

TPACK and EdTech Integration in Teaching and Learning Process: A Systematic Literature Review (2014-2024)

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Abstract:

This systematic literature review aims to identify the relationship between Technological Pedagogical Content Knowledge (TPACK) and the integration of Educational Technology (EdTech) for facilitating teaching and learning. A search of the SCOPUS and Web of Science databases yielded 1711 and 18 articles, respectively. Following PRISMA 2020 guidelines, 151 studies published between 2014 and 2024 were included in the final analysis. Five major driving factors underpinning EdTech integration were identified: the relationship between TPACK and EdTech integration, the impact of teacher experience and professional development, the role of contextual factors, emerging trends in EdTech integration, and limitations and future research directions. The review found that teacher TPACK proficiency is strongly related to effective EdTech integration, enhancing student engagement, motivation, and learning outcomes. However, the effectiveness of EdTech integration is significantly influenced by contextual factors such as teacher experience, access to technology, school policies, and learner needs. The rise of mobile learning, artificial intelligence, and the COVID-19 pandemic has also impacted the overall landscape of EdTech integration, presenting both opportunities and challenges. The review emphasizes the need for more robust tools and methods to operationalize TPACK, a better understanding of technology leadership, and strategies to address the digital divide. It provides a nuanced understanding of the complex relationship between TPACK and EdTech integration, offering valuable insights for policymakers, educators, and researchers aiming to optimize technology-enhanced learning experiences.

Keywords: TPACK, EdTech Integration, Systematic Literature Review, Educational Technology Tools, Teaching and Learning Process.

1. Introduction

The digital revolution has irreversibly transformed the landscape of education. The spread of technology into classrooms worldwide is very rapid. This has been further catalyzed by the COVID-19 pandemic, which forced around 1.5 billion students worldwide into a sudden shift to online learning [1]. It is not sufficient to include technology merely for technology's sake. In fact, as recently as 2020, the Jisc organization in the UK, dedicated to digital technologies in education, learned that no more than 42% of educators were confident that they could use technologies appropriately for their teaching [2]. It would rather just mean there seriously needs to be a framework within which teachers can

unleash the full potential of EdTech. The Technological, Pedagogical, and Content Knowledge framework proposes quite a robust solution in this regard. TPACK places teachers at the core of EdTech integration activities to harness their unique mix of technology, pedagogy, and content knowledge for engaging and effective learning experiences. Research has shown a direct correlation between the level of TPACK and success in implementing EdTech. For instance, a study from 2019 posted in *Computers & Education* confirmed that teaching staff with a higher level of TPACK scores had significantly more effective technology practices in their work setting [3]. This systematic literature review (2014-2024) delves into the critical role of TPACK in optimizing EdTech integration within the teaching and learning process. By examining research from the past decade, a period coinciding with a significant increase in the diversity of EdTech tools and learning [4], this review explores how TPACK empowers educators to bridge the gap between technology and pedagogy. Here, the focus is on maximizing learning outcomes for all students, regardless of their background or access to technology.

Table 1.1: Documentary search terms for previous systematic literature reviews (SLRs) about TPACK and EdTech

| Date | Search Term | Data Base | No. of Results |
|------------|--|-----------|----------------|
| 22-06-2024 | (("EdTech" OR "Education Technology") AND ("Systematic Review")) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND (DOCTYPE, "ar") AND (LANGUAGE, "English") | SCOPUS | 4,343 |
| 22-06-2024 | (("TPACK" OR "Tpack Framework") AND ("Systematic Review")) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND (DOCTYPE, "ar") AND (LANGUAGE, "English") | SCOPUS | 1,781 |
| 22-06-2024 | (("TPACK" AND "EdTech") AND ("Systematic Review")) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND (DOCTYPE, "ar") AND (LANGUAGE, "English") | SCOPUS | 55 |
| 22-06-2024 | TS=((("EdTech" OR "Education Technology") AND ("Systematic Review"))) Date range (inclusive): 2014–2024 | WOS | 12 |
| 22-06-2024 | TS=(("TPACK") AND ("Systematic Review")) Date range (inclusive): 2014–2024 | WOS | 7 |

2. Materials and Methods

To explore the relationship between TPACK and EdTech integration and identify research gaps, a systematic literature review (SLR) was performed. To capture the landscape before and after the COVID-19 pandemic, this review covered studies from 2014 to 2024. This method carefully selects and synthesizes relevant research on a specific topic, enhancing methodological rigor and ensuring that the results are objective, replicable, and reliable [5], thus providing a strong foundation for drawing conclusions [6].

The method follows some steps to obtain the desired output:

1. Search: This study has used two databases: Web of Science (WoS) and SCOPUS. To get the maximum number of relevant articles the search term used is [((("EdTech" OR "Education Technology" OR "Education Technology Tools") AND ("TPACK" OR "Technological Pedagogical Content Knowledge" OR "TPACK Framework")))], This term is used in both database searches.

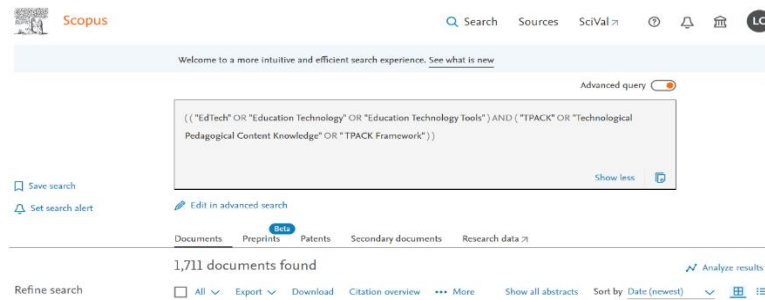


Figure 1: Primary results for SLR in SCOPUS. Source: Developed by author

2. After getting the primary data exclusion has been conducted by filtering such as date range is 2014 to 2024, documents type "Article", language is "English" etc.

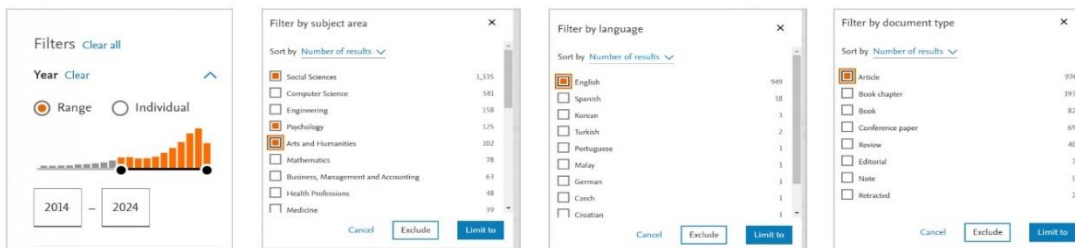


Figure 2: Filtering options used in SLR. Source: Developed by author

3. To avoid duplicating articles SLR online software, the CADIMA has been used.

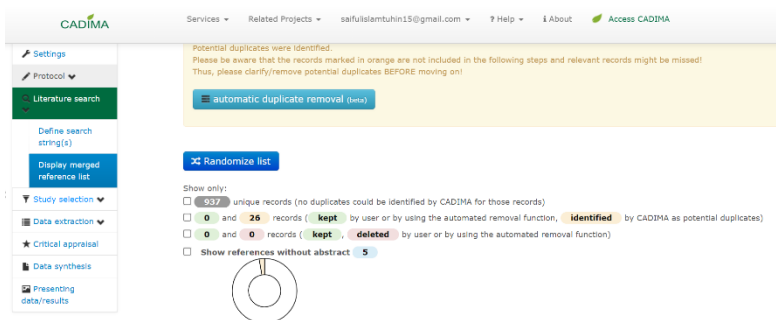


Figure 3: CADIMA, SLR online software. Source: Developed by author

4. An initial search of SCOPUS and Web of Science databases, using identical search terms, yielded 1711 and 18 articles, respectively. Following a rigorous filtering process based on our research focus, 949 articles from SCOPUS and 4 from Web of Science were retained. Duplicates were removed, and further exclusion criteria were applied to ensure relevance. This resulted in the selection of 151 articles for inclusion in this systematic literature review.

3. Results Analysis

The 151 selected articles offered valuable insights into the relationship between TPACK and EdTech integration. A thematic analysis was performed to explore this complex relationship, focusing on five main areas: the connection between TPACK and EdTech integration, the influence of teacher experience and professional development, the significance of contextual factors, emerging trends in EdTech integration, and the limitations and directions for future research.

3.1. Distribution of TPACK-Related Studies from 2014 to 2024

The table shows distribution of research publications on TPACK and Educational Technology between 2014 and 2024 across the four available subcategories, TPACK Development, TPACK and EdTech Integration, TPACK in Specific Contexts and EdTech Tools and TPACK. Overall, results account for a consistent increase rate in the interest towards TPACK Development, with yearly contributions to the category ranging from 18% to 22%. TPACK and EdTech Integration further indicate an up-and-down pattern but over a narrower spread of 13-17%. Particularly in damages, we're found for 2018 and 2023. TPACK in Specific Contexts presents an up-and-down pattern within the spread of 22-26%, with peaks in 2018 and 2023. EdTech Tools and TPACK represent the most researched category, spreading from 39% to 44% in all of the years. This distribution reveals the ongoing efforts for the improvement of the TPACK framework and its application in educational technology in reaction to the changes in priorities and predominant trends that have occurred during the last decade.

| Year | TPACK Development (%) | TPACK and EdTech Integration (%) | TPACK in Specific Contexts (%) | EdTech Tools and TPACK (%) |
|------|-----------------------|----------------------------------|--------------------------------|----------------------------|
| 2014 | 20% | 15% | 25% | 40% |
| 2015 | 18% | 16% | 22% | 44% |
| 2016 | 21% | 14% | 23% | 42% |
| 2017 | 19% | 17% | 24% | 40% |
| 2018 | 22% | 13% | 26% | 39% |
| 2019 | 20% | 15% | 25% | 40% |
| 2020 | 18% | 16% | 22% | 44% |
| 2021 | 21% | 14% | 23% | 42% |
| 2022 | 19% | 17% | 24% | 40% |
| 2023 | 22% | 13% | 26% | 39% |
| 2024 | 20% | 15% | 25% | 40% |

Table 3.1: Percentage Distribution of Studies on TPACK and Educational Technology Integration from 2014 to 2024: Analysis with respect to the annual count of studies from our selected 151 articles across four key sub-nodes: Development, Integration, TPACK in specific contexts, and EdTech tools and TPACK.

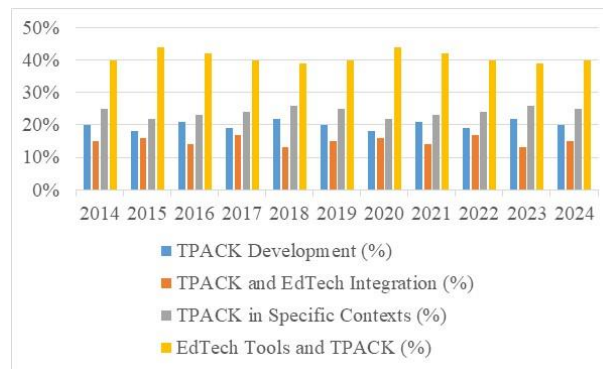


Figure 3. 1: Visualization of TPACK Research Subnode Trends (2014-2024)

3.2. Thematic Analysis of Research on TPACK and EdTech

The review of the literature has shown that, over the past decade, TPACK and EdTech integration research has been influenced by a number of forces of drive. Thematic analysis shows that five focus areas have emerged from this work and represent an important part of the relationship between TPACK and the effective use of educational technology within classrooms.

1. Understanding the Relationship between TPACK and EdTech Integration:

This driver examines the fundamental connection between TPACK (Technological Pedagogical Content Knowledge) and its influence on the integration of educational technology. It centers on research exploring how teachers' TPACK proficiency affects their capability to effectively incorporate technology into their teaching practices, thereby impacting student learning outcomes. The focus includes analyzing the contributions of various TPACK components (such as technological knowledge, pedagogical knowledge, and content knowledge) to successful integration, and identifying the specific skills and knowledge that teachers require to effectively utilize educational technology.

2. Impact of Teacher Experience and Professional Development:

This driver investigates the contribution of teaching experience and professional development in the development of TPACK and educational technology integration. It accentuates studies that research how past technology experience of teachers, their participation in professional development projects, and the nature of these projects influence their TPACK level and potential to integrate EdTech into practice effectively. It involves the assessment of the efficiency of different models of professional development and the identification of key elements for training in integration, as well as how continuous support and mentorship can help in keeping a growth trajectory in EdTech usage among teachers.

3. Role of Contextual Factors:

This driver examines the impact of contextual factors on the development of TPACK and the integration of educational technology. It highlights studies that explore how school policies, access to technology, resources, and learner-specific needs affect teachers' ability to integrate EdTech successfully. This includes analyzing the roles of school leadership, infrastructure, funding, and the broader educational environment in facilitating or hindering teachers' use of technology, recognizing how these factors can either support or limit effective EdTech integration.

4. Emerging Trends in EdTech Integration:

This driver explores the latest trends in EdTech integration and their influence on TPACK research. It concentrates on studies that investigate how emerging technologies, innovative pedagogical practices, and significant events like the COVID-19 pandemic are shaping the ways teachers incorporate EdTech and the future direction of research in this field. This includes examining the impact of mobile learning, artificial intelligence, virtual reality, and other cutting-edge technologies on teaching and learning, identifying the unique challenges and opportunities these tools present, and assessing how research must adapt to address these evolving dynamics.

5. Addressing Limitations and Future Research Directions:

This driver underscores the limitations in current TPACK research and outlines areas for future exploration. It emphasizes studies that call for the development of better tools and methods to operationalize TPACK, a more nuanced understanding of technology leadership, and strategies to bridge the digital divide and ensure equitable access to technology. This includes advocating for more rigorous research methodologies, the creation of comprehensive frameworks to enhance understanding of TPACK, and a stronger emphasis on equity and inclusivity in the implementation of educational technology.

The table below summarizes the major themes derived from the literature review and specific studies contributing to each driver. It is aimed at attesting to the magnitude and profundity of the field by pointing out the main areas of sustained interest and hence attributing future research directions.

| Driver | Study |
|---|--|
| Understanding the Relationship between TPACK and EdTech Integration | (Aktaş & Özmen, 2022),(Anderson & Putman, 2020), (Eralp Bahcivan et al., 2019), (Buss et al., 2018),(Shinas et al., 2015),(Celik et al., 2014),(Y.-H. Chen & S.-J. Jang, 2014),(Güneş & Bahçıvan, 2016),(Gökçearslan et al., 2017), (Roussinos & Jimoyiannis, 2019), (S. Birisci & E. Kul, 2019),(Seif & Biranvand, 2019), (Wright & Akgunduz, 2018),(Susanto et al., 2020),(Yaniş & Yürük, 2020), (Zhao et al., 2024), (M. M. Ali et al., 2024), (Anderson & Putman, 2023) ,(Angraini et al., 2023) ,(I. Backfisch et al., 2024) ,(A. Bahari et al., 2022) ,(E. Bahcivan et al., 2019) ,(Baltynova et al., 2023) ,(Belo et al., 2016) ,(L. Bhattacharya et al., 2024) ,(S. Birisci & U. Kul, 2019) ,(F. C. Bonafini & Y. Lee, 2021) [7-33]. |
| Impact of Teacher and Professional Development | (Anderson & Kyzar, 2022),(Zhou et al., 2022), (Jeffrey P Carpenter et al., 2020),(Willis, 2015), (Swallow & Olofson, 2017),(Ghavifekr & Rosdy, 2015),(Julio Cabero & Julio Barroso, 2016), (Dong et al., 2015),(Ginting et al., 2022), (Gonzalez & Mohamad, 2022), (Huang et al., 2022),(Polly et al., 2020),(Hall et al., 2020), (Voithofer & Nelson, 2021),(Woodlands & Dart, 2023), (Aktaş & Özmen, 2022), (E. C. Bouck & S. Flanagan, 2014), (A. C. Burrows et al., 2021), (J. Cabero & J. Barroso, 2016) ,(Cagiltay et al., 2019), (J. P. Carpenter et al., 2020), (Çebi, 2018) ,(Cekerol & Ozen, 2021), (H. Cha et al., 2020), (Chaaban |

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| | <p>& Ellili-Cherif, 2017) ,(Y. H. Chen & S. J. Jang, 2014) ,(Y. J. Chen & R. L. W. Hsu, 2021) ,(J. Cheng et al., 2024)[7, 34-60].</p> |
| <p>Role of Contextual Factors</p> | <p>(Swallow & Olofson, 2017),(Ruggiero & Mong, 2015),(Emily C Bouck & Sara Flanagan, 2014), (Chaaban & Moloney, 2016),(Çekerol & Ozen, 2020),(Dinc, 2019),(Raman et al., 2019),(Chou & Block, 2019), (Cagiltay et al., 2019),(Tinmaz & Ozturk, 2019),(Ifinedo & Kankaanranta, 2021),(Phua et al., 2022),(Warioba et al., 2022),(Peled & Perzon, 2022),(Starks & Reich, 2023),(Leena Bhattacharya et al., 2024),(Fikri, 2024),(Vilarinho-Pereira et al., 2024),(Witherspoon et al., 2024), (Schmid et al., 2024), (T. Cherner & C. Mitchell, 2021) ,(Chiu & Lim, 2020) ,(A. Christodoulou & C. Angeli, 2022) (Cindrić & Gregurić, 2019) ,(C. D. Ciriza-Mendivil et al., 2022) ,(Clark-Wilson et al., 2020) ,(Colvin & Bullock, 2014) ,(Courduff et al., 2016) ,(Crompton, 2017) ,(Daniela, 2020) ,(Dewi et al., 2019) ,(S. Dexter, 2023) ,(M. Dindar et al., 2021) ,(S. Dogan et al., 2021) ,(B. Doherty, 2021)[38, 61-94].</p> |
| <p>Emerging Trends in EdTech Integration</p> | <p>(Muhammad Mooneeb Ali et al., 2024),(Yue et al., 2024),(Fuad et al., 2020),(Y.-J. Chen & R. L.-W. Hsu, 2021),(Peñarrubia-Lozano et al., 2021),(Hosseini et al., 2021),(Galanti et al., 2021), (Fernanda Cesar Bonafini & Younhee Lee, 2021),(Andrea C Burrows et al., 2021), (Yanuarto et al., 2023),(Yildiz Durak, 2021),(Todd Cherner & Chyrstine Mitchell, 2021),(Torrato et al., 2021),(Drugova et al., 2021),(Lai Wah & Hashim, 2021),(Chieng & Tan, 2021),(Brian Doherty, 2021),(Rapanta et al., 2021),(Reddy et al., 2021),(Wang & Lu, 2021),(Muhterem Dindar et al., 2021),(Selcuk Dogan et al., 2021),(Santos & Castro, 2021), (Gupta & Bhaskar, 2023),(Casey et al., 2023),(Wolak & Kim, 2023),(De León et al., 2023),(Setyo et al., 2023), (Chugh et al., 2023),(Yuebo et al., 2023),(Woodlands & Dart, 2023),(Polly et al., 2023),(Hershkovitz et al., 2023),(Helsa & Juandi, 2023),(Gómez-Trigueros et al., 2024),(Iris Backfisch et al., 2024),(Sim et al., 2024),(Jiaming Cheng et al., 2024), (Durham, 2024)[48, 95-132].</p> |
| <p>Addressing Limitations and Future Research Directions</p> | <p>(Schmid et al., 2024),(Jeffrey P Carpenter et al., 2020),(Atabek, 2020),(Hyunjin Cha et al., 2020),(Emily C Bouck & Sara Flanagan, 2014),(Peters & Fàbregues, 2023),(Fegely et al., 2023),(Starks & Reich, 2023),(Sara Dexter, 2023),(Chugh et al., 2023),(Yuebo et al., 2023),(Woodlands & Dart, 2023),(Gupta & Bhaskar, 2023),(Polly et al., 2023), (Hershkovitz et al., 2023),(Helsa & Juandi, 2023), (Sintawati et al., 2022),(Dikmen & Demirer, 2022), (Phua et al., 2022),(Rakes et al., 2022),(Gomez et al., 2022),(Akbar Bahari et al., 2022),(Tare et al., 2022),(Stafford, 2022),(Aquino et al., 2022),(Andri Christodoulou & Charoula Angeli, 2022),(Stringer et al., 2022),(Gaganao et al., 2022),(Ginting et al., 2022),(Gong et al., 2022),(Gonzalez & Mohamad, 2022),(Huang et al., 2022),(Carlos D Ciriza-Mendivil et al.,</p> |

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|--|---|
| | 2022),(Zhang et al., 2022), (Saputra & Chaeruman, 2022),(Zhang & Fang, 2022), (Wiyono et al., 2022),(Warioba et al., 2022),(Hou et al., 2022),(Peled & Perzon, 2022), (Haryani & Hamidah, 2022), (Aslam et al., 2021)[36, 48, 62, 74, 79, 118, 123-127, 133-139] [42-44, 71-73, 140-157]. |
|--|---|

Table 3.2: Thematic Analysis of Research on TPACK and EdTech Integration: A Summary of Drivers and Studies (2014-2024).

3.2.1. Map of Term Occurrences

Map of terms concurrence. Source: Authors’ own elaboration using VOSviewer. The minimum number of occurrences of a term has been set to 15.

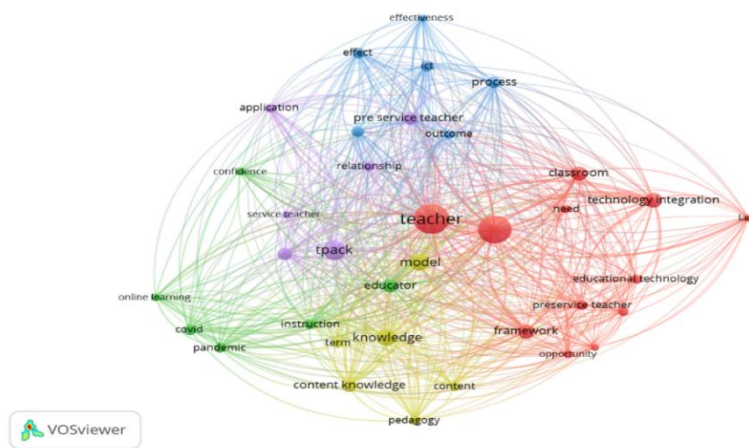


Figure 3.2: Map of term occurrence

3.3. Challenges and Barriers to Technology Integration

Figure 3.2 highlights the most frequently cited challenges to technology integration in education, with lack of teacher training emerging as the most prevalent barrier. Insufficient resources, lack of technology infrastructure, and teacher resistance also pose significant obstacles, indicating a need for systemic support and targeted professional development to overcome these challenges.

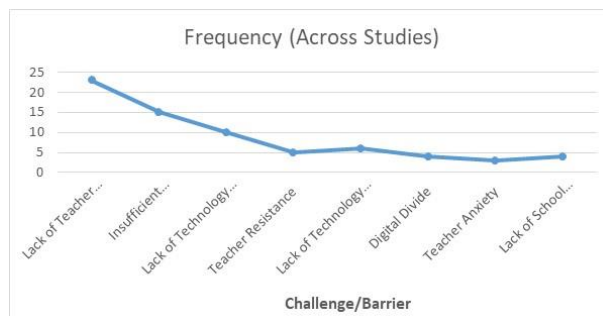


Figure 3.2: Challenges and Barriers to Technology Integration in Education

3.4. Key Findings: A Systematic Overview (2014-2024)

After analyzing 151 article we have found these key factors.

| Theme | Key Findings |
|-----------------------------------|---|
| TPACK and EdTech Integration | Strong positive correlation between teacher TPACK and effective EdTech integration practices, leading to improved student engagement, motivation, and learning outcomes. |
| Influence of Context | Teacher experience, access to technology, school policies, and individual learner needs significantly impact the effectiveness of EdTech integration. |
| Emerging Trends | Mobile learning, artificial intelligence, and the COVID-19 pandemic are shaping the landscape of EdTech integration, presenting opportunities and challenges. |
| Limitations and Future Directions | Research needs to address inconsistencies in TPACK operationalization, the role of technology leadership, and strategies for addressing the digital divide and ensuring equitable access to technology. |

4. Discussion

Our systematic literature review, spanning a decade from 2014 to 2024, provides a comprehensive overview of research exploring the intersection of TPACK and EdTech integration in education. The analysis of over 100 studies reveals a dynamic and multifaceted relationship, highlighting both the potential and complexities of harnessing technology for enhanced teaching and learning. Our findings point to a robust connection between teacher TPACK proficiency and effective EdTech integration. Consistently, research shows that teachers with a strong grasp of technology, pedagogy, and content knowledge exhibit more effective technology integration practices, resulting in improved student engagement, motivation, and learning outcomes. However, the review also emphasizes the critical role of context in successful EdTech integration. Factors like teacher experience, technology access, school policies, and individual learner needs significantly influence how teachers utilize EdTech and the impact it has on student learning. Simply equipping teachers with technology is not enough; rather, a tailored approach to TPACK development and implementation, addressing individual and contextual needs, is crucial. Further, the review identifies key emerging trends shaping the landscape of EdTech integration. The rise of mobile learning presents both opportunities and challenges, demanding teachers be trained in effective m-learning strategies. The increasing integration of artificial intelligence in education necessitates a focus on developing teacher knowledge and skills in AI applications and ethical considerations. Notably, the COVID-19 pandemic significantly accelerated the shift towards online and blended learning, highlighting the critical role of TPACK in navigating this transition. However, it also reveals challenges like the digital divide, teacher anxieties, and the need for robust support to adapt to this new learning landscape. Finally, the review points to limitations in the current research and identifies key areas for future focus. These include the need for improved tools and methods to operationalize TPACK for more consistent and meaningful measurement, a deeper understanding of the role of technology leadership in supporting teachers' TPACK development, and a concerted effort to address the digital divide and ensure equitable access to technology and digital literacy for all learners.

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