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EXPLORING SELF-EFFICACY IN STEM-TPACK TEACHING: A SYSTEMATIC RAPID REVIEW OF THE LITERATURE

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Abstract:

This systematic rapid review explores the relationship between lecturer self-efficacy and STEM-TPACK teaching practices, with particular attention to studies relevant to lecturers and pre-service educators. Seven Scopus-indexed studies published between January 2021 and 2025 were identified through structured database searches and screened against defined inclusion criteria. The evidence suggests that self-efficacy is a recurring factor influencing how STEM content, pedagogical strategies, and digital technologies are integrated through the TPACK framework, collectively known as STEM-TPACK teaching practice. However, its influence appears to be contingent on contextual variables such as teaching experience, educational level, and professional development exposure. In higher-education settings, self-efficacy was associated with improved confidence in digital pedagogy and research instruction. In K–12 and pre-service contexts, its role ranged from a strong direct predictor to a mediating or secondary influence. While several studies confirmed a positive relationship, the limited focus on lecturers highlights a notable research gap. Further research is needed that tracks changes in self-efficacy longitudinally and compares findings across diverse institutional settings to deepen understanding of its role in STEM-TPACK implementation.

Keywords:

Self-efficacy, STEM-TPACK, Technological Pedagogical Content Knowledge, Systematic Rapid Review

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Introduction

The fast rate of technology development has transformed the teaching and learning environment, particularly in Science, Technology, Engineering, and Mathematics (STEM) education. With the national education system, including the Malaysian Polytechnic, to emphasize interdisciplinary, inquiry-based instruction, there has been an increasing need for lecturers to use digital tools in their instructional practices. The Technological Pedagogical Content Knowledge (TPACK) framework has been employed to steer educators in the complex connection between delivered content, pedagogy, and technology (Zou et al., 2024). However, to actually integrate these integrative practices into the classroom, teachers need more than just knowing how to use them; they also need confidence in their ability to teach them (Adipat et al., 2023).

Teacher self-efficacy refers to a person's belief in their ability to effectively plan and execute instruction, and is widely recognized as one of the most important psychological factors influencing classroom innovation, particularly in the area of educational technology integration (Portaro, 2024). Regarding TPACK and STEM, adepts' commitment to digital tools, handling of intradisciplinary content, and maintaining technology-enhanced instruction might be influenced by their TPACK and STEM self-efficacy. Although the relationship between self-efficacy and TPACK-informed STEM teaching has been established conceptually, the field has collected evidence of this relationship in piecemeal form across disciplines and institutional types (Zeng et al., 2022; Joshi, 2023).

Existing studies have typically examined self-efficacy and TPACK either in isolation or within narrowly defined teaching environments, such as pre-service teacher education or single-discipline STEM courses. Despite growing interest, little synthesized evidence is available to clarify how lecturer self-efficacy actually supports or constrains the implementation of STEM-TPACK practices in higher education, particularly in polytechnic institutions. This absence of synthesis limits our understanding of how psychological readiness aligns with pedagogical innovation in STEM teaching.

To address this gap, the present study employs a Systematic Rapid Review (SRR) approach to synthesize peer-reviewed literature published between 2021 and 2025. The review focuses specifically on studying the relationship between lecturer self-efficacy and STEM-TPACK teaching practices. By identifying common findings, methodological patterns, and conceptual gaps, the study aims to inform both academic discourse and institutional policy on effective STEM instruction. The guiding research question is:

RQ: What is the relationship between lecturer self-efficacy and STEM-TPACK teaching practices?

Literature Review

TPACK framework (Mishra & Koehler, 2006) is widely adopted to guide educators in integrating technology, pedagogy, and content effectively, particularly within STEM disciplines. However, scholars stress that possessing knowledge alone does not guarantee successful integration. Here, teachers' self-efficacy or belief in their capabilities is equally vital (Bandura, 1997). TPACK self-efficacy supports teachers in confidently adopting technology-rich, inquiry-based STEM instruction.

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Empirical studies have demonstrated that self-efficacy significantly influences TPACK-related teaching practices. For instance, Chai, Jong and Yan (2020) used regression analysis to reveal that teachers' TPACK (Technological Pedagogical Content Knowledge) is significantly linked with their efficacy in implementing STEM education. Similarly, Mansour, Said and Abu-Tineh (2024) found that self-efficacy strongly predicted STEM-TPACK competencies among science and mathematics teachers, signaling the importance of confidence in technology-mediated pedagogy. A large-scale systematic review by Joshi (2023) confirmed that professional development interventions, especially those tailored to content areas, consistently enhance teachers' TPACK self-efficacy. However, the review also highlighted that many studies rely on self-report measures and lack contextual depth. While Joshi identified improved self-efficacy linked to argumentation practices and subject-based professional development, limited attention was given to STEM-specific contexts, such as labs, simulations, or engineering projects.

Overall, while the positive relationship between self-efficacy and STEM-TPACK teaching is well-supported, significant gaps remain. Most research is cross-sectional, discipline-specific, and focused on K–12 settings. Few studies investigate self-efficacy in higher education or vocational STEM environments, and validated measures within integrated STEM-TPACK domains are still lacking. To address these gaps, the present study anchors its literature review using a Systematic Rapid Review (SRR) approach. By systematically collating and thematically analysing studies published between 2021 and 2025, this review offers a structured foundation for understanding how self-efficacy influences STEM-TPACK teaching practices among educators. Importantly, it centers on lecturer-focused and higher education contexts, where empirical evidence remains sparse yet urgently needed. This SRR-driven synthesis not only informs the conceptual framing of the study but also identifies priority areas for future empirical investigations, including the development of validated measurement tools and the evaluation of professional development programs aimed at enhancing lecturer self-efficacy in STEM-TPACK integration.

Methodology

The Systematic Rapid Review Approach

This study adopts a Systematic Rapid Review (SRR) to synthesize evidence on STEM-TPACK teaching practices, focusing on professional development, self-efficacy, and attitude among Malaysian polytechnic lecturers. The SRR approach was selected to balance methodological rigor with timeliness, enabling the review to be completed within a shorter timeframe (four to twelve weeks) to inform the study's conceptual framework and subsequent phases (Tricco, Langlois, & Straus, 2017).

Unlike a Conventional Systematic Review (CSR), which typically spans six months to two years with comprehensive searches across multiple databases, dual-reviewer screening, extensive critical appraisal, and meta-analysis (Higgins et al., 2022), the SRR streamlines several steps. This review will focus on a single, high-impact academic database, justified by its comprehensive coverage of STEM education and TPACK-related studies, ensuring efficiency without compromising relevance. Screening will be conducted by a primary reviewer with verification, and a simplified quality appraisal tool will be applied, followed by a narrative and tabular synthesis (Hamel et al., 2021; Khangura et al., 2012). While Systematic

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Literature Reviews (SLR) also use structured methods, they primarily map conceptual literature and are less suited for generating decision-oriented evidence (Tricco et al., 2015).

The SRR will adhere to PRISMA guidelines for transparent reporting of the search strategy, inclusion criteria, study selection, and synthesis (Higgins et al., 2022). Figure 1 provides an overview of the article selection process.

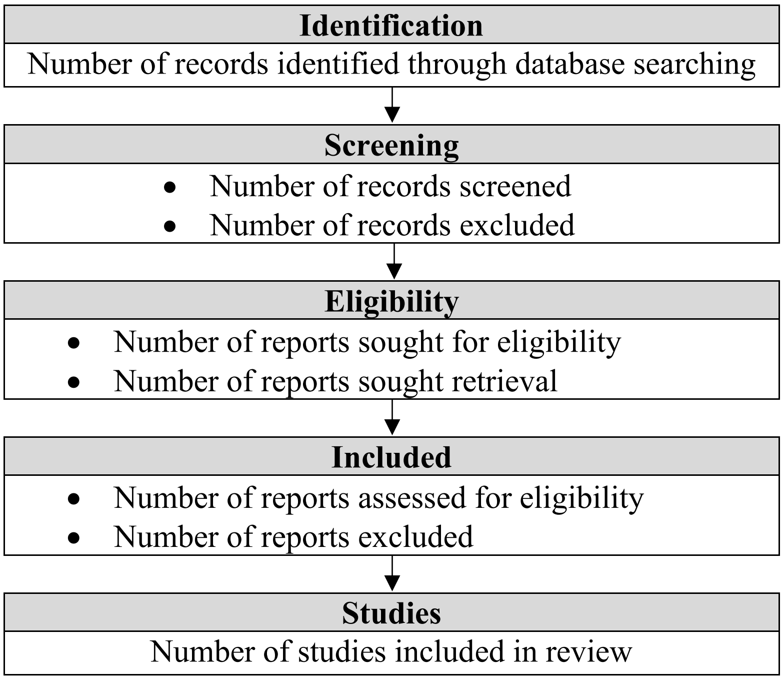

Figure 1: Flow Diagram Of Article Selection

Search Strategies

In this study, a systematic rapid review employed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to promote transparency and consistency in the selection of studies (Page et al., 2021). The final search was conducted on 20 June 2025, and only one electronic database, Scopus, was used because it has a comprehensive indexing of peer-reviewed literature in the fields of education, social sciences, and STEM-related fields. To identify relevant studies, a clearly defined search string was applied:

((("teach*" OR "lectur*" OR "educat*" OR "instruct*") AND "self efficacy" AND "STEM" AND "TPACK")) AND (limit-to (DOCTYPE , "ar")) AND (limit-to (language , "English"))

This search string was crafted to retrieve documents that report on studies that are examining self-efficacy in STEM and TPACK among teachers, lecturers, or instructors. Truncation symbols (e.g., teach*) were used to increase the sensitivity to related terms (such as teaching, teacher, teachers). The search logic was refined using Boolean operators (AND/OR) to enhance the relevance of selected articles. The publication year was limited to 2021-2025, to pick up on recent developments and contemporary attitudes about the issue. To ensure quality and accessibility, only peer-reviewed journal articles in the English language were used.

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Inclusion and Exclusion Criteria

To ensure the relevance and rigor of the included studies, clearly defined inclusion and exclusion criteria were established. These criteria were applied during the screening and selection process as guided by the PRISMA protocol (Page et al., 2021). Table 1 summarises the inclusion and exclusion criteria for article selection.

Table 1: Summarises the Inclusion and Exclusion Criteria for Article Selection

Component	Inclusion Criteria	Exclusion Criteria
Population	Educators at any level (preschool, primary, secondary/K/12, post-secondary), including pre-service and in-service teachers/lecturers in STEM-TPACK teaching.	Non-teaching staff, industry trainers, or facilitators are not involved in formal or classroom-based instruction.
Concept	Studies that measure or qualitatively explore self-efficacy related specifically to STEM-TPACK teaching.	Studies focusing on general self-confidence/self-esteem or program/course success unrelated to teachers' belief in their teaching capability
Context	Formal educational settings (e.g., schools, colleges, universities, technical/vocational institutions); any delivery format (in-person, online, hybrid)	Informal settings (e.g., museums, public STEM outreach) unless directly involving formal teaching responsibilities
Outcome / Focus	Empirical evidence showing a relationship between self-efficacy and STEM-TPACK teaching practices, strategies, instructional design, or student outcomes	Descriptive studies on self-efficacy without linkage to teaching practices or measurable outcomes
Study Design	Empirical studies only: quantitative (e.g., regression, SEM), qualitative (e.g., interviews, observations), or mixed-methods research	Theoretical/conceptual papers, literature reviews, editorials, commentaries, and other non-empirical formats
Publication Type	Peer-reviewed journal articles and full conference papers with complete data and methodology	Abstract only (publications, posters, book chapters, dissertations)
Language	English only	Non-English publications
Time period	2021 to 2025	Articles outside the time period

Result and Discussion

A total of seven records were identified through database searching using Scopus. All seven records proceeded to the screening stage, where no records were excluded based on titles and abstracts. Subsequently, seven full-text reports were sought and successfully retrieved for eligibility assessment. After reviewing the full texts, all seven reports met the eligibility criteria, resulting in seven studies included in the final review. A review of seven peer-reviewed studies revealed consistent evidence supporting the central role of lecturer self-efficacy in facilitating the effective integration of the TPACK framework into STEM teaching practices. These studies, drawn from diverse global contexts including Canada, South Africa, Turkey, Qatar, China, and Thailand, collectively demonstrate that self-efficacy significantly shapes

International Journal of Modern Education
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Volume 7 Issue 26 (September 2025) PP. 797-806
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teachers' technological engagement, pedagogical strategies, and instructional outcomes in STEM education. Table 1 shows articles obtained from Scopus.

Table 2: Articles Obtained from Scopus

Author & Year	Country	Title	Key Findings
DeCoito and Estaiteyeh (2022a)	Canada	Online Teaching During the COVID-19 Pandemic: Exploring Science/STEM Teachers' Curriculum and Assessment Practices in Canada	This research found that gaps were discovered in the TPACK framework and self-efficacy of teachers, and therefore, they affected their curriculum development, pedagogical practices, and assessment. These findings reflect significant challenges in TPACK and self-efficacy during emergency remote teaching.
DeCoito and Estaiteyeh (2022b)	Canada	Transitioning to Online Teaching During the COVID-19 Pandemic: An Exploration of STEM Teachers' Views, Successes, and Challenges	In the study, the researcher found that teachers encountered numerous problems that negatively influenced their attitude and beliefs towards online teaching, and the support provided to them was not proportional to their expectations. It also determined that the experience of the teachers, self-efficacy, and technological competency helped them slightly improve their perceptions of online teaching, but was not adequate to change their mindset. These results reflect the limitations of self-efficacy and TPACK in overcoming systemic and contextual barriers during emergency transitions.
Mangundu (2023)	South Africa	STEM Pre-service Teachers' e-Readiness for Online Multimodal Teaching Methods Usage in Pietermaritzburg, South Africa	It was established that STEM pre-service teachers hold a positive attitude toward multimodal online learning, but at the same time, they do not express confidence in applying multimodal online resources in classroom settings. Additionally, online multimodal teaching experiences had an impact on the attitudes of pre-service teachers, and consequently, on the TPACK self-efficacy of STEM pre-service teachers. The findings highlight the influence of experiential factors on self-efficacy in integrating technology for multimodal teaching.
Yildiz Durak, Atman Uslu,	Turkey	Examining the Predictors of	The study found that science teachers' self-efficacy was related to

International Journal of Modern Education IJMOE
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Volume 7 Issue 26 (September 2025) PP. 797-806
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Canbazoğlu Bilici and Güler (2023)		TPACK for Integrated STEM: Science Teaching Self-Efficacy, Computational Thinking, and Design Thinking	technological pedagogical engineering knowledge (TPEK), T-integrated STEM, and technological pedagogical science knowledge (TPSK). Additionally, it discovered that computational thinking in teaching has a positive effect on self-efficacy, design thinking, and the development of TPMK, TPEK, and TPSK. Moreover, the design thinking skill is connected with TPMK, TPEK, and TPSK structures. These findings highlight the interdependent roles of teaching self-efficacy, computational thinking, and design thinking in predicting TPACK competence in integrated STEM teaching.
Mansour et al. (2024)	Qatar	Factors Impacting Science and Mathematics Teachers' Competencies and Self-Efficacy in TPACK for PBL and STEM	The study found that gender, formal teacher education, and the unique expertise of teachers had a significant impact on TPACK self-efficacy. In contrast, teaching experience and school level did not prove to be significantly different. It also indicated that male teachers have achieved higher scores in technology integration, and that school culture plays a pivotal role, particularly in secondary schools. These findings indicate the role of context-sensitive professional development and support in enhancing self-efficacy in TPACK in PBL and STEM.
Sun, Tian, Sun, Fan and Yang (2024)	China	Pre-service Teachers' Inclination to Integrate AI into STEM Education: Analysis of Influencing Factors	The findings showed that TPACK, self-efficacy, perceived usefulness, and perceived ease of use significantly and directly affect the pre-service STEM teachers' readiness to integrate AI, serving as mediators for the relationship between TPACK and readiness to integrate AI. These results highlight the interactive effects of self-efficacy, technical knowledge, and perceived benefits on STEM teachers' intentions to integrate AI.
Sukma and Pum (2025)	Thailand	BEST: An Instructional Design Model to Empower Graduate Student	The study found that students demonstrated significant improvements in self-efficacy, peer learning, and critical thinking while maintaining

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IJMOE
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Volume 7 Issue 26 (September 2025) PP. 797-806
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	Self-Efficacy in Research Methodology through TPACK Integration	active learning engagement. The BEST model was effective in supporting TPACK integration and enhancing self-efficacy among graduate students in research methodology.

A number of researchers have underlined that self-efficacy is a primary predictor of successful TPACK implementation. For instance, Yildiz Durak et al. (2023) and Sukma and Pum (2025) noted a significant effect of self-efficacy on important ED factors like ID, CT, and TPACK in complex STEM scenarios. These effects were even stronger for self-efficacy when it was paired with design thinking or assisted by structured approaches such as BEST. The research also found that self-efficacy not only acted as a predictor but also as a mediator in technology adoption. Sun et al. (2024) highlighted the importance of self-efficacy in the relationship between TPACK and AI integration, showing how cognitive perceptions (e.g., perceived usefulness and ease of use) interact with TPACK to influence behavioural intent.

The literature also noted that contextual and experiential factors affect self-efficacy, with implications for TPACK effectiveness. Mansour et al. (2024) and Mangundu (2023) found that gender, formal education, and prior teaching experience shaped technological confidence and implementation success. These findings reinforce the importance of targeted professional development and supportive institutional environments for cultivating TPACK competencies. Conversely, studies conducted during the COVID-19 pandemic (DeCoito & Estaiteyeh, 2022a,2022b) revealed that even experienced educators faced challenges in maintaining TPACK integration due to insufficient support and negative experiences with emergency online teaching. These results highlight the limitations of self-efficacy when systemic or resource constraints are present, suggesting that high self-efficacy alone may not guarantee successful STEM-TPACK integration under stress conditions.

This review identifies three dominant themes influencing the relationship between self-efficacy and STEM-TPACK practices: (1) the mediating role of self-efficacy in overcoming contextual and systemic teaching challenges, particularly during online or emergency instruction; (2) the contribution of cognitive and affective factors such as computational thinking, design thinking, and perceived ease of use to TPACK development; as well as (3) the importance of institutional support, professional development, and teacher background variables (e.g., gender, experience) in shaping self-efficacy. Collectively, these themes underscore the dynamic interplay between personal beliefs and contextual enablers in shaping effective STEM-TPACK integration.

Overall, the reviewed studies collectively support the conclusion that lecturer self-efficacy is foundational but not independently sufficient for effective STEM-TPACK implementation. It must be reinforced through practical experience, institutional support, and sustained professional development initiatives to fully realize its potential in advancing STEM education. This rapid review, while methodologically structured, is inherently limited by its scope and time constraints. The streamlined search and screening procedure potentially resulted in the omission of some potentially relevant studies that were not compatible with the direct inclusion criteria or published beyond indexed databases. A limitation of the reviewed literature is that very few studies empirically and directly examined the relationship between lecturer self-efficacy and STEM-TPACK teaching practices. While many studies referenced or incorporated self-efficacy and TPACK individually, causal or correlational analyses explicitly linking the

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two constructs were limited. Furthermore, many studies have focused on pre-service teachers rather than practicing lecturers, thereby reducing the direct applicability to higher education or in-service contexts. Future studies should empirically investigate the causal relationship between lecturer self-efficacy and STEM-TPACK teaching practices using robust quantitative or mixed-methods designs. They should also focus more extensively on in-service lecturers in higher education contexts to bridge the current gap in the literature and discover the longitudinal impact of professional development programs on both self-efficacy and TPACK growth.

Conclusion

This rapid review critically explored the relationship between lecturer self-efficacy and STEM-TPACK teaching practices, addressing the research question and achieving the study's primary objective. The synthesis of current literature confirms that lecturer self-efficacy is a significant determinant of effective technology integration and pedagogical application within STEM education. While self-efficacy consistently influences technology integration and instructional confidence, few studies have directly examined this relationship. Contextual factors, professional development, and experiential learning significantly shape self-efficacy outcomes. However, gaps remain in empirical evidence, especially within higher education settings. Strengthening research in this area is crucial to inform targeted interventions that enhance STEM teaching through the integration of pedagogical and technological competencies.

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