to-solution mapping links global challenges identified in research to feasible, context-responsive strategies for strengthening STEM education in early childhood.

## **CONTRIBUTION**

This paper makes four key contributions to the field of early childhood STEM education. First, it provides a balanced critique of two distinct methodological

traditions, revealing both the analytical strengths and the limitations that shape their findings. This comparative stance offers a clearer understanding of how different approaches contribute to the broader research landscape.

Second, it connects locally grounded, practice-based insights with the wider body of international evidence, producing a more cohesive view of how early STEM learning can be understood and improved across diverse contexts.

Third, it introduces the SEEDS framework as an original conceptual model that integrates developmental theory with empirical observation, offering a balanced foundation for both classroom practice and policy formulation.

Finally, it translates the SEEDS model into practice by proposing practical tools—such as teacher reflection checklists and challenge-to-solution mappings—ensuring that the framework moves beyond theory into actionable strategies that educators and policymakers can readily apply.

## IMPLICATIONS

The implications of this work reach across professional practice, policy development, and future research. For teachers and practitioners, the SEEDS framework serves as both a guide and a reflective mirror. It helps educators plan lessons that are scaffolded and playful, while ensuring that every activity remains inclusive, age-appropriate, and connected to the wider learning ecosystem. By using SEEDS as a daily reference, teachers can fine-tune their practice in ways that promote genuine inquiry and joyful exploration among children.

For policy leaders, the framework provides a grounded structure for designing training programmes and curriculum documents. Its focus on guided discovery, experiential play, and equitable access allows policymakers to translate national aspirations into classroom realities, ensuring that system-level efforts are informed by both local experience and international benchmarks.

For researchers, SEEDS opens opportunities to explore new methodological possibilities. It points to the value of combining qualitative case insights with the wider

lens of scoping or systematic reviews. Future studies might test the framework through mixed-method, multi-site, or longitudinal designs that place emphasis on rigour, transparency, and reflexive analysis.

### **LIMITATIONS**

Although this critique offers meaningful insights, it is not without its boundaries. The analysis depends largely on the information presented within the two reviewed studies, and it is possible that some methodological details—such as inter-coder reliability checks or researcher reflexivity measures—were carried out but not clearly reported. This gap in documentation may have led to an underestimation of each study’s methodological strength.

A further limitation lies in the SEEDS framework itself. Although it is conceptually robust and practically adaptable, it has yet to be verified through empirical investigation. The elements proposed within SEEDS have not been translated into measurable indicators that could be examined through real-world data. Future inquiries should therefore employ longitudinal or mixed-method approaches to test the framework’s internal relationships and its relevance across different classroom and policy settings. Establishing such empirical evidence would elevate SEEDS from a theoretically grounded model to a validated framework capable of guiding evidence-based improvements in early childhood STEM education.

### **CONCLUSION**

This paper has presented a critical exploration of two key contributions to early childhood STEM education: a Malaysian case study that captures the texture and complexity of classroom practice, and an international scoping review that maps wider research trajectories. Together, these studies demonstrate how contrasting methodological orientations—one rooted in contextual depth and the other in analytical scope—can enrich rather than oppose each other. The case study brings developmental theory to life within the lived realities of Malaysian preschools, while the scoping review situates those experiences within a broader conversation on global best practices and persistent challenges.

Drawing on insights from both sources, this study introduces the SEEDS framework as a conceptual bridge linking local realities with international perspectives. By integrating the principles of Scaffolding, Experiential Play, Equity, Developmental Fit, and Systems Alignment, the framework establishes a coherent foundation for educators, policymakers, and researchers seeking to elevate the quality and inclusivity of early STEM learning. Although the SEEDS framework has not yet been empirically tested, it offers a strong conceptual basis for developing equity-driven, developmentally appropriate, and systemically coherent approaches to early childhood STEM education. The next phase of this research will focus on transforming SEEDS into measurable constructs and evaluating its validity through field-based studies in Malaysian preschools. Through such progression, SEEDS is envisioned as a living framework that unites theory, policy, and practice in pursuit of more sustainable and inclusive early learning environments worldwide.

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