Salud, Ciencia y Tecnología. 2025; 5:2187
doi: 10.56294/saludcyt20252187

ORIGINAL

A Qualitative Needs Analysis for Developing a Design Thinking Pedagogical Framework for Secondary Science Teachers in Malaysia

Análisis cualitativo de necesidades para el desarrollo de un marco pedagógico de Design Thinking para profesores de ciencias de secundaria en Malasia

Norzilawati Zainal Abidin[1], Farah Mohamad Zain[1], Abdul Hamid Busthami Nur[1]

[1]School of Education, College of Arts and Sciences, Universiti Utara Malaysia, Malaysia.

Cite as: Zainal Abidin N, Mohamad Zain F, Busthami Nur AH. A Qualitative Needs Analysis for Developing a Design Thinking Pedagogical Framework for Secondary Science Teachers in Malaysia. Salud, Ciencia y Tecnología. 2025; 5:2187. https://doi.org/10.56294/saludcyt20252187

Submitted: 24-05-2024 **Revised:** 22-07-2025 **Accepted:** 04-10-2025 **Published:** 05-10-2025

Editor: Prof. Dr. William Castillo-González

Corresponding author: Norzilawati Zainal Abidin

ABSTRACT

Introduction: in response to the Malaysia Education Blueprint 2013-2025 and the pedagogical demands of Industrial Revolution 4.0, this study investigates the need for a contextualized Design Thinking (DT) pedagogical model for secondary school science teachers in Malaysia.
Method: guided by Phase I of the Design and Development Research (DDR) methodology, this qualitative study employed semi-structured interviews with three experienced science educators to explore their perceptions, challenges, and expectations related to DT integration in classroom instruction. Thematic analysis revealed three dominant themes: (1) the absence of a structured implementation framework, (2) challenges in aligning DT with national assessment practices, and (3) systemic barriers such as limited resources and time constraints. Informants emphasized the need for localized, practical guidelines, adaptable assessment tools, and sustainable training mechanisms.
Results: these findings highlight a critical gap in current pedagogical practice and serve as empirical grounding for the development of a DT pedagogical model in Phase II.
Conclusions: the study contributes to STEM education by advocating for a model that is both theoretically robust and operationally feasible within the Malaysian educational landscape.

Keywords: Design Thinking; STEM Education; Pedagogical Model; Needs Analysis; Malaysian Science Teachers; DDR; Constructivism.

RESUMEN

Introducción: en respuesta al Plan Educativo de Malasia 2013-2025 y a las exigencias pedagógicas de la Revolución Industrial 4.0, este estudio investiga la necesidad de un modelo pedagógico contextualizado de Design Thinking (TD) para el profesorado de ciencias de secundaria en Malasia.
Método: guiado por la Fase I de la metodología de Investigación de Diseño y Desarrollo (DDR), este estudio cualitativo empleó entrevistas semiestructuradas con tres educadores de ciencias con experiencia para explorar sus percepciones, desafíos y expectativas en relación con la integración del TD en la enseñanza en el aula. El análisis temático reveló tres temas dominantes: (1) la ausencia de un marco de implementación estructurado, (2) los desafíos para alinear el TD con las prácticas nacionales de evaluación, y (3) las barreras sistémicas, como la limitación de recursos y tiempo. Los informantes enfatizaron la necesidad de directrices prácticas y localizadas, herramientas de evaluación adaptables y mecanismos de formación sostenibles.
Resultados: estos hallazgos ponen de relieve una brecha crítica en la práctica pedagógica actual y sirven como base empírica para el desarrollo de un modelo pedagógico de TD en la Fase II.

Conclusiones: el estudio contribuye a la educación STEM al promover un modelo teóricamente sólido y operativamente viable en el panorama educativo malasio.

Palabras clave: Design Thinking; Educación STEM; Modelo Pedagógico; Análisis de Necesidades; Profesorado de Ciencias Malasio; DDR; Constructivismo.

INTRODUCTION

The rapid transition toward innovation-driven economies underpinned by the Fourth Industrial Revolution (IR 4.0) has prompted a global reconfiguration of educational paradigms. In this evolving landscape, traditional modes of didactic instruction cantered on rote memorization and content delivery—are increasingly viewed as inadequate for preparing learners to navigate complex, dynamic societal challenges.(1) In response, educational systems are called to foster higher-order competencies such as critical thinking, creativity, collaboration, and problem-solving—collectively referred to as 21st-century skills.

Science education, in particular, stands at the nexus of this pedagogical shift due to its foundational role in cultivating scientifically literate citizens and preparing a future-ready workforce. To remain relevant and impactful, science instruction must evolve from static content transmission to active, inquiry-based learning approaches that engage students as co-constructors of knowledge.(2) Within this context, Design Thinking (DT) has emerged as a promising pedagogical framework. Characterized by its iterative, human-centered, and interdisciplinary approach to problem solving, DT aligns well with the goals of STEM education by fostering experiential learning, empathy-driven inquiry, and adaptive reasoning.(3)

Recent empirical studies underscore DT's potential to enhance student engagement, deepen conceptual understanding, and promote cross-disciplinary integration in science classrooms.(4) As such, DT is increasingly recognized not only as a creative strategy for curriculum delivery but also as a transformative pedagogical tool for reimagining science education in the IR 4.0 era.(5)

Globally, numerous studies have demonstrated the promise of DT in engaging learners, enhancing STEM outcomes and fostering 21st-century skills. However, these studies often emerge from well resourced educational contexts and offer generalized implementation frameworks. In contrast, Malaysia's secondary education system lacks a contextualized pedagogical model that guides science teachers in applying DT within national curriculum constraints. While the Malaysia Education Blueprint (MEB) 2013-2025 calls for learner-centered and innovative teaching, there is limited empirical understanding of how science teachers conceptualize DT or the specific challenges they face in applying it effectively.

Despite a growing global interest in Design Thinking (DT) as an innovative pedagogical approach, current literature remains insufficient in capturing the nuanced, micro-level pedagogical realities experienced within Malaysian secondary science classrooms. These realities include, but are not limited to, curricular rigidity, a persistent culture of examination-oriented instruction, limited integration of information and communication technologies (ICT), and acute time constraints faced by educators.(6,7) Such systemic conditions create a pedagogical ecosystem where the implementation of flexible, student-centered frameworks like DT is inherently constrained.

Furthermore, although prominent DT models—such as the Stanford d.school framework—have gained international traction for fostering creative problem-solving and learner autonomy, these models are largely developed within Western sociocultural and institutional contexts. As a result, they lack alignment with Southeast Asian educational norms, particularly with regard to hierarchical classroom structures, teacher-centric instructional styles, and centralized curriculum mandates.(8) Notably, these models also do not account for the realities of professional development in the region, which often relies on one-off workshops with minimal follow-up support or contextual customization.(9)

This disjuncture underscores a critical gap in the literature: the absence of a grounded needs analysis that could inform the design of a localized, context-sensitive DT pedagogical framework. Such a framework must not only reflect the practical constraints and affordances of Malaysian science classrooms but also be strategically aligned with national education policies such as the Malaysian Education Blueprint 2013-2025. Without this foundational layer of empirical insight, efforts to introduce DT into the Malaysian science education landscape risk being either superficial or unsustainable.

This study responds to that gap by initiating Phase I of a Design and Development Research (DDR) approach, conducting a qualitative needs analysis with experienced Malaysian science teachers. The goal is to identify core pedagogical needs, contextual limitations, and instructional opportunities that will inform the co-design of a DT pedagogical framework tailored for Malaysia's secondary STEM context. By doing so, the study contributes to both national educational reform and the broader global conversation on contextualizing design thinking in diverse teaching environments.(10)

LITERATURE REVIEW

Design Thinking in STEM Education

Design Thinking (DT) has emerged as a transformative educational approach that cultivates critical thinking, collaboration, creativity, and innovation—skills central to 21st-century education. Defined as a human-centered, iterative process, DT empowers learners to solve real-world problems by applying empathy, ideation, prototyping, and testing. Within STEM education, DT aligns particularly well with constructivist pedagogies, offering learners the opportunity to bridge abstract scientific concepts with authentic, hands-on applications.[11]

The interdisciplinary nature of DT promotes meaningful engagement, as it encourages students to synthesize knowledge across science, technology, engineering, and mathematics domains. Razali et al. affirm that DT enhances students' capacity to tackle complex challenges by fostering systems thinking and adaptive problem-solving. Furthermore, DT supports the development of soft skills—such as communication, reflection, and empathy—that are increasingly valued in both academic and industry settings.[2]

Empirical research supports the integration of DT within STEM curricula. Fan and Yu observed that students exposed to DT-infused engineering modules demonstrated significantly stronger problem-solving skills and deeper conceptual understanding. Similarly, English (2019) found that elementary students engaged in DT-based tasks exhibited enhanced collaboration and cognitive engagement. These findings affirm the pedagogical potential of DT not only as an instructional method but also as a mindset that fosters lifelong learning competencies.

However, despite its promise, successful implementation of DT requires context-sensitive adaptations. Curriculum alignment, teacher preparedness, resource availability, and cultural expectations all influence how effectively DT can be integrated into science education—especially in diverse educational systems such as Malaysia's. This underscores the importance of developing localized pedagogical models that translate global DT frameworks into actionable practices for specific classroom realities.[12]

Global DT Pedagogical Models

Globally, Design Thinking (DT) has been operationalized through structured frameworks that guide problem-solving in education, notably the IDEO model and the Stanford d.school framework. These models typically follow a five-stage cycle—Empathize, Define, Ideate, Prototype, and Test—and have been successfully applied in diverse educational contexts to promote learner agency, creativity, and real-world relevance. For example, the Stanford. school framework emphasizes a flexible, iterative process where learners co-create solutions that are empathetic and user-centered, reflecting principles of experiential and constructivist learning.[13] These global models have shown positive outcomes in Western and well-resourced educational systems. They support interdisciplinary learning, promote socio-emotional skills, and foster innovation across STEM domains. However, their direct transferability to developing country contexts, such as Malaysia, remains limited. Educational environments in Malaysia are characterized by nationalized curricula, examination-oriented instruction, limited ICT infrastructure in certain regions, and rigid school hierarchies—conditions that are not adequately addressed by these models.[14]

Furthermore, most global DT models assume a high degree of teacher autonomy, classroom flexibility, and access to maker-space resources—factors not consistently available in Malaysian secondary schools. As a result, the uptake of DT in Malaysian classrooms is often fragmented or superficial. Teachers may be exposed to DT concepts through isolated training workshops but lack continuous support, instructional resources, or curriculum alignment to sustain its implementation.[15] The absence of contextualized pedagogical guidelines, particularly ones grounded in local education policy (e.g., MEB 2013–2025), restricts the effective adoption of DT practices. Therefore, this study argues for the development of a Malaysia-specific DT pedagogical model, one that considers systemic constraints, aligns with national assessment standards, and supports science teachers in navigating classroom realities. Such a model would serve as a bridge between international best practices and local feasibility, ensuring that DT pedagogy is not only aspirational but also actionable within the Malaysian educational framework.[9]

Theoretical Frameworks for Model Development

The theoretical grounding of this study integrates two complementary frameworks: Constructivist Learning Theory and the Technological Pedagogical Content Knowledge (TPACK) framework, both of which provide critical lenses through which the proposed Design Thinking (DT) pedagogical model is conceptualized and contextualized. Constructivist Learning Theory, rooted in the works of Piaget and Vygotsky, posits that learners actively construct knowledge through interaction with their environment and engagement in meaningful activities. This paradigm emphasizes learner agency, problem-solving, and reflection—all of which align seamlessly with the principles of DT. The iterative and student-centered nature of DT, which involves empathizing with users, ideating solutions, prototyping, and testing, mirrors constructivist pedagogy by enabling students to co-construct understanding through experiential learning cycles. In this way, DT functions not merely as a teaching strategy, but as a cognitive framework that cultivates self-directed inquiry and deeper learning.[14]

In parallel, the TPACK framework addresses the complex interplay between technology, pedagogy, and content knowledge in instructional design. As Malaysian classrooms increasingly integrate digital tools—particularly in the post-pandemic era—the ability of science teachers to balance these three knowledge domains becomes essential. A DT-based model grounded in TPACK can guide teachers to not only deliver content effectively but also to design learning experiences that are technologically enriched and pedagogically sound.[4]

By combining these two frameworks, this study ensures that the resulting DT pedagogical model is both epistemologically coherent and practically relevant. Constructivism provides the philosophical foundation, emphasizing learning as a process of making meaning, while TPACK offers a pragmatic framework to guide the integration of DT into real-world classroom environments. Together, they establish a robust theoretical scaffold for developing a localized model that addresses the pedagogical challenges and systemic constraints faced by Malaysian science teachers.[5]

METHOD

This study employed the first phase of the Design and Development Research (DDR) model, which focuses on needs analysis as the foundational step in designing an educational intervention. DDR is particularly well-suited for education-based research aimed at developing context-sensitive instructional models because it integrates theoretical exploration with empirical fieldwork.[16]

Research Design

A qualitative exploratory design was adopted to understand science teachers' experiences, challenges, and expectations in implementing Design Thinking (DT) within Malaysian secondary school settings. This approach enabled the researchers to capture rich, contextual insights that inform the subsequent design of a localized DT pedagogical model.[17]

Participants

Purposeful sampling was used to select three experienced secondary science teachers from different regions of Malaysia. All participants had a minimum of five years of teaching experience and prior exposure to 21st-century teaching approaches, including DT workshops. Pseudonyms were used to protect participant confidentiality.

Data collection

Semi-structured interviews were conducted to explore teachers' perceptions, practices, and barriers related to DT integration in science classrooms. Each interview lasted approximately 45–60 minutes and was conducted either face-to-face or via secure video conferencing platforms, depending on geographic accessibility. Interviews were audio-recorded with participant consent and transcribed verbatim for analysis

Data Analysis

Thematic analysis was employed using Braun and Clarke's six-step framework: familiarization with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. This approach ensured systematic identification and interpretation of key patterns in the data. NVivo software was used to facilitate coding and organization of qualitative themes.

Trustworthiness

To enhance the study's credibility and trustworthiness, the following strategies were implemented:

- Member Checking: Transcripts were returned to participants for verification to ensure accuracy of interpretations.
- Triangulation: Data interpretation was cross-checked with literature and peer-reviewed by a second coder to reduce researcher bias.
- Audit Trail: Detailed notes of coding decisions and analytical reflections were maintained throughout the research process.
- Rich Descriptions: Verbatim quotes from participants were used to support the findings and enhance transferability. This rigorous methodological approach ensured that the findings of this needs analysis are both valid and reflective of the authentic challenges faced by Malaysian science educators. These insights serve as a robust empirical foundation for the prototype development phase in the DDR process.

RESULTS

Thematic analysis of the interview data yielded three core themes that reflect the pressing pedagogical needs and contextual challenges experienced by Malaysian secondary science teachers in integrating Design

Thinking (DT) into their instructional practices.

Theme 1: Absence of a Structured Implementation Framework

All participants emphasized the lack of a standardized or practical guide for incorporating DT into science classrooms. While DT concepts were occasionally introduced through short-term professional development workshops, there was no follow-through in terms of practical, curriculum-aligned tools or sustained support mechanisms. Teachers reported difficulty in operationalizing DT principles in everyday instruction and expressed the need for a user-friendly, adaptable model tailored to their subject and assessment requirements.

"We've heard about design thinking in seminars, but we don't really know how to apply it effectively in our own classrooms, especially with syllabus constraints." — Informant 1

"If I had a simple, step-by-step framework that matched what I already teach, I would feel more confident using DT. Right now, it just feels like an extra burden." — Informant 2

"Some teachers want to try new approaches, but they feel stuck because there's no clear guidance or lesson samples on how to embed DT in science subjects." — Informant 3

Additionally, participants highlighted that although DT offers rich pedagogical potential, its implementation requires clear scaffolding, instructional materials, and examples of successful integration within the science curriculum. Teachers expressed frustration over the ambiguity in current DT resources and the lack of step-by-step procedures that align with existing curriculum standards. This finding aligns with prior research, which indicates that the diffusion of DT is often hindered by a disconnect between conceptual training and classroom implementation.

Theme 2: Challenges in Assessment Integration

Participants reported challenges in aligning DT-based activities—particularly project-based learning (PBL)—with standardized national assessments. The absence of formative assessment rubrics or guidelines tailored to DT outcomes often left teachers uncertain about how to evaluate creativity, empathy, and iterative thinking in a measurable way.

"We try using PBL, but we don't know how to assess it properly. There's no rubric or criteria that match the national science curriculum." — Informant 2

"I worry that if I spend too much time on creative projects, students might not perform well in exams. There's pressure to focus on tested content." — Informant 1

"It's hard to mark something subjective like creativity or empathy. We need clear standards and examples from the Ministry to feel confident." — Informant 3

Participants also expressed concern that DT activities might not be valued within the existing examination-oriented framework. They called for detailed criteria or national-level exemplars that could offer clarity on assessment expectations. This echoes Fan and Yu's findings that successful DT implementation requires not only pedagogical innovation but also assessment reform that recognizes diverse cognitive processes and student outputs.

Theme 3: Systemic Barriers and Resource Constraints

Teachers highlighted structural constraints such as limited class time, insufficient access to ICT tools, and varying levels of student readiness as key barriers. These systemic issues were further compounded by post-pandemic disruptions and inconsistent access to teacher training.

"It's hard to do hands-on design projects when we don't even have enough basic lab resources or computer access." — Informant 3

"We barely have time to finish the syllabus, let alone experiment with new methods like DT. Time is a major issue." — Informant 1

"Some students lack the skills or confidence for open-ended projects. They need more structure, and so do we as teachers." — Informant 2

Participants noted that in overcrowded classrooms and under-resourced schools, project-based approaches were often sidelined in favor of more traditional lecture-based instruction. Teachers also mentioned logistical challenges in managing group work, sourcing project materials, and allocating time for iterative prototyping and reflection. Such barriers indicate that any DT pedagogical model must be flexible, scalable, and sensitive to diverse school environments. A one-size-fits-all model imported from global contexts would likely fail under these localized constraints.

DISCUSSION

Together, these themes underscore the urgent need for a context-sensitive DT pedagogical model that is practical, assessment-aligned, and infrastructure-aware. The findings corroborate earlier work, emphasizing that models developed in high-resource or autonomous educational settings may not transfer seamlessly to systems like Malaysia's without adaptation.

By grounding the model development in teacher voices and empirical insights, this study makes a meaningful contribution to the field of STEM pedagogy. It also addresses a documented gap in the literature—namely, the lack of localized DT instructional frameworks that align with national education policies such as the Malaysia Education Blueprint (MEB) 2013–2025. These insights form the foundational input for Phase II of the Design and Development Research process, which will involve the design of prototypes and iterative expert validation of the DT pedagogical model.

CONCLUSIONS

This Phase I study has identified a critical need among Malaysian secondary school science teachers for a Design Thinking (DT) pedagogical model that is both practical and contextually relevant. The thematic findings reveal that while teachers are conceptually open to DT, they face significant barriers in implementation due to the absence of structured guidelines, alignment with assessment practices, and systemic resource limitations.

Teachers highlighted specific challenges such as lack of curriculum integration, ambiguity in assessment practices, and difficulties in managing project-based activities due to time, technology, and infrastructure constraints. These concerns reflect the need for a DT framework that is grounded in local pedagogical realities while incorporating global best practices. The study's contribution lies in providing empirical evidence to guide the development of a localized DT model aligned with national educational objectives such as those articulated in the Malaysia Education Blueprint (2013–2025). By foregrounding the voices of science educators, this research ensures that the model to be developed in Phase II of the DDR process will be not only theoretically sound but also pragmatically useful.

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FINANCING
The authors did not receive financing for the development of this research.

CONFLICT OF INTEREST
The authors declare that there is no conflict of interest.

ACKNOWLEDGEMENTS
The authors extend their appreciation to Universiti Utara Malaysia Sintok Kedha.

AUTHORSHIP CONTRIBUTION
Conceptualization: Norzilawati Zainal Abidin, Farah Mohamad Zain, Abdul Hamid Busthami Nur.
Data curation: Norziawati Zainal Abidin, Farah Mohamad Zain, Abdul Hamid Busthami Nur.
Formal analysis: Norzilawati Zainal Abidin, Farah Mohamad Zain, Abdul Hamid Busthami Nur.
Research: Norzilawati Zainal Abidin, Farah Mohamad Zain, Abdul Hamid Busthami Nur.
Methodology: Norzilawati Zainal Abidin, Farah Mohamad Zain, Abdul Hamid Busthami Nur.
Project management: Norzilawati Zainal Abidin, Farah Mohamad Zain, Abdul Hamid Busthami Nur.
Resources: Norzilawati Zainal Abidin, Farah Mohamad Zain, Abdul Hamid Busthami Nur.
Software: Norzilawati Zainal Abidin.
Supervision: Farah Mohamad Zain, Abdul Hamid Busthami Nur.
Validation: Norzilawati Zainal Abidin.
Display: Norzilawati Zainal Abidin, Farah Mohamad Zain, Abdul Hamid Busthami Nur.
Drafting - original draft: Norzilawati Zainal Abidin.
Writing - proofreading and editing: Farah Mohamad Zain, Abdul Hamid Busthami Nur.