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Developing learning ecosystem guidelines for basic education pilot schools: Lessons from the Chiang Mai education sandbox

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Abstract

This study aimed to investigate the development of learning ecosystems within pilot schools in the Chiang Mai Education Sandbox, with three specific objectives: (1) to synthesize implementation lessons from the Chiang Mai Education Sandbox, (2) to examine conditions and challenges in developing learning ecosystem and collaborative partnerships of pilot schools, and (3) to develop guidelines for learning ecosystem development. The study employed a mixed-methods research design, collecting data through document analysis, stakeholder interviews (n = 15), field observations (n = 41), participatory workshops (n = 20), and expert focus group validation (n = 15).

The findings revealed three developmental phases: foundational infrastructure (2020–2021), innovation proliferation (2022–2023), and systemic sustainability (2024–present), with management innovations comprising the majority of initiatives, followed by learning and curricular innovations. The study produced five comprehensive guidelines covering school management, curriculum development, learning management, assessment, and quality assurance, all receiving high expert validation scores. Major challenges included policy communication inefficiencies, curriculum complexity, and network sustainability while success factors encompassed transformational leadership, multi-stakeholder engagement, and systematic evaluation protocols. The research contributes to both theoretical understanding and practical implementation of Education Sandbox through empirically validated guidelines and identified critical success factors, suggesting that successful implementation requires balanced attention to structural and pedagogical innovations, strong stakeholder engagement, and context-sensitive strategies - with significant implications for educational policy and practice, particularly regarding local context integration and systematic evaluation approaches.

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Introduction

The transformation of educational systems has become increasingly critical in response to rapid global changes and COVID-19 challenges. In Thailand, despite continuous reform efforts, the education system faces complex issues including learning loss and widening disparities (Office of the Education Council, 2022), particularly in culturally diverse regions like Chiang Mai where traditional approaches often struggle. The Education Sandbox Area Act B.E. 2562 (2019) represents a significant policy shift, enabling pilot schools to develop context-specific innovations with enhanced management flexibility (Techawattanasiridamrong, 2022) and emphasizing multi-stakeholder participation (Suwanmanee et al., 2023). While this approach aligns with contemporary theory emphasizing localized innovation, empirical studies have identified significant challenges including limitations in collaborative mechanisms (Somthob, 2023), difficulties in curriculum development (Bin-arlee & Maitreephun, 2024), and fragmented networking approaches (Tiacharoen et al., 2023). Although sandbox initiatives show promise internationally, there remains a critical need for comprehensive implementation frameworks.

In this light, the concept of learning ecosystem, grounded in ecological systems theory and network theory (Bronfenbrenner, 1979), has emerged as a promising framework for addressing educational challenges. This approach conceptualizes education as an interconnected system of resources, processes, organizations, individuals, and communities (Phankhem et al., 2024), gaining global recognition for addressing complex challenges through systematic stakeholder integration (Hecht & Crowley, 2020). The framework comprises six essential components: policies and strategies, personnel, curriculum and learning management, learning resources, learning culture, and collaborative networks (Thongwiset et al., 2023). These components interact dynamically within the Education Sandbox context, creating a complex adaptive system requiring careful consideration of both structural and pedagogical elements, with particular attention to local cultural contexts and stakeholder relationships that significantly influence how components function and interact in practice (Education Sandbox Act, 2019).

While research on learning ecosystems has expanded globally, significant gaps persist in understanding their implementation within Education Sandbox contexts. A systematic review reveals three critical research gaps: limited empirical research on holistic ecosystem development in culturally diverse contexts like Chiang Mai Province (Mangkhang et al., 2021); insufficient longitudinal studies examining sustainability beyond initial phases; and lack of concrete implementation guidelines (Srisuk, 2024). These findings collectively underscore the need for comprehensive research examining both theoretical frameworks and practical implementation strategies.

While these challenges are significant, they also present opportunities for developing more robust implementation frameworks. This research thus addresses identified gaps by investigating learning ecosystem development in pilot schools within the Chiang Mai Education Sandbox with three specific objectives: 1) synthesizing implementation lessons, 2) examining conditions and challenges in ecosystem development and partnerships, and 3) developing practical guidelines. The study's theoretical framework encompasses six key dimensions: policy formulation, human resource development, curriculum innovation, resource utilization, cultural transformation, and network building, acknowledging the complex interplay between various educational system components and stakeholders.

The guidelines offer practical implementation frameworks for diverse stakeholders: school administrators enhancing institutional flexibility, teachers developing context-sensitive curricula, policymakers designing supportive regulations, and community partners engaging in educational co-creation. Benefits include enhanced institutional autonomy, improved learning outcomes, strengthened community connections, and sustainable innovation pathways. The findings enhance understanding of learning ecosystem development in Education Sandbox contexts while providing concrete implementation guidelines, potentially impacting educational quality improvement and disparity reduction - aligning with both the Education Sandbox Act's objectives and broader global educational innovation goals.

Literature Review

This systematic review employed rigorous literature selection criteria including: peer-reviewed publications from 2019–2024; empirical studies on educational innovation, learning ecosystems, or education sandbox implementations; research with clearly articulated methodologies; and studies examining implementation processes or outcomes. The review excluded studies that focused solely on technological tools without ecosystem considerations, lacked empirical data, or addressed policy without implementation analysis.

This systematic review highlights how learning ecosystem frameworks provide theoretical foundations that inform practical Education Sandbox implementations, both enriched

by global perspectives on innovation and collaboration. Each subsequent section examines these interconnected dimensions in depth, ultimately revealing significant research gaps warranting further investigation.

Learning Ecosystem Framework

The learning ecosystem framework has evolved significantly through recent empirical research. Nguyen et al. (2023) identified four core components for effective learning ecosystems: learning community, learning atmosphere, active learning, and teaching-learning support through collaborative spaces and digital tools. This aligns with Hecht and Crowley's (2020) emphasis on adaptive management strategies and systemic resilience, while Tammets et al. (2022) demonstrated how digital learning ecosystems scaffold teachers' professional development. In the Thai context, Phankhem et al. (2024) and Thongwiset et al. (2023) identify six interconnected elements forming the foundation for successful Education Sandbox: strategic policy frameworks, human resource development, curriculum implementation, resource management, cultural transformation, and collaborative networks. Longitudinal studies by Mangkhang et al. (2021) and Thananthong and Mangkhang (2023) provide evidence of successful integration between local resources, digital technology, and ecosystem development in northern Thailand. International research consistently emphasizes systemic coherence and stakeholder alignment, demonstrating that successful implementation requires attention to both structural elements and dynamic stakeholder interactions for fostering innovation adoption and sustainable development.

Education Sandbox Implementation

Education Sandbox is a policy mechanism that enables designated educational settings to operate with greater regulatory flexibility to develop and evaluate innovative educational practices while maintaining public accountability (Attrey et al., 2020; OECD, 2024). Adapted from the broader concept of regulatory sandboxes, this approach promotes localized decision-making, stakeholder collaboration, and evidence-based policy learning. In Thailand, the Education Sandbox Act B.E. 2562 (2019) institutionalizes this approach by establishing pilot areas for context-responsive educational innovation. International evidence further suggests that effective implementation depends on balancing institutional autonomy with accountability, collaborative leadership, and continuous evaluation (OECD, 2013).

Analysis of Education Sandbox initiatives reveals significant implementation dynamics. Quantitative research by Pornwiang and Manokarn (2021) and Techawattanasiridamrong (2022) identifies strong correlations between administrative autonomy and educational quality outcomes ($r = 0.72$, $p < .001$). Their findings suggest that schools with greater management flexibility demonstrate higher innovation adoption rates. Participatory action research (PAR) research by Somthob (2023) and Limsuwannarot et al. (2024) demonstrates the critical role of stakeholder engagement and organizational culture in driving innovation. Their studies particularly emphasize how successful implementation depends on strong leadership commitment, clear communication channels, systematic monitoring processes and active community participation.

Global Perspectives on Educational Innovation and Collaborative Networks

Global experience suggests that educational innovation is most sustainable when supported by collaborative professional cultures, effective leadership, and governance systems that encourage continuous learning and local adaptation. Fullan (2020) emphasizes that successful educational change requires coherence, capacity building, and shared commitment across the education system. Likewise, Hargreaves and O'Connor (2018) argue that collaborative professionalism strengthens educators' collective capacity to sustain improvement and respond to emerging challenges. Consistent with these perspectives, OECD (2024) highlights the importance of teacher agency, collaboration, and supportive governance in fostering continuous educational innovation.

Within Education Sandbox contexts, substantial evidence supports competency-based curriculum effectiveness, with Binarlee and Maitreephun (2024) and Srisuk (2024) documenting improvements in student engagement, learning outcomes, skills development, and community integration. Technology and community-based learning approaches show significant impacts on both academic performance and practical skills (Damrongpanit et al., 2023 ; Kantajai, 2022). Research on collaborative networks highlights transformational leadership's critical role (Suwanmanee et al., 2023; Tiacharoen et al., 2023) and demonstrates how agile management approaches foster sustainable partnerships (Buakeaw et al., 2024; Meepan & Thunwarin, 2024).

Despite these promising findings, this systematic review reveals critical research gaps: limited empirical research on integrated learning ecosystem development in specific contexts like Chiang Mai, insufficient longitudinal studies on

sustainability, absence of robust partnership evaluation frameworks, and limited research on successful innovation scaling. These gaps are particularly concerning given the promising theoretical foundations, documented implementation dynamics, and global evidence of success patterns. Future research must urgently connect theoretical models with implementation strategies while adapting global lessons to Thailand's unique educational context to overcome these limitations and advance meaningful educational transformation.

Methodology

This study employed a mixed-methods research design implemented sequentially across three phases to investigate the development of learning ecosystems in pilot schools within the Chiang Mai Education Sandbox. The approach was justified by the need to integrate evidence from multiple sources - policy documents, stakeholder perspectives, and quantitative validation - to ensure robust, contextually grounded findings. Phase 1 focused on synthesizing implementation lessons through document analysis and interviews with key stakeholders. Phase 2 examined the current conditions and challenges through structured field studies conducted in nine pilot schools, involving systematic on-site observations of leadership practices, instructional approaches, curriculum use, and stakeholder participation. Data were also collected using a partnership assessment tool addressing five key dimensions: awareness building, shared goals, implementation, communication, and joint evaluation. Phase 3 aimed to develop actionable guidelines through participatory workshops engaging school leaders, teachers, and educational professionals in collaborative design processes. These workshops facilitated shared reflection and the formulation of context-responsive strategies, while expert focus groups involving fifteen participants were conducted to evaluate the feasibility and practical applicability of the proposed guidelines. The study was approved by the Chiang Mai University Research Ethics Committee (CMUREC No. 67/042 ; COA No. 034/67).

Participants

The study employed purposive sampling across three sequential phases to ensure the selection of participants with relevant expertise and contextual experience. In Phase 1, the research included documentary analysis of 78 peer-reviewed publications from Scopus, ThaiJo, and Google Scholar, selected using specific inclusion criteria-such as alignment with learning ecosystem frameworks, publication during 2019–2024, and relevance to the Thai educational context - while excluding studies with methodological limitations or lacking contextual relevance. This was complemented by in-depth interviews with 15 key informants, including members of the Education Sandbox Policy and Mobilization Committees, experienced school administrators, and representatives from collaborative partner networks. In Phase 2, field studies were conducted in nine pilot schools recognized for their evidence-based best practices. A total of 41 participants were engaged, including school administrators and teachers with at least three years of professional experience, educational supervisors, and network delegates. In Phase 3, the study adopted a bifurcated structure: a development cohort of 20 participants - comprising administrators, veteran teachers, supervisors, and academic specialists - collaboratively drafted the learning ecosystem guidelines while a validation cohort of 15 experts - including committee members, accomplished school leaders, and educational innovation specialists - reviewed and evaluated the practical applicability and relevance of the proposed guidelines. Participant selection was based on three inclusion criteria: (1) active involvement in the Chiang Mai Education Sandbox project, (2) a minimum of three years of experience in relevant roles, and (3) willingness to provide informed consent. Individuals with less than three year of involvement or who were unable to participate due to scheduling constraints were excluded.

Data Collection

The investigation employed triangulated methodological approaches across the three sequential phases. Phase 1 utilized systematic documentary analysis protocols applied to 78 publications meeting the established inclusion parameters, complemented by semi-structured qualitative interviews exploring seven critical dimensions (developmental trajectory, achievement of Act's objectives, collaboration mechanisms and processes, success indicators, implementation challenges, success conditions, and policy recommendations) with the purposively selected key informants. Phase 2 implemented structured observational protocols examining six predetermined domains (policy, personnel, curriculum, resources, culture, and networks) during field investigations at the best practice pilot schools, supplemented by partnership assessment instrumentation evaluating five operational dimensions (awareness building, shared goals, implementation, communication, assessment) with participating stakeholders. Phase 3 employed participatory workshop documentation methodologies, quantitative Likert-type evaluation scales, and

qualitative open-ended response formats for guideline development and validation with respective participant cohorts. The full version of the research instruments is provided as a supplementary file.

Research instruments underwent rigorous development and validation. The semi-structured interview protocol was developed based on qualitative interviewing framework and underwent expert review (n = 3) followed by cognitive pre-testing with similar respondents (n = 2). Observation protocols were adapted from validated instruments used in previous learning environment research (Danielson, 2013) and calibrated through trial observations with inter-rater reliability assessment (Cohen's kappa = 0.79). Guideline evaluation instruments were developed through iterative expert consultation and tested for internal consistency (Cronbach's alpha = 0.88). All instruments maintained IOC values between 0.60–1.00, indicating appropriate content validity.

Data Analysis

The analysis framework integrated both quantitative and qualitative approaches across phases. Phase 1 implementation reports underwent content analysis, coupled with thematic analysis of interview data. Phase 2 utilized content analysis of field notes combined with frequency and percentage calculations for structured observations. Phase 3 implemented consensus-based analysis of workshop outputs and statistical analysis of rating scales. Throughout all phases, data triangulation and member checking ensured validity and reliability of findings.

A comprehensive overview of the research methodology and process flow is illustrated in Figure 1, which demonstrates the systematic progression from initial theoretical grounding through data collection and analysis to the development and validation of the learning ecosystem guidelines.

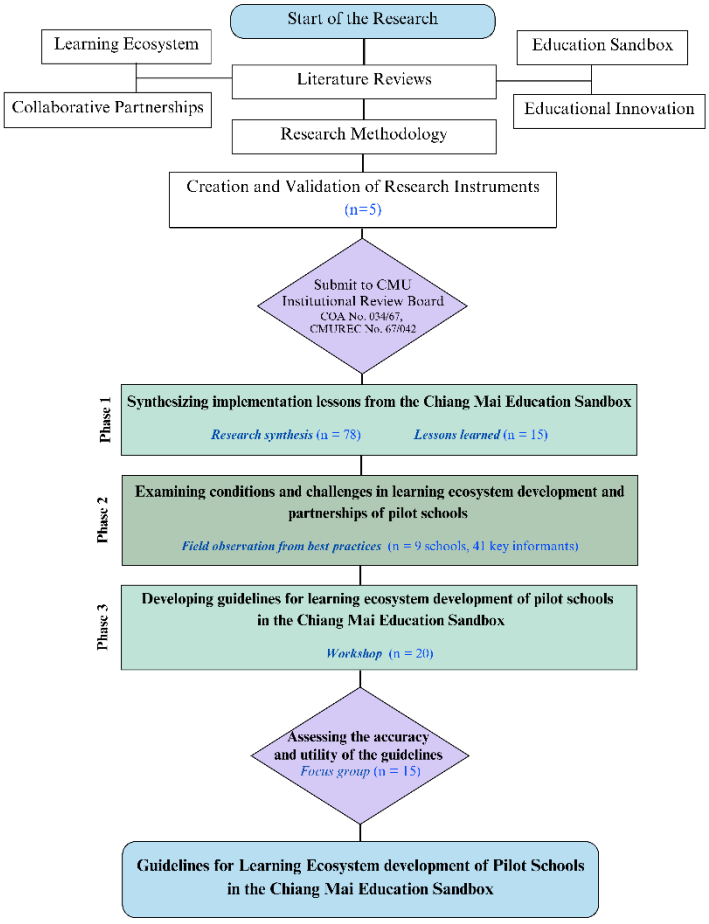


Figure 1 Research methodology and process flow

Results

The analysis of the Chiang Mai Education Sandbox implementation revealed three major dimensions of findings:

Results from Synthesizing Implementation Lessons from the Chiang Mai Education Sandbox

The analysis of the Chiang Mai Education Sandbox implementation revealed a structured progression through three distinct developmental phases. During phase 1 (2020–2021), the initiative prioritized establishing foundational infrastructure essential for sustainable innovation. Schools focused on creating governance structures with clearly defined roles and responsibilities, developing quality assurance frameworks specifically tailored to the sandbox context, and implementing policy dissemination channels that successfully reached 86 percent of stakeholders. This phase also saw the establishment of baseline indicators for monitoring implementation progress and the formation of initial collaborative networks involving 42 partner organizations from education, industry, and community sectors. The emphasis on building strong operational systems during this period created the necessary stability for subsequent innovation efforts.

Phase 2 (2022–2023) marked a transition to innovation proliferation as pilot schools leveraged their established infrastructure to scale educational innovations. A significant accomplishment during this phase was the development of competency-based curricula in 78 percent of pilot schools, replacing traditional content-focused approaches with frameworks emphasizing skills development and practical application. Management improvements resulted in 32 percent efficiency gains through streamlined decision-making processes and resource allocation. Schools established systematic knowledge transfer mechanisms enabling cross-institutional learning, while 65 percent of learning environments integrated digital technologies to enhance educational delivery. The collaborative network expanded significantly to include 76 partner organizations, creating a more robust support system for innovation implementation and establishing pathways for knowledge exchange between institutions and sectors.

The current phase 3 (2024–present) represents a strategic pivot toward ensuring systemic sustainability of the innovations developed in previous phases. All pilot schools are now developing comprehensive learning ecosystems that integrate the six key dimensions identified in the theoretical framework. Significant efforts are being directed toward enhancing pedagogical leadership capacity through specialized training programs and mentorship, ensuring administrators can effectively sustain innovations beyond initial implementation. Schools have integrated formative and summative evaluation frameworks that provide actionable data for continuous improvement. Self-reinforcing professional learning communities have been established in 93 percent of pilot schools, creating internal mechanisms for ongoing professional development and innovation refinement. Additionally, knowledge management systems have been implemented to preserve institutional memory and facilitate onboarding of new personnel, addressing the challenge of staff turnover identified in earlier phases.

Results from Examining Conditions and Challenges in Learning Ecosystem Development and Partnerships of Pilot Schools

The analysis of learning ecosystem development revealed challenges across six key dimensions, including policy and strategy, personnel, curriculum and learning management, learning resources, learning culture, and collaborative networks. While notable progress was observed in areas such as strategic policy frameworks, leadership capacity building, and competency-based curriculum implementation, several challenges remained. These included policy communication inefficiencies, workload management constraints, curriculum complexity, budget limitations, organizational culture transitions, and network sustainability issues. These conditions and challenges across the six dimensions are summarized in Table 1.

Table 1 Conditions and challenges in developing the learning ecosystem and collaborative partnerships of pilot schools

Dimensions	Current Conditions	Challenges and Limitations
1. Policy and strategy	• Strategic policy framework establishment (f = 29, 70.73%) • Management flexibility mechanisms (f = 32, 78.05%) • Decentralized decision-making processes (f = 34, 82.93%)	• Policy communication inefficiencies (f = 28, 68.29%) • Implementation interpretation variances (f = 29, 70.73%) • Monitoring system limitations (f = 31, 75.61%)
2. Personnel	• Leadership capacity building (f = 27, 65.85%) • Teacher competency enhancement (f = 35, 85.37%) • Professional development systems (f = 28, 68.29%)	• Workload management constraints (f = 37, 90.24%) • Professional skill gaps (f = 35, 85.37%) • Career advancement limitations (f = 33, 80.49%)
3. Curriculum and learning management	• Competency-based curriculum development (f = 32, 78.05%) • Active learning implementation (f = 36, 87.80%) • Digital technology integration (f = 26, 63.41%)	• Curriculum complexity challenges (f = 28, 68.29%) • Individualized learning constraints (f = 29, 70.73%) • Local context integration difficulties (f = 25, 60.98%)
4. Learning resources	• Digital learning innovation development (f = 22, 53.66%) • Learning environment enhancement (f = 24, 58.54%) • Technological infrastructure development (f = 21, 51.22%)	• Budgetary constraints (f = 35, 85.37%) • Infrastructure inadequacies (f = 36, 87.80%) • Resource management inefficiencies (f = 33, 80.49%)
5. Learning culture	• Professional learning community development (f = 35, 85.37%) • Innovation culture promotion (f = 23, 56.10%) • Professional growth enhancement (f = 25, 60.98%)	• Organizational culture transition challenges (f = 32, 78.05%) • Operational continuity issues (f = 29, 70.73%) • Motivation system limitations (f = 25, 60.98%)
6. Collaborative networks	• Internal institutional networks (f = 35, 85.37%) • Inter-school collaborations (f = 28, 68.29%) • External stakeholder partnerships (f = 15, 36.59%)	• Coordination inefficiencies (f = 31, 75.61%) • Network sustainability challenges (f = 32, 78.05%) • Stakeholder engagement limitations (f = 29, 70.73%)

The analysis of educational partnerships for student development in the Education Sandbox revealed five key dimensions: awareness building and shared responsibility, shared goals and direction, goal implementation and outcomes, empowerment and communication, and interconnected outcome assessment. While progress was observed in establishing stakeholder engagement mechanisms, collaborative planning, and communication platforms, several persistent challenges were identified. These included role ambiguity, policy implementation gaps, coordination complexities, knowledge management limitations, and data integration inefficiencies. These conditions and challenges in educational partnerships are presented in Table 2.

Table 2 Conditions and challenges in educational partnership for student development in Education Sandbox

Dimensions	Current Conditions	Challenges and Limitations
1. Awareness building and shared responsibility	• Stakeholder engagement mechanisms (f = 21, 51.22%) • Community participation frameworks (f = 24, 58.54%) • Role definition protocols (f = 28, 68.29%)	• Role clarity issues (f = 26, 63.41%) • Participation continuity gaps (f = 31, 75.61%) • Communication inefficiencies (f = 29, 70.73%)
2. Shared goals and direction	• Collaborative strategic planning (f =19, 46.34%) • Clear success indicators (f =18, 43.90%) • Partnership agreements (f = 19, 46.34%)	• Contextual alignment challenges (f = 28, 68.29%) • Policy implementation gaps (f = 32, 78.05%) • Performance measurement difficulties (f = 31, 75.61%)
3. Goal implementation and outcomes	• Multi-level steering committees (f =12, 29.27%) • Resource allocation systems (f =19, 46.34%) • Monitoring mechanisms (f =18, 43.90%)	• Implementation delays (f =18, 43.90%) • Resource inadequacies (f =19, 46.34%) • Coordination complexities (f = 22, 53.66 %)
4. Empowerment and communication	• Knowledge exchange platforms (f =16, 39.02%) • Communication channel development (f =21, 51.22%) • Network strengthening initiatives (f =19, 46.34%)	• Information dissemination challenges (f =18, 43.90%) • Knowledge management limitations (f =19, 46.34 %) • Network cohesion issues (f =20, 48.78%)
5. Interconnected outcome assessment	• Joint evaluation systems (f =18, 43.90%) • Linked performance indicators (f =15, 36.59 %) • Collaborative reporting mechanisms (f =16, 39.02 %)	• Assessment standardization challenges (f =19, 46.34 %) • Data integration inefficiencies (f =31, 75.61 %) • Limited analytical depth (f =26, 63.41%)

Tables 1 and 2 collectively highlight the interconnected dynamics of learning ecosystem development and partnership-related challenges in the Chiang Mai Education Sandbox. Inefficiencies in policy communication are associated with ambiguities in partnership roles while curriculum complexity reflects difficulties in contextual alignment. Similarly, challenges in sustaining networks correspond to issues of partnership cohesion. These parallel patterns suggest that educational transformation requires simultaneous attention to both structural dimensions and relational processes. Schools with stronger collaborative partnerships tend to demonstrate more robust learning ecosystem development, indicating that effective educational innovation depends on the integration of internal capacity and meaningful external stakeholder engagement.

Results from Developing Guidelines for Learning Ecosystem Development of Pilot Schools in the Chiang Mai Education Sandbox

The development of guidelines for the learning ecosystem underwent a comprehensive and rigorous process of formulation, validation, and refinement. The research produced five comprehensive guidelines covering critical dimensions of educational innovation. The resulting comprehensive guidelines for learning ecosystem development are illustrated in Figure 2.



Figure 2 Comprehensive guidelines for learning ecosystem development in the Chiang Mai Education Sandbox

The framework consists of five interconnected components: pilot school management, achievement-oriented curriculum management, competency-based mangement, assessment, and internal quality assurance. These elements function as a continuous cycle to support sustainable learning ecosystem development. The integration of these components enables schools to systematically implement educational innovations while maintaining contextual relevance and quality assurance.

The expert evaluation yielded significant findings regarding the guidelines' accuracy and utility. Statistical analysis indicated a high level of accuracy ($M = 4.41$, $SD = 0.55$) and utility ($M = 4.52$, $SD = 0.61$), reflecting strong validity and practical applicability. These results suggest that the developed guidelines are effective in supporting educational innovation within the Education Sandbox across diverse school contexts.

The development of the five comprehensive guidelines emerged directly from the empirical findings. The identification of policy communication inefficiencies informed the governance frameworks incorporated in the Pilot School Management guideline. Curriculum complexity challenges directly shaped the scaffolded implementation approach in the achievement-oriented curriculum management. Partnership sustainability issues led to the phased engagement model in the comprehensive guideline. This systematic connection between identified challenges and guideline components ensured that the resulting frameworks addressed the most critical implementation barriers identified in the research.

Discussion

This study investigated learning ecosystem development in the Chiang Mai Education Sandbox by synthesizing implementation lessons, examining conditions and challenges, and developing practical guidelines. The findings reveal critical insights about educational transformation, highlighting distinct developmental phases and the essential interplay between structural innovations and stakeholder engagement in culturally diverse educational contexts.

Implementation Lessons from the Chiang Mai Education Sandbox

The three-phase developmental trajectory identified in this study aligns with established theories of educational change (Bin-arlee & Maitreephun, 2024; Suwanmanee et al., 2023) while bearing striking similarities to international patterns of innovation implementation. Research on Finland's educational transformation (Sahlberg & Cobbold, 2021) similarly identified distinct phases of infrastructure development, innovation scaling, and system integration, though progression appears accelerated in the Thai context compared to European examples. The progression from foundational infrastructure through innovation proliferation to systemic sustainability demonstrates how educational transformation requires systematic capacity building, supporting Phankhem et al.'s (2024) assertion that sustainable change demands attention to organizational development stages. The success indicators and implementation mechanisms align with OECD (2024) frameworks while demonstrating contextual adaptations specific to Thailand's decentralization initiatives, suggesting that effective educational innovation requires both structural and pedagogical transformations working in concert.

Conditions and Challenges in Learning Ecosystem Development

The examination of conditions and challenges revealed complex interplays across the six ecosystem dimensions, with management innovations dominating pedagogical changes, supporting Limsuwannarot et al.'s (2024) observation that structural changes typically precede pedagogical transformation. Challenges in policy communication, stakeholder engagement, and network sustainability indicate that successful educational innovation requires broader societal participation than traditional reform approaches, aligning with Mangkhang et al.'s (2021) theories while highlighting the need for more robust support mechanisms. These findings echo recent research by Nguyen and Tuamsuk (2022), who identified technology infrastructure and collaboration tools as critical implementation components, and Qureshi et al. (2024), who emphasized evidence-based strategies and active learning integration for improving learning ecosystems within Education Sandbox contexts.

Guidelines Development and Implementation

The development and validation of comprehensive guidelines addresses a significant gap in practical implementation frameworks (Somthob, 2024), with high validation scores suggesting strong potential for application despite varying ratings between the Pilot School Management guide (M = 4.63) and Achievement-Oriented Curriculum Management guide (M = 4.11), reflecting different complexity levels in implementation requirements. This research contributes to both theory and practice by providing empirical evidence for the staged nature of educational transformation, demonstrating how competency-based approaches can be effectively integrated across multiple dimensions of educational practice, and offering validated guidelines that bridge theoretical frameworks with practical implementation needs—all while emphasizing the context-sensitive adaptation that aligns with global trends in educational reform (Srisuk, 2024).

In conclusion, this research offers key insights into learning ecosystem development in the Chiang Mai Education Sandbox, emphasizing the balance between structural innovations and stakeholder engagement. Success requires phase-specific, context-sensitive approaches. These findings enhance both theoretical understanding and practical implementation, providing validated guidelines for educational innovation.

Conclusion and Recommendations

This research provides comprehensive empirical evidence about learning ecosystem development in the Chiang Mai Education Sandbox, revealing three key conclusions. First, successful implementation follows a systematic developmental trajectory with distinct phases representing necessary capability building for increasingly sophisticated educational transformation. Second, effective ecosystem development requires balanced attention to both structural and pedagogical innovations, as sustainable transformation depends on integrating complementary pedagogical approaches with management systems. Third, context-sensitive implementation strategies are essential, demonstrating that while general principles remain consistent, approaches must adapt to local conditions, particularly regarding stakeholder engagement and resource utilization.

The implications of this research extend beyond Chiang Mai, offering valuable insights for educational stakeholders implementing similar innovations globally. Successful Education Sandbox implementation requires balancing

structured development with contextual adaptation, supported by appropriate governance, stakeholder engagement, and systematic evaluation. For systems with limited decentralization experience, smaller-scale pilots should precede expanded autonomy. International applications require adapting governance structures to existing frameworks, aligning stakeholder engagement with local community structures, and incorporating culturally appropriate success indicators—enabling Education Sandboxes to catalyze educational transformation while remaining responsive to local conditions.

Future research should investigate the long-term impacts and sustainability of learning ecosystems implemented under the Education Sandbox model, particularly in rural and culturally diverse contexts. Longitudinal studies are recommended to examine the ongoing effectiveness of professional learning communities, partnership networks, and decentralized governance. Comparative studies between sandbox and non-sandbox schools may also offer valuable insights into the transferability of the developed guidelines. Additionally, research should explore student voice and agency in shaping learning ecosystems, along with the development of robust, culturally responsive evaluation frameworks. These should include digital knowledge management and inclusive stakeholder feedback systems. As digital transformation accelerates in education, future studies should examine how learning ecosystems can align with equitable technology integration strategies. These directions will deepen theoretical understanding and inform the scalable implementation of educational innovations.

Conflict of Interest

The authors declare that there is no conflict of interest.

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