REVIEW

Innovative Strategies for TPACK Development in Pre-Service English Teacher Education in the 21st Century: A Systematic Review

Ling Ye [1,2] ⓘ , *Hanita Hanim Ismail [1*]* ⓘ , *Azlina Abdul Aziz [1]* ⓘ

[1] *Faculty of Education, Universiti Kebangsaan Malaysia, Bangi 43600, Malaysia*

[2] *School of Foreign Languages, Hubei Engineering University, Xiaogan 432000, China*

ABSTRACT

In today's rapidly evolving educational landscape, integrating technology into language instruction is crucial for preparing pre-service English teachers to meet 21st-century learning demands. This systematic review explores the development of Technological Pedagogical Content Knowledge (TPACK) in pre-service English teacher education, emphasizing its role in enhancing teaching competence and promoting sustainable practices. Following PRISMA guidelines, studies were sourced from five major databases: Web of Science, Scopus, ERIC, ScienceDirect, and ProQuest, covering literature published from 2015 to 2024. The screening process involved predefined inclusion and exclusion criteria, including timeline, literature type, peer review, and language. After comprehensive screening, 27 empirical studies were included in the meta-analysis and thematically analyzed using NVivo 12 software. The review evaluates traditional and emerging TPACK development methods, focusing on instructional design frameworks like the ADDIE model and advanced digital tools. Findings highlight the increasing significance of AI-driven technologies and digital tools for content creation, learning management, and collaboration, essential components of modern learning environments. Nonetheless, challenges persist, including limited technical skills, resource shortages, and inadequate training. The study also acknowledges limitations related to the time frame, literature type, language restrictions, and database choices, which may affect generalizability. The review advocates for focused professional development and stronger integration of emerging technologies, particularly AI. It suggests creating tailored theoretical models for pre-service English teachers to align TPACK with global educational standards. Future research should examine how these technologies can enhance TPACK integration in teacher education

CORRESPONDING AUTHOR:

Hanita Hanim Ismail, Faculty of Education, Universiti Kebangsaan Malaysia, Bangi 43600, Malaysia; Email: hanitahanim@ukm.edu.my

programs, supporting the development of 21st-century learning in a digital landscape.

Keywords: Technological Pedagogical Content Knowledge (TPACK); Pre-Service English Teacher Education; Professional Development; 21st-Century Learning; Systematic Review

1. Introduction

1.1. TPACK and Pre-Service English Teacher Education

As globalization advances and English becomes the global lingua franca, the demand for qualified English teachers is growing. English teachers in the 21st century must adopt sound educational philosophies and continuously refine their instructional methods to meet modern educational demands[1, 2]. Enhancing the quality of English language teacher education is essential to improving the overall standard of the profession, beginning with strong pre-service English teacher education programs. These programs are critical for equipping prospective teachers with the knowledge, skills, and pedagogical approaches necessary to teach English in diverse educational settings. English teachers today need to develop a comprehensive understanding of both traditional and modern technologies to facilitate learning and improve outcomes.

In recent years, rapid advancements in information and communication technology, particularly Generative AI (GenAI), have sparked intense debate and profoundly influenced educational transformation[3–5]. The 2030 Agenda for Sustainable Development and Sustainable Development Goals (SDGs) recognize the potential of ICTs to bridge the digital divide and foster inclusive knowledge societies[6]. Researches highlight that teachers' competencies are crucial for student learning outcomes[7–9]. However, existing research often fails to provide practical strategies for applying TPACK in real classroom settings, which poses a challenge for pre-service teachers. Consequently, educators must stay updated with emerging technologies and pedagogical methods to create enriched learning environments that meet diverse student needs. Sustainable professional development is essential for teachers to effectively integrate these new tools and approaches.

The TPACK model, proposed by Mishra and Koehler[10], comprises three core elements: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK), along with four composite elements formed by their intersections: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and TPACK itself[10, 11]. It evolved from Shulman's concept of Pedagogical Content Knowledge (PCK).[12] have expressed concerns about how language teachers convey linguistic knowledge using appropriate technology and pedagogy as technology becomes increasingly integrated into language instruction. This highlights a gap in empirical evidence supporting effective TPACK training tailored for language instruction, limiting the applicability of the framework. Recognized as the most effective model for evaluating teachers' proficiency in technology integration[13], TPACK is technology-agnostic, emphasizing the harmonious integration of tools with pedagogy and content rather than focusing on specific technologies[14]. This adaptability ensures that TPACK remains relevant despite the emergence of AI technologies.

However, the growing integration of AI in education raises concerns about the TPACK framework's ability to address evolving teaching needs[15, 16].[14] propose a broader definition of Contextual Knowledge (XK) that includes generative AI's impact on individuals, society, and education. The revised 2019 TPACK diagram features an outer circle labeled "Contextual Knowledge," highlighting the need to understand the broader educational context (see **Figure 1**). This revision enhances the framework's applicability, positioning teachers as intrapreneurs who navigate their environments to foster sustainable educational change[17]. Moreover, the integration of AI technologies complicates the TPACK framework, necessitating a more nuanced understanding of its components and their applicability to modern teaching challenges.
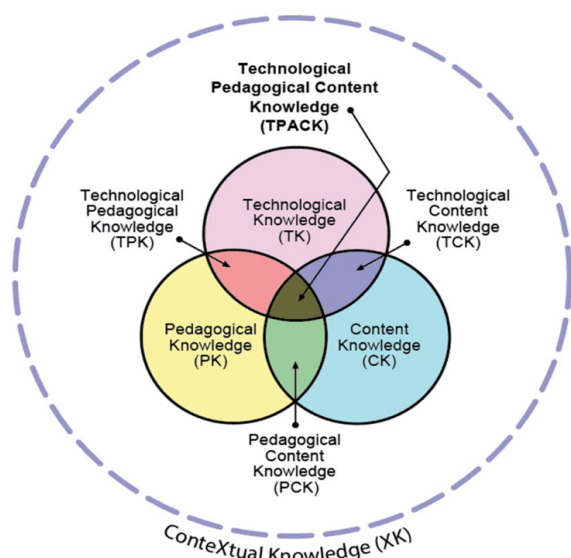
Figure 1. The canonical TPACK diagram [18].

In the 21st century, it is crucial for pre-service teachers to recognize the importance of integrating ICT into their teaching practices and to be well-prepared for this integration. The TPACK model provides a robust structure for cultivating digital competence in pre-service teachers, both during their initial education and throughout their careers [19]. It has become a key component of teacher education and professional development programs, offering a systematic approach to effectively incorporating technology into teaching [20]. Teacher preparation programs play a vital role in shaping future educators' knowledge, attitudes, and confidence in using technology in the classroom [21, 22]. Research in this area is supported by an active international community of scholars and practitioners across various content areas, including mathematics, science, social studies, music, and physical education [23–26]. Yet, there remains a scarcity of research focused on domain-specific TPACK, particularly in the context of English language teacher education.

Developing TPACK is essential for effectively integrating technology into their instructional practices [27]. However, research [12] has shown that relatively few studies focus on domain-specific TPACK, particularly in language teaching. There is limited knowledge about the findings of TPACK research related to language teacher education over the past decade. The existing studies mainly explore pre-service English teachers' perceptions of TPACK [28, 29], TPACK assessment [30, 31], TPACK application [32, 33] and TPACK development [34, 35].

Some studies highlight effective interventions for developing TPACK, such as using Facebook in a TEFL program [34], implementing technology-based instruction in microteaching courses [35], and integrating corpus-based language pedagogy in TESOL training [36]. Despite these efforts, developing TPACK for sustainable pre-service English teacher education remains challenging due to the rapid emergence of new technologies. The studies exhibit several limitations that may affect their overall findings. Firstly, reliance on self-reported data introduces potential bias, skewing results. Additionally, trainers' limited experience with specific educational tools may compromise training quality for pre-service teachers. Moreover, conducting research at a single institution restricts the generalizability of results, while focusing on specific stages of pedagogical reasoning limits a comprehensive understanding of TPACK development. Together, these factors indicate that the findings may not fully capture the diverse experiences of pre-service English teacher education. Furthermore, as an emerging technology, AI hasn't been covered in the previous TPACK development programs. Consequently, addressing these gaps is crucial for advancing TPACK research and enhancing its integration into teacher education programs.

1.2. Aim of This Systematic Review

A comprehensive systematic review of a specific topic can reveal key trends within a field [37]. In this context, the present study aims to conduct an in-depth examination of empirical studies on innovative strategies for TPACK development in pre-service English teacher education in the 21st century. It focuses on the methods employed for TPACK development, the tools utilized, and the challenges encountered by pre-service English teachers. Specifically, the study aims to answer the following questions:

1) What are the methods employed to develop TPACK in pre-service English teacher education?
2) What are the tools utilized to develop TPACK in pre-service English teacher education?
3) What challenges do pre-service English teachers encounter in TPACK development?

This systematic review seeks to identify existing research gaps and provide actionable recommendations to advance TPACK development within the dynamic landscape of pre-service English teacher education. The broader impact

extends to advancing the UN's Sustainable Development Goals, particularly quality education (SDG 4) and reduced inequalities (SDG 10), by promoting the digital competencies of future educators and fostering more inclusive and effective learning environments.

2. Materials and Methods

Systematic reviews provide an overview of the literature, suggest areas for future research, address topics outside the scope of individual studies, highlight problems in primary research, and develop or assess hypotheses. They offer insightful information to researchers, policymakers, and other stakeholders [37].

This systematic review adheres to the guidelines outlined in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. The PRISMA framework, which was first presented by Moher et al. [38] and modified by Page et al. [39], offers a thorough structure for choosing, evaluating, and summarizing studies. It consists of three stages: identification, screening, and inclusion. The purpose of the 27-item PRISMA checklist is to increase systematic reviews' uniformity and transparency. In order to enhance the review's value for fellow scholars, **Figure 2** illustrates the meticulous process of locating and incorporating papers. The PRISMA framework's application in this study is explained in the parts that follow.
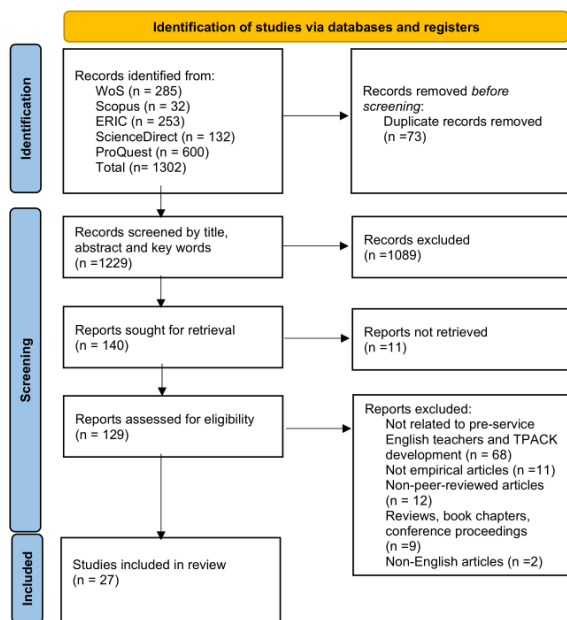

Figure 2. PRISMA diagram.

2.1. Identification

In the identification phase, several well-regarded academic databases were utilized to ensure comprehensive coverage of relevant literature. The databases selected for this study included Web of Science (WoS), Scopus, Education Resources Information Center (ERIC), ScienceDirect, and ProQuest. These databases were chosen because they are widely recognized for their extensive and high-quality collections of articles in various disciplines, including the use of technology in education, which is highly relevant to the review questions [40].

To identify relevant articles, a combination of specific keywords and their variations was utilized. The primary keywords selected for this study included TPACK, pre-service teachers, and English. These keywords were chosen due to their frequent appearance in previous studies, recommendations from subject matter experts, and suggestions from online thesauruses. The search targeted articles published between 2015 and 2024 to capture recent advancements and trends, ensuring the review remains up-to-date and relevant.

The search strategy employed Boolean operators (AND, OR), phrase searching, and truncation to both refine and broaden the search results. In line with the research questions, combinations such as ("Technological Pedagogical Content Knowledge" OR TPACK OR TPCK) AND ("trainee teachers" OR "pre-service teachers" OR "student teachers" OR "initial teachers" OR "teacher candidates" OR "prospective teachers" OR "novice teachers") AND (English) were used to ensure comprehensive coverage. The detailed search strings are provided in **Table 1**. By this end, a total of 1302 articles were retrieved from the above five databases. Zotero software was used to manage the identified references, facilitating their organization, screening, and analysis.

2.2. Screening

After eliminating duplicates (n = 72) from the initial dataset (n = 1301), the remaining articles (n = 1229) underwent further screening based on their titles, abstracts, and keywords, resulting in the exclusion of 1089 irrelevant papers. This left 140 articles, of which 11 were not available in full-text. Subsequently, the remaining articles were assessed against specific inclusion and exclusion criteria (refer to **Table 2**). The exclusion criteria filtered out records that

Table 1. Search strings used in the systematic review process.

Database	Search String
WoS	TS = ("Technological Pedagogical Content Knowledge" OR TPACK OR TPCK) AND ("trainee teachers" OR "pre-service teachers" OR "student teachers" OR "initial teachers" OR "teacher candidates" OR "prospective teachers" OR "novice teachers") AND (English)
Scopus	TITLE-ABS-KEY ("Technological Pedagogical Content Knowledge" OR track OR TPCK) AND ("trainee teachers" OR "pre-service teachers" OR "student teachers" OR "initial teachers" OR "teacher candidates" OR "prospective teachers" OR "novice teachers") AND (English)
ERIC	("Technological Pedagogical Content Knowledge" OR TPACK OR TPCK) AND ("trainee teachers" OR "pre-service teachers" OR "student teachers" OR "initial teachers" OR "teacher candidates" OR "prospective teachers" OR "novice teachers") AND (English)
ScienceDirect	("Technological Pedagogical Content Knowledge" OR TPACK OR TPCK) AND ("trainee teachers" OR "pre-service teachers" OR "student teachers" OR "teacher candidates" OR "prospective teachers") AND (English)
ProQuest	("Technological Pedagogical Content Knowledge" OR TPACK OR TPCK) AND ("trainee teachers" OR "pre-service teachers" OR "student teachers" OR "initial teachers" OR "teacher candidates" OR "prospective teachers" OR "novice teachers") AND (English)

were unrelated to pre-service English teachers and TPACK development (n = 68), non-empirical studies (n = 11), non-peer-reviewed articles (n = 12), reviews, book chapters, conference proceedings (n = 9), and non-English articles (n = 2) using the advanced search features of each database.

The criteria for inclusion and exclusion in this systematic review were carefully crafted to ensure the selection of high-quality, pertinent studies. Studies released prior to 2015 were eliminated in order to preserve the review's applicability, while studies released between 2015 and 2024 were thought to capture current advancements and trends. Studies not directly relevant to this topic were eliminated; instead, research concentrating on the TPACK development of pre-service English teachers was included, guaranteeing consistency with the study goals. To exclude theoretical or anecdotal information, reviews, book chapters, and conference proceedings were omitted. Only empirical research giving unique data were accepted to give tangible proof. To ensure the quality of the included studies, only peer-reviewed articles were considered, excluding non-peer-reviewed articles. Lastly, to prevent language barriers from affecting the review, only studies published in English were included, with non-English articles being excluded.

This rigorous selection procedure improved the systematic review's validity and reliability by guaranteeing that the included studies were current, directly related to pre-service English teachers' TPACK development, methodologically sound, and easily available.

2.3. Included

Following a thorough screening process, including full-text review, 27 articles met the inclusion criteria and were identified as valuable for addressing the research questions of this study. To enable a thorough answer to the research questions in this systematic review, these papers went through in-depth analysis and coding to extract relevant data.

2.4. Data Analysis and Coding

The selected articles were analyzed thematically using NVivo 12 software. Thematic analysis is designed to identify, analyze, and report patterns or themes within qualitative data. Its adaptability makes it suitable for various research questions and disciplines[41]. For this study, a thematic synthesis approach was applied, involving the coding of data according to themes pertinent to the research questions. Coding is the process of systematically organizing data by dividing it into segments and assigning labels to represent distinct categories. This includes categorizing sentences, paragraphs, or images to facilitate analysis[42]. The coding scheme is explicitly demontrated in **Appendix A**. Several measures were implemented to ensure the reliability and validity of the thematic analysis. Two authors took part in the initial coding to maintain consistency. Inter-coder reliability was assessed by comparing the assigned codes, achieving an agreement rate of 0.87, which is satisfactory for qualitative research[43]. Any differences were addressed through discussion, leading to

Table 2. Inclusion and exclusion criteria.

Criteria	Inclusion	Exclusion
Timeline	2015–2024	Before 2015
Scope	Related to pre-service English teachers and TPACK development	Not related to pre-service English teachers and TPACK development
Literature type	Empirical study	Reviews, book chapters conference proceedings
Peer-review	Peer-reviewed articles	Non-peer-reviewed articles
Language	English	Non-English

adjustments in the coding framework. The identified themes were further reviewed to confirm their alignment with the research questions, reinforcing the validity of the findings.

2.5. Limitations of the Method

This systematic review employed the PRISMA methodology to comprehensively assess the literature on TPACK development, yet several limitations must be noted. The exclusion of non-peer-reviewed sources, book chapters, and articles in languages other than English may have led to the omission of critical insights pertinent to TPACK development. Moreover, focusing exclusively on studies published from 2015 to 2024 may limit the analysis to recent trends, potentially disregarding foundational research that could enhance understanding of current practices. To gain a more comprehensive perspective on TPACK development in pre-service English teacher education, future research should broaden the scope to include a wider array of literature, such as gray literature and studies in multiple languages.

3. Results

The thematic synthesis uncovered key patterns and trends in TPACK development within pre-service English teacher education. Based on the coding scheme and thematic analysis, three main categories were generated in alignment with the research questions: methods, tools, and challenges. Within these categories, seven themes and twenty-four sub-themes emerged. First, the overview of the reviewed literature will be illustrated. Then, the findings will focus on a detailed examination of methods, tools, and challenges associated with TPACK development in pre-service English teacher education.

3.1. Overview of the Included Literature

Through a comprehensive and transparent selection process followed by the PRISMA guidelines, a total of 27 studies were identified and included in the final analysis. These studies were published between 2015 and 2024. The subsequent section presents an overview of these studies, focusing on the distribution of publications by year and regions where the research was conducted and the research designs employed in the review articles.

3.1.1. Distribution of Articles Based on Time

Figure 3 illustrates publication trends in TPACK development research within pre-service English teacher education from 2015 to 2024. The data indicate minimal activity in the early years, with only one article published in 2015 and a slight increase to three articles in 2016, suggesting a growing interest in the field. While the number of publications fluctuated in subsequent years, a notable rise is observed in 2022 and 2023, each yielding five empirical studies—the highest totals of the decade. This increase likely correlates with rapid advancements in educational technology, which have opened new avenues for applying the TPACK framework in pre-service English teacher education.
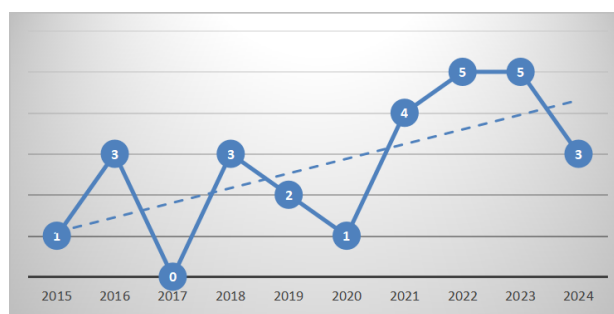
Figure 3. Distribution of articles by year.

It is essential to note that the data for 2024 reflects only three articles as of September 1, potentially underrepresenting the year's output. Nevertheless, these publications contribute significantly to ongoing research. Overall, the findings indicate a clear upward trend in TPACK-related research over the past decade, highlighting the increasing emphasis on integrating subject-specific TPACK frameworks into teacher education programs to enhance the technological, pedagogical, and content knowledge of future English educators.

3.1.2. Distribution of Articles Based on Region

Figure 4 presents the geographic distribution of TPACK development research in pre-service English teacher education, showcasing a variety of contributing regions. Turkey leads with eight articles, followed by Indonesia with four. Taiwan and Spain each contribute three articles. Hong Kong and Thailand each have two articles, while mainland China, Malaysia, Egypt, the U.S., and Germany contribute one each.
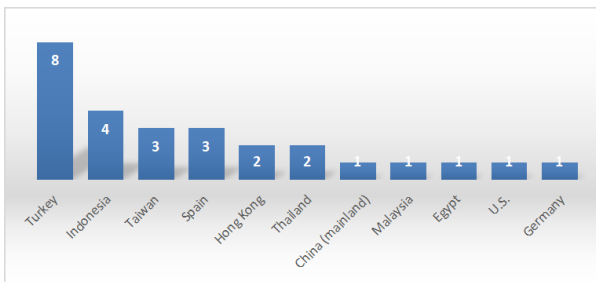

Figure 4. Distribution of articles by region.

The data reveal a significant focus on TPACK development in Asian regions, particularly in Turkey, Indonesia, Taiwan, Hong Kong, Thailand, mainland China, and Malaysia. This regional emphasis reflects a strong interest in integrating TPACK frameworks into English teacher education. Although contributions from North America, Europe, and Africa are less frequent, they signal an emerging international engagement with TPACK. Overall, this analysis highlights a global shift towards recognizing TPACK's importance in pre-service English teacher education, particularly driven by advancements in educational technology.

3.1.3. Distribution of Articles Based on Research Designs

A successful research outcome hinges on selecting an appropriate research design, which guides data collection and the achievement of research objectives[44]. Creswell & Creswell[42] categorizes research designs into three types: quantitative, qualitative, and mixed-methods. As shown in **Figure 5**, mixed-methods research comprises the largest proportion at 52%, followed by qualitative methods at 37%, with quantitative methods making up only 11%.
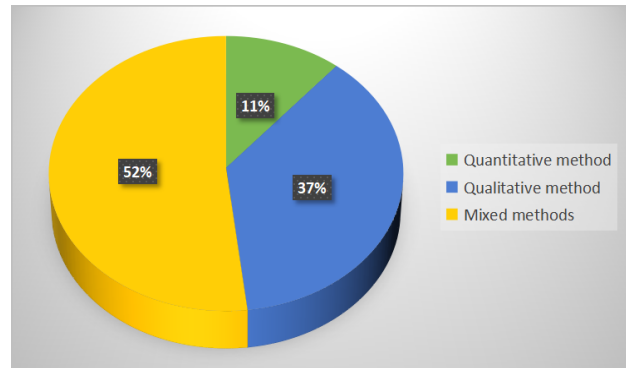

Figure 5. Distribution of research design.

Only three studies employed quantitative methods, including one survey-based design and two quasi-experimental designs. Conversely, ten studies utilized qualitative methods to explore TPACK development through various data collection techniques, such as interviews, lesson designs, recorded teaching videos, reflection journals, class observations, group discussions, and curriculum documents. Furthermore, fourteen studies utilized mixed-methods designs, leveraging the strengths of both qualitative and quantitative approaches for a more nuanced analysis.

This review indicates a diverse range of research designs employed in studying TPACK development, with mixed methods being the most prevalent. This approach allows for a more comprehensive understanding of TPACK by integrating qualitative and quantitative data[45].

3.2. Methods Employed to Develop TPACK in Pre-Service English Teacher Education

In response to RQ 1, the methods employed to develop TPACK can be categorized into two main themes: TPACK development strategies and TPACK development models. The subsequent section will delve into both themes in detail, offering a comprehensive overview of the various methods employed in this area.

3.2.1. TPACK Development Strategies

The strategies employed to develop TPACK in pre-service English teacher education in this review can be divided into six sub-themes as shown in **Figure 6**: Instructional design projects (n = 15), TPACK-based modules (n = 4), AR-based projects (n = 2), Corpus-based projects (n = 2), Digital storytelling projects (n = 2), and social media-based projects (n = 2). Among these, the Instructional design projects account for the largest proportion with about 55.6%, followed by TPACK-based modules with about 14.8%. The remaining four strategies account for roughly 7.4% each.
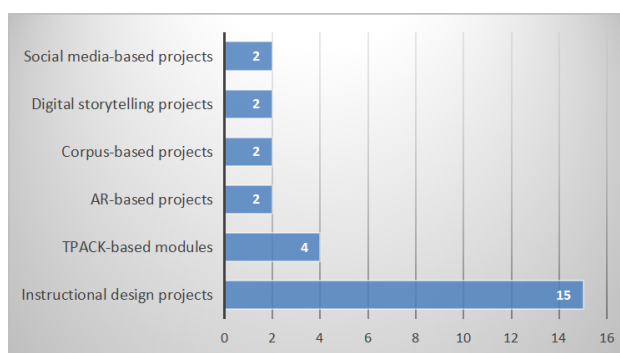
Figure 6. Distribution of TPACK development strategies.

Instructional design projects: They are educational projects or tasks that entail the systematic design, creation, and execution of instructional materials and learning activities[46]. As for TPACK development in English pre-service teacher education in this study, the Instructional design projects include designing digital instructional materials[19, 47–51], designing online teaching materials in the context of web-conferencing[52], creating flipped classroom lessons[53], video designs in the format of TED talk[54], microteaching lesson designs[35, 55], online collaborative teaching designs[56, 57], and Project-based learning (PBL) practice[58, 59].

TPACK-based modules: Some modules are specifically designed in line with the TPACK framework, aiming to enhance pre-service English teachers' ability to integrate technology effectively into their pedagogy. Examples of such projects include targeted TPACK training sessions and workshops, as discussed by Ersanli[60], which allowed participants to produce actual learning materials, thereby enhancing their TPACK by combining technology with content and pedagogical knowledge. Additionally, TPACK training modules have been implemented in various studies[13, 61, 62]

to systematically build pre-service teachers' TPACK through structured learning activities. These projects often involve a combination of theoretical instruction and practical application, providing a comprehensive approach to TPACK development.

AR-based projects: Augmented Reality (AR) is a technology that blends the physical environment with digital elements in real time, offering an enhanced immersive experience by overlaying content such as 3D images, sound, and text onto the real world[63]. Teacher training programs have implemented AR with mixed results[64]. As for pre-service English teacher education, Belda-Medina[65] motivates teacher candidates to develop their own AR projects, resulting in the creation of 47 vision-based and location-based projects using various AR authoring tools. These projects were then applied in teaching English to children. Moreover, Belda-Medina & Calvo-Ferrer[66] highlight integrating AR into the curriculum to develop TPACK in pre-service English teachers. Over five weeks, teacher candidates used various software development kits (SDKs) to create collaborative AR projects, which allowed them to concurrently improve their Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK).

Corpus-based projects: The application of language corpora in language teaching and learning, referred to as "data-driven learning" (DDL), has become a well-established research domain[67]. Crosthwaite et al.[68] explore how Indonesian pre-service secondary teachers integrated corpus consultation into their EFL lesson plans following comprehensive DDL training. The training encompassed an online course, live workshops, and expert advice. The teachers developed lesson plans with student-led corpus activities, which were assessed by educators for their TPACK levels. Besides, Ma et al.[36] incorporate corpus technology into the development of TPACK for pre-service TESOL (Teaching English to Speakers of Other Languages) teachers, focusing on corpus-based language pedagogy (CBLP).

Digital storytelling projects: Digital storytelling (DS) combines storytelling with diverse digital multimedia elements, including images, audio, and video, as described by[69]. It has impacted teachers' and students' skills in information gathering, problem-solving, and their attitudes toward collaboration[70]. Regarding TPACK development in English pre-service teacher education, Sancar-Tokmak &

Yanpar-Yelken[71] engage 71 FLE (foreign language English) pre-service teachers in scenario writing, material selection, storyboarding, and story production, while collaborating and reflecting on their experiences. This project enhances their confidence in using technology in teaching and prepares them for effective classroom practices by integrating content knowledge, pedagogical strategies, and technological skills. Similarly, Asik[72] designs a DS project which required pre-service English teachers to create digital stories for young learners, involving brainstorming themes, writing 200–300-word scripts, and designing storyboards with copyright-free images. They were also instructed to include transitions, titles, and credits, optionally add background music, and record their narrations to evaluate their storytelling and pronunciation skills.

Social media-based projects: social media is regarded as a transformative element in education[73]. It is described as a collection of internet-based applications that utilize Web 2.0 technologies and ideologies to facilitate the creation and sharing of user-generated content[74], which holds significant potential for enhancing learning experiences through active interaction and collaboration[75, 76]. Lau[77] employs a quantitative design to explore the relationship between pre-service teachers' social media usage (SMU) in informal settings and their development of TPACK. Inpeng & Nomnian[34] emphasize the integration of Facebook as a technological tool into a Teaching English as a Foreign Language (TEFL) program to enhance students' English language literacy, pedagogical knowledge, and ICT skills.

3.2.2. TPACK Development Models

In this study, TPACK development models refer to frameworks designed or adapted to facilitate the growth of TPACK among pre-service English teachers. This review identifies six distinct TPACK development models as shown in **Figure 7**: the ADDIE model, the TPACK-in-practice model, the MCSCL model, the TbI model, the SQD model, and the SAMR model, with ADDIE model adopted most.

ADDIE model: The ADDIE model is a well-established framework employed by educational designers and training professionals to create educational and training programs[78]. The acronym ADDIE represents the five core stages of designing and developing learning experiences: Analysis, Design, Development, Implementation, and Evaluation. This model has been utilized in three studies[13, 50, 51]

to advance TPACK among pre-service English teachers.
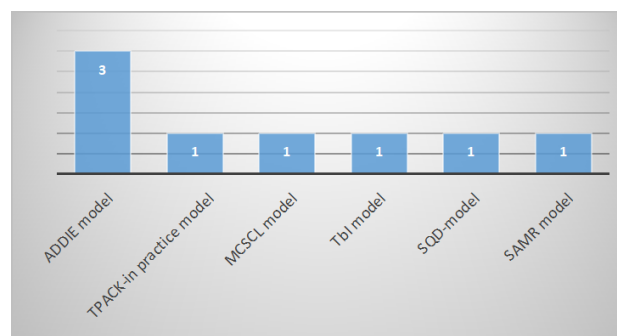
Figure 7. Distribution of TPACK development models.

TPACK-in practice model: Lisa et al.[62] proposed a TPACK-in practice model to develop TPACK among pre-service English teachers. In the first phase, the lecturer covered the theoretical foundations of using educational technology apps and the TPACK framework. In the second phase, participants identified and reviewed various apps, considering factors such as introduction, user experience, technical details, limitations, and references. Finally, they designed technology-enhanced English lesson plans, using apps like Quizizz for grammar lessons and EdPuzzle for listening activities.

MCSCL model: MCSCL, or mobile Computer-Supported Collaborative Learning model, is a pedagogical approach focused on facilitating collaborative learning through mobile devices and shared spaces. It integrates principles such as mobility, context, interaction, and collaborative learning[79]. Belda-Medina[65] utilizes the MCSCL model through project-based learning, where teacher candidates collaboratively develop AR projects with mobile devices. This method promotes active participation, interaction, and real-world technology application. Structured guidance supports participants' TPACK development, while assessments and feedback opportunities enhance the collaborative learning experience.

TbI model: Niess[80] proposes a model for integrating technology into teaching, with levels categorized as: (1) Recognizing, (2) Accepting, (3) Adapting, (4) Exploring, and (5) Advancing. Muslimin et al.[35] apply this model in their research by guiding pre-service teachers (PSTs) through these stages to help students recognize, accept, adapt, explore, and effectively use technology for English as a Foreign Language (EFL) learning. This approach, termed Technology-based Instruction (TbI), involves recognizing and accepting tech-

nology, adapting materials, exploring features, and using technology for public presentation and enhancement of student work.

SQD-model: The SQD (Synthesis of Qualitative Evidence) model[81] offers a framework for preparing pre-service teachers to integrate technology into their teaching. It highlights critical factors at both the micro and institutional levels. At the micro level, the model emphasizes the importance of role models, reflection, instructional design, collaboration, authentic experiences, and feedback. At the institutional level, the model underscores the necessity of co-operation within/between institutions, training staff, access to resources and technology planning and leadership. Lachner et al.[61] integrate the SQD-model into their research design by structuring the TPACK-module around its key features, which include reflection, collaboration, and feedback.

SAMR model: The SAMR model, developed by Puentedura[82], categorizes technology integration into four levels: Substitution, Augmentation, Modification, and Redefinition. These levels range from using technology as a direct substitute for traditional methods to enabling tasks that were previously impossible. While originally intended to enhance general education through technology, the SAMR model has been adapted for mobile learning (mLearning) in English language teaching, offering a framework to evaluate and transform learning activities using mobile devices[83]. Ong & Annamalai[18] explore the use of the SAMR model as a framework to assess ICT tasks for teaching English, aligning its stages–Substitution, Augmentation, Modification, and Redefinition–with TPACK21cls development. The study evaluates pre-service teachers' ability to integrate technology into teaching by analyzing tasks at different SAMR levels.

3.3. Tools Utilized to Develop TPACK in Pre-Service English Teacher Education

To answer RQ 2, the tools utilized to develop TPACK in pre-service English teacher education in this review can be generally classified into four themes based on their different functions: content creation tools, communication and collaboration tools, interaction and feedback tools, and learning management and resource platforms. Each theme encompasses various sub-themes, which are crucial for facilitating the integration of technology into teaching practices.

3.3.1. Content Creation Tools

A significant category of tools utilized in TPACK development is content creation tools, which encompass both multimedia creation and digital storytelling platforms. Multimedia creation tools such as PowerPoint, Prezi, Windows Movie Maker, Moviemaker, Debut Video Capture Software, Bandicam, FlashBack, V Recorder, Camtasia, Avs4you PowerDirector, Wondershare Filmora, InShot, Film Maker, TED Talks (for video design), and Canva are extensively employed by pre-service teachers to produce visually engaging instructional content[19, 54, 56, 60, 62, 72]. These tools facilitate the creation of presentations, videos, and other multimedia materials that enhance the delivery of educational content.

In addition, digital storytelling and interactive content creation platforms such as Storybird, Littlebirdtales, DomoAnimate, My StoryMaker, Ed-puzzle, Wordwall, Puzzle maker (e.g., discoveryeducation.com, rif.org, puzzle.org), Thinglink, H5P, Clarisketch, Word Cloud, Glogster, Plickers, HP Reveal, Padlet, Penzu, PhotoStory 3, and MS Photo Story 3 are widely used to design interactive and narrative-driven learning activities[47, 49, 71, 72]. These platforms support the development of creative content that actively engages students through storytelling and interactive exercises.

3.3.2. Communication and Collaboration Tools

Communication and collaboration tools are crucial for promoting interaction between pre-service teachers and their students, as well as among peers and instructors. This category includes instant messaging and video conferencing tools like Skype, Zoom, Adobe Connect, Telegram Group, Screen-O-Matic, WhatsApp, Email, Google Drive, Google Docs, Google Slides, Google Meet, Wiki, and Edmodo, which enable real-time communication and facilitate both synchronous and asynchronous discussions, collaborative projects, and resource sharing[13, 19, 35, 52, 56, 57, 60, 62].

Moreover, social media tools such as Facebook, WeChat, Bilibili, Pinterest, Interpals, and Postcrossing are employed to create communities of practice, allowing pre-service teachers to share experiences, resources, and insights with a broader network of educators[34, 36, 59, 60, 77].

3.3.3. Interaction and Feedback Tools

To enhance interactive learning and provide timely feedback, various tools are employed within this category. Assessment and feedback tools such as Kahoot,

Quizizz, Quizzes, Hotpotatoes, Google Forms, Mentimeter, and Smartboard and Podcast offer interactive quizzes, surveys, and real-time feedback, which are essential for evaluating student understanding and fostering engagement[13, 19, 35, 47, 59, 60, 62].

Additionally, interactive design and AR tools like Jamboard, Interactive Board, Aumentaty, Roar, HP Reveal, and ZapWorks offer immersive learning experiences by integrating digital elements into physical learning environments, thereby enhancing student interaction and engagement[19, 47, 65, 66].

3.3.4. Learning Management and Resource Platforms

Learning management and resource platforms are vital for structuring and delivering educational content. Online learning and resource platforms such as Moodle, Schoology, Chinese University MOOC, and Edmodo serve as comprehensive environments where pre-service teachers can access course materials, engage in discussions, and submit assignments[19, 36, 57, 59, 60]. Furthermore, resources like e-twinning projects, e-portfolios, and online dictionaries (e.g., Tureng, Zargan) are crucial for supporting language learning and collaborative endeavors[60].

Finally, educational resources and corpus tools like Lextutor, SketchEngine, COCA, CAP website, Versatext, British Academic Written English corpus (BAWE) Online writing centers (British Council, BBC), Authentic materials, Online stories, Newspapers, and ESL websites are widely utilized to enhance language teaching by providing access to linguistic data and resources that inform both content knowledge and pedagogical approaches[36, 60, 68].

3.4. Challenges Faced by Pre-Service English Teachers in TPACK Development

In answering RQ 3, the development of TPACK among pre-service English teachers is met with several challenges, which can be broadly categorized into four main areas: insufficient technical proficiency and integration, time and resource constraints, psychological and contextual barriers, and deficiencies in training and support. Each of these challenges impedes the effective incorporation of technology into teaching practices.

3.4.1. Insufficient Technical Proficiency and Integration

A prominent challenge identified is the insufficient technical proficiency among pre-service teachers, which adversely affects their ability to integrate technology effectively into their teaching practices. Many pre-service English teachers were reported having limited prior experience with educational technologies, such as digital storytelling tools, social media tools, ICT tools, VR tools, corpus technology etc., making it difficult to integrate them effectively into their teaching[34, 36, 52, 56, 65, 68, 71, 72, 77]. What's more, even some pre-service English teachers have strong technical skills, they still face difficulties in creating effective technology-supported teaching materials, which demonstrates a lack of TCK and TPK[49, 54, 58]. Moreover, this lack of proficiency is often exacerbated by the varying levels of technological infrastructure in different regions since the reviewed articles mainly from Asia, while some from North America, Europe, and Africa, leading to inconsistent training experiences and outcomes.

3.4.2. Time and Resource Constraints

Another significant challenge is the limitation of time and resources.[19, 71] highlight that pre-service teachers often face difficulties in allocating adequate time for engaging with new technologies due to competing academic commitments. Ali & Waer[13] also note that restricted access to technological resources in certain educational settings exacerbates this issue, thereby hindering the development and application of technology-related pedagogical skills. This challenge varies considerably across different educational contexts, with some regions facing more severe resource limitations that impede effective TPACK development.

3.4.3. Psychological and Contextual Barriers

Psychological and contextual factors present additional obstacles.[53, 72] identify that anxiety about technology use and a lack of confidence can deter pre-service teachers from fully integrating technological tools into their teaching. Furthermore,[47, 52] highlight that contextual barrier, such as institutional resistance to technological change and an unsupportive school culture, further complicate the integration process. These psychological challenges can vary significantly by region, as cultural attitudes towards technology and education influence pre-service teachers' willingness to

adopt new tools.

3.4.4. Deficiencies in Training and Support

Lastly, inadequacies in training and support are frequently cited as barriers to TPACK development. According to [71], insufficient training programs often leave pre-service teachers inadequately prepared for effective technology integration. [56] observe that even available training is often too generalized and fails to address the specific needs of language teachers. Recent studies [36, 59] echo these concerns, emphasizing the necessity for more targeted and ongoing support to enable pre-service teachers to develop the competencies required for effective technology integration. Moreover, while AI and advanced tools show potential, their integration into training programs poses unique challenges regarding accessibility and effective pedagogical application. A critical examination of these limitations is essential for ensuring that pre-service teachers are adequately prepared to leverage these tools in diverse educational contexts.

4. Discussion

This systematic review provides an in-depth analysis of 27 empirical studies focusing on the development of TPACK in pre-service English teacher education. The findings highlight various methods employed, tools utilized, and challenges faced by pre-service teachers in integrating technology into their pedagogical practices. This discussion connects these findings with the broader literature on pre-service English teacher education, offering insights into the implications for both research and practice.

4.1. Methods for Developing TPACK

In terms of TPACK development strategies, Instructional design projects emerged as the dominant strategy for developing TPACK in pre-service English teacher education, which emphasizes the importance of hands-on, project-based learning in fostering technological competencies. [84] stress that Instructional Design (ID) has been a key driver in fostering the pedagogical and technological transformation of both educators and students. Recent research reinforces the emphasis on instructional design by demonstrating its crucial role in integrating technology, pedagogy, and content knowledge and the complementary relationship between Instruc-

tional Design Knowledge (IDK) and TPACK [85]. TPACK-based modules are the second most used strategy, providing structured frameworks for integrating technology with pedagogy and content knowledge. Other TPACK development strategies, such as AR-based projects, corpus-based projects, digital storytelling projects, and social media-based projects, underscore the diverse applications of technology in pre-service English teacher education, each offering unique advantages and features that cater to specific aspects of TPACK development [86, 87]. Collectively, these strategies demonstrate the adaptability of TPACK development to various technological innovations and the unique demands of pre-service English teacher education. However, with the rapid emergence of new technologies, particularly AI, some scholars [88, 89] have emphasized the critical need to integrate AI technology into instructional designs to fully harness its potential and drive innovation in education. According to [90], integrating AI in instructional design not only allows designers to shift their focus from routine tasks to more complex and creative activities, enhancing the overall learning experience, but also leads to the emergence of new roles, such as AI content strategist and AI technology specialist, aimed at leveraging AI tools to improve learning outcomes.

In addition, various models such as ADDIE, TPACK-in-practice, MCSCL, TbI, SQD, and SAMR have been employed to guide TPACK development in pre-service EFL teacher education, with ADDIE model most employed in the review. The ADDIE model is an instructional design framework that has influenced many curriculum designers. Studies demonstrate that the ADDIE model can be used to design instructional strategies that enhance various teaching competencies of teachers [91] and language competences of students [92]. These models offer structured frameworks that support the systematic integration of technology into teaching practices. However, there is still a significant gap in theoretical foundations specifically addressing TPACK development within this context, as evidenced by the fact that only eight articles in this review proposed TPACK development models. To bridge this gap, future research should focus on creating and validating theoretical models that are specifically tailored to the needs of pre-service English teachers.

Integrating AI technologies into the TPACK framework presents significant opportunities for enhancing ped-

agogical practices in pre-service English teacher education. By utilizing AI tools, educators can offer personalized learning experiences that cater to individual student needs, thereby strengthening the technological knowledge (TK) aspect of TPACK. Additionally, these technologies enable data-informed decision-making, allowing pre-service teachers to assess real-time feedback and adjust their instructional methods, which highlights the critical role of pedagogical knowledge (PK) in developing effective learning environments. Moreover, AI-driven content creation tools can augment content knowledge (CK) by helping educators curate and generate a wide array of high-quality resources tailored to their curriculum, thus reinforcing the TPACK model's emphasis on integrating technology with both content and pedagogy.

4.2. Tools for Developing TPACK

Digital tools play a crucial role in developing TPACK among pre-service English teachers by supporting content creation, communication, collaboration, interaction, feedback, and learning management.[93] implement a digital storytelling (DST) project within a teacher education program to enhance participants' language, digital, and pedagogical literacies. Guided by the TPACK framework, this initiative combined traditional storytelling with diverse multimodal resources, leading to significant improvements in content knowledge, digital competencies, creativity, critical thinking, and instructional skills. Similarly,[94] confirm that utilizing various ICT tools–including web applications, digital platforms, and educational software–effectively facilitates English language teaching and further advances TPACK development.

With the advancement of technology, AI is gaining increasing prominence in language education. This groundbreaking technology is seen as a promising resource for enhancing language learning environments through the provision of automated feedback, intelligent tutoring systems, and personalized learning experiences[95]. The exploration of GenAI reveals both similarities and distinctions compared to other digital technologies, highlighting its protean, opaque, and unstable traits, as well as its generative and social characteristics that make it revolutionary[96]. These attributes impact various knowledge domains within TPACK, including TK, TPK, and TCK. This aligns with how tradi-

tional digital tools–such as web platforms, applications, and software–contribute to TPACK development by enhancing content creation, communication, and pedagogical methods. Furthermore, the examination of GenAI's influence on Contextual Knowledge (XK)[17] suggests a need for a broader perspective on how such technologies will reshape individuals, society, and the educational landscape, reinforcing the importance of integrating diverse digital tools to advance TPACK and address future educational challenges.

4.3. Challenges in Developing TPACK

Despite advancements in TPACK development, several challenges persist, including inadequate technical proficiency, time and resource constraints, psychological and contextual barriers, and deficiencies in training and support. These challenges are reflected in a lot of studies[97, 98], which notes issues such as insufficient technical skills, inadequate online resources, and limited professional development opportunities.[99] also investigate Iranian EFL pre-service teachers' experiences with computer-assisted language learning (CALL). Their study highlighted similar obstacles, including transfer failure and inadequate facility conditions. Additionally, Fathi and Ebadi identified motivators such as perceived usefulness and peer collaboration, which play a crucial role in the adoption and sustained use of technology in teaching.

Additionally, deficiencies in training and support are emphasized by[100], which underscores the need for comprehensive professional development programs.[101] highlights the importance of focused training and support for effective TPACK development. The study recommends that trainers concentrate on integrating TPACK comprehensively rather than just on technology knowledge. It also notes that regular use of technology is crucial for enhancing teachers' TPACK self-efficacy, emphasizing the need for ongoing, practical training to improve technology integration in teaching.

21st-century learning increasingly demands that educators effectively integrate technology with pedagogy and content to prepare students for success in a rapidly evolving digital world[27]. This integration is crucial for addressing current educational needs and aligning with essential 21st-century skills such as critical thinking, problem-solving, creativity, communication, collaboration, digital literacy, civic responsibility, and global awareness[102].

The TPACK framework plays a vital role in meeting

these demands. It facilitates the development of a comprehensive skill set that encompasses pedagogical, content, and technological knowledge, which is essential for modern teaching. [101] highlights that by leveraging various technological tools, pre-service English teachers can enhance their teaching practices, create engaging and interactive learning experiences, and foster stronger student connections. Furthermore, TPACK provides valuable guidance for designing curricula that align with 21st-century skills, thereby better preparing pre-service teachers for their future roles and improving their ability to produce 21st-century learners.

5. Conclusion

In conclusion, this systematic review emphasizes the growing emphasis on TPACK development in pre-service English teacher education over the past decade. It highlights the global acknowledgment of TPACK's crucial role in preparing educators for the digital era. The review identifies effective strategies, such as instructional design projects using models like ADDIE, and underscores the importance of digital tools in TPACK development.

However, this review has limitations that may have affected the comprehensiveness of its findings. First, the focus on studies published between 2015 and 2024, as well as the restriction to peer-reviewed journal articles written in English, may have introduced a degree of selection bias. This timeframe may have excluded relevant studies that predate 2015 or have been published more recently, while language limitations potentially overlooked significant research conducted in non-English-speaking regions. Additionally, the exclusion of non-peer-reviewed sources, such as book chapters and conference proceedings, might have resulted in the omission of valuable insights, especially from emerging fields and regions with fewer peer-reviewed publications. These restrictions could limit the generalizability of the findings across different contexts, particularly in regions where research publication in English is less prevalent. To achieve a more holistic view of TPACK development in pre-service English teacher education, future studies should widen their scope by including diverse sources, such as gray literature and research published in different languages.

Despite these, addressing ongoing challenges, such as insufficient technical skills, limited resources, and a lack of adequate training and support. Addressing these obstacles is crucial for advancing TPACK development and ensuring that pre-service English teachers are well-equipped for the demands of today's educational environment. Future research should prioritize the development and validation of theoretical models tailored specifically to the needs of pre-service English teachers, along with further exploration into the integration of emerging technologies like AI, which will be instrumental in achieving more comprehensive TPACK development.

The rapid advancement of AI technologies necessitates a reassessment of pre-service English teacher education programs to better prepare educators for technology-enhanced classrooms. This review emphasizes the need for AI-driven tools in TPACK training to enhance both technological and pedagogical skills, which are key to improving content delivery. This study emphasizes the critical need to integrate AI-driven tools into TPACK training, which can bolster technological skills while also improving pedagogical approaches and content delivery. Future research should aim to develop specific strategies for incorporating AI into teacher education curricula, ensuring that pre-service teachers acquire the essential knowledge and skills to succeed in this dynamic educational landscape.

To support Sustainable Development Goals, particularly SDG 4 (Quality Education) and SDG 10 (Reduced Inequalities), enhancing technical training and expanding access to digital resources in underserved regions is essential. Continuous professional development will ensure educators stay current with technological advancements, improving educational outcomes and reducing inequalities. A continued focus on TPACK is crucial for equipping pre-service English teachers to meet the challenges of an evolving educational landscape and effectively integrate 21st-century learning skills, contributing to a more sustainable and equitable future.

Author Contributions

Conceptualization, L.Y., H.H.I., and A.A.A.; methodology, L.Y., H.H.I., and A.A.A.; validation, H.H.I., and A.A.A.; formal analysis, L.Y., H.H.I., and A.A.A.; investigation, L.Y., H.H.I., and A.A.A.; data curation, H.H.I., and A.A.A.; writing—original draft preparation, L.Y.; writing—review and

editing, L.Y., H.H.I., and A.A.A.; supervision, H.H.I., and A.A.A.; project ad-ministration, L.Y. All authors have read and agreed to the published version of the manuscript.

Funding

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The data for this systematic review were obtained from publicly accessible research articles available through academic databases such as Web of Science, Scopus, ERIC, ScienceDirect, and ProQuest. The relevant articles are listed in the references section of this paper, and original data can be accessed directly through these databases. No proprietary or restricted datasets were utilized, and all data are publicly available. Any access limitations for specific articles are detailed within the respective publications.

Conflicts of interest

The authors declare no conflict of interest.

Appendix A

Table A1. Coding schemes for RQ 1.

RQ	Category	Theme	Sub-Theme	Coding Items (Examples)
RQ 1	Methods	TPACK development strategies	Instructional design projects	[19, 35, 47, 49–54, 56, 57] etc.
			TPACK-based modules	[13, 60–62]
			AR-based projects	[65, 66]
			Corpus-based projects	[36, 68]
			Digital storytelling projects	[71, 72]
			Social media-based projects	[34, 77]
		TPACK development models	ADDIE model	[13, 50, 51]
			TPACK-in practice model	[62]
			MCSCL model	[65]
			TbI model	[35]
			SQD-model	[61]
			SAMR Model	[19]

Table A2. Coding schemes for RQ 2.

RQ	Category	Theme	Sub-Theme	Coding Items (Examples)
RQ 2	Tools	Content creation tools	Multimedia creation tools	PowerPoint, Prezi, Windows Movie Maker, Moviemaker, etc.
			Digital Storytelling and Interactive Content Creation	Storybird, Littlebirdtales, DomoAnimate, My StoryMaker, Ed-puzzle, Wordwall, Puzzle maker, PhotoStory 3, MS Photo Story 3, etc.
		Communication and collaboration tools	Instant Messaging and Video Conferencing tools	Skype, Zoom, Adobe Connect, Telegram Group, Screen-O-Matic, WhatsApp, Email, Google Drive,etc.
			Social media tools	Facebook, WeChat, Bilibili, Pinterest, Interpals, Postcrossing

Table A2. *Cont.*

RQ	Category	Theme	Sub-Theme	Coding Items (Examples)
RQ 2	Tools	Interaction and feedback tools	Assessment and feedback tools	Kahoot, Quizizz, Quizzes, Hotpotatoes, Google Forms, Mentimeter, Smartboard, Podcast
			Interactive design and AR Tools	Jamboard, Interactive Board, Aumentaty, Roar, HP Reveal, ZapWorks
		Learning management and resource platforms	Online learning and resource platforms	Moodle, Schoology, Chinese University MOOC, EdmodoThe Internet, e-twinning project, e-portfolios, Online dictionaries (tureng, zargan, etc.)
			Educational resources and Corpus tools	Lextutor, SketchEngine, COCA, CAP website, Versatext, British Academic Written English corpus (BAWE), etc.

Table A3. Coding schemes for RQ 3.

RQ	Category	Theme	Sub-Theme	Coding Items (Examples)
RQ 3	Challenges	Challenges in TPACK development	Insufficient technical proficiency and integration	[56, 58, 60, 62, 77], etc.
			Time and resource constraints	[13, 19, 71], etc.
			Psychological and contextual barriers	[35, 52, 53, 72], etc.
			Deficiencies in training and support	[36, 49, 50, 59], etc.

References

[1] Madanat, H., Ab Rashid, R., Hashmi, U.M., et al., 2024. Jordanian English language educators' perceived readiness for virtual learning environment. Heliyon. 10(4), e25766. DOI: https://doi.org/10.1016/j.heliyon.2024.e25766

[2] North, B., Piccardo, E., Goodier, T., et al., 2022. Enriching 21st-Century Language Education. The CEFR Companion volume in practice. Available from: http://hdl.handle.net/20.500.12162/5760 (cited 15 September 2024).

[3] Chan, C.K.Y., Hu, W., 2023. Students' voices on generative AI: Perceptions, benefits, and challenges in higher education. International Journal of Educational Technology in Higher Education. 20(1), 43. DOI: https://doi.org/10.1186/s41239-023-00411-8

[4] Chiu, T.K.F., 2024. Future research recommendations for transforming higher education with generative AI. Computers and Education: Artificial Intelligence. 6, 100197. DOI: https://doi.org/10.1016/j.caeai.2023.100197

[5] Yeralan, S., Lee, L.A., 2023. Generative AI: Challenges to higher education. Sustainable Engineering and Innovation. 5(2), 107–116. DOI: https://doi.org/10.37868/sei.v5i2.id196

[6] Bajpai, N., Biberman, J., 2021. Digital transformation and the 2030 sustainable development agenda. ICT India Working Paper, No. 44, Columbia University, Earth Institute, Center for Sustainable Development (CSD), New York, NY. Available from: https://hdl.handle.net/10419/249833 (cited 15 September 2024).

[7] Aksoy, E., 2023. Perceived Effects of Online Practicum on Teaching Experience Post COVID-19: English Language Teachers' Opinions. Journal of Language Teaching and Learning. 13(2), 1–15. Available from: https://www.jltl.com.tr/index.php/jltl/article/view/553 (cited 15 September 2024).

[8] Palacios Hidalgo, F.J., Gómez Parra, M., Huertas Abril, C.A., 2020. Digital and Media Competences: Key Competences for EFL Teachers. Teaching English with Technology. 20(1), 43–59. Available from: https://www.ceeol.com/search/article-detail?id=826641 (cited 15 September 2024).

[9] Simonović, N., 2021. Teachers' key competencies for innovative teaching. International Journal of Cognitive Research in Science, Engineering and Education (IJCRSEE). 9(3), 331–345. DOI: https://doi.org/10.23947/2334-8496-2021-9-3-331-345

[10] Mishra, P., Koehler, M.J., 2006. Technological pedagogical content knowledge: A framework for teacher knowledge. Teachers College Record. 108(6), 1017–1054. DOI: https://doi.org/10.1111/j.1467-9620.2006.00684.x

[11] Koehler, M.J., Mishra, P., Yahya, K., 2007. Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy, and technology. Computers & Education. 49(3), 740–762. DOI: https://doi.org/10.1016/j.compedu.2005.11.012

[12] Tseng, J.-J., Chai, C.S., Tan, L., et al., 2022. A critical review of research on technological pedagogical and content knowledge (TPACK) in language teaching. Computer Assisted Language Learning. 35(4), 948–971. DOI: https://doi.org/10.1080/09588221.2020.1868531

[13] Ali, A.D., Waer, H., 2023. Integrating TPACK in a Pre-Service Teachers' EFL Course: Impacts

on Perception, Knowledge, and Practices. Australian Journal of Teacher Education. 48(3), 67–94. DOI: https://search.informit.org/doi/10.3316/informit.T2024030500008791615757895

[14] Mishra, P., Warr, M., Islam, R., 2023. TPACK in the age of ChatGPT and Generative AI. Journal of Digital Learning in Teacher Education. 39(4), 235–251. DOI: https://doi.org/10.1080/21532974.2023.2247480

[15] Elmaadaway, M.A.N., Abouelenein, Y.A.M., 2023. In-service teachers' TPACK development through an adaptive e-learning environment (ALE). Education and Information Technologies. 28(7), 8273–8298. DOI: https://doi.org/10.1007/s10639-022-11477-8

[16] Sofyan, S., Habibi, A., Sofwan, M., et al., 2023. TPACK–UotI: the validation of an assessment instrument for elementary school teachers. Humanities and Social Sciences Communications. 10(1), 1–7. DOI: https://doi.org/10.1057/s41599-023-01533-0

[17] Mishra, P., 2019. Considering contextual knowledge: The TPACK diagram gets an upgrade. In Journal of digital learning in teacher education. Taylor & Francis: New York, NY, USA. Volume 35, pp. 76–78.

[18] Mishra, P., 2019. Considering Contextual Knowledge: The TPACK Diagram Gets an Upgrade. Journal of Digital Learning in Teacher Education. 35(2), 76–78. DOI: https://doi.org/10.1080/21532974.2019.1588611

[19] Ong, Q.K.L., Annamalai, N., 2024. Technological pedagogical content knowledge for twenty-first century learning skills: The game changer for teachers of industrial revolution 5.0. Education and Information Technologies. 29(2), 1939–1980. DOI: https://doi.org/10.1007/s10639-023-11852-z

[20] Farhadi, S., Öztürk, G., 2023. Technological pedagogical content knowledge (TPACK) level and needs of pre-Service english as a foreign Language (EFL) Teachers: Evidence from Turkey. Revista Educacion. 47(1), 187–203. DOI: http://dx.doi.org/10.15517/revedu.v47i1.51920

[21] Park, M., Son, J.-B., 2022. Pre-service EFL teachers' readiness in computer-assisted language learning and teaching. Asia Pacific Journal of Education. 42(2), 320–334. DOI: https://doi.org/10.1080/02188791.2020.1815649

[22] Wilson, M.L., 2023. The impact of technology integration courses on preservice teacher attitudes and beliefs: A meta-analysis of teacher education research from 2007–2017. Journal of Research on Technology in Education. 55(2), 252–280. DOI: https://doi.org/10.1080/15391523.2021.1950085

[23] Bretscher, N., 2023. Conceptualizing TPACK within mathematics education: Teachers' strategies for capitalizing on transitions within and beyond dynamic geometry software. Digital Experiences in Mathematics Education. 9(2), 232–254. DOI: https://doi.org/10.1007/s40751-022-00115-0

[24] Wijayati, E., Setyosari, P., Kuswandi, D., et al., 2024. Examining the impact of social science teachers' technological pedagogical content knowledge (TPACK) on acceptance of online teaching and learning. Al-Hayat: Journal of Islamic Education. 8(1), 323–336. DOI: https://doi.org/10.35723/ajie.v8i1.516

[25] Wohlfart, O., Mödinger, M., Wagner, I., 2024. Information and communication technologies in physical education: Exploring the association between role modeling and digital literacy. European Physical Education Review. 30(2), 177–193. DOI: https://doi.org/10.1177/1356336X231193556

[26] Yildiz Durak, H., Atman Uslu, N., Canbazoğlu Bilici, S., et al., 2023. Examining the predictors of TPACK for integrated STEM: Science teaching self-efficacy, computational thinking, and design thinking. Education and Information Technologies. 28(7), 7927–7954. DOI: https://doi.org/10.1007/s10639-022-11505-7

[27] Liando, N.V.F., Tatipang, D.P., Wuntu, C.N., 2023. TPACK framework towards 21st century's pre-service English teachers: Opportunities and challenges in application. Edumaspul: Jurnal Pendidikan. 7(1), 1799–1815. DOI: https://doi.org/10.33487/edumaspul.v7i1.6479

[28] Drajati, N.A., Rakerda, H., Sulistyawati, H., et al., 2021. Investigating the adoption of TPACK-21CL by English pre-service teachers in a COVID-19 teaching practicum. Indonesian Journal of Applied Linguistics. 11(1), 124–133. DOI: https://doi.org/10.17509/ijal.v11i1.34625

[29] Mariette, K.S., 2022. Pre-Service English Teacher's Perception and Understanding Toward TPACK Framework During Microteaching Course. Journal of Educational Study. 2(2). DOI: https://doi.org/10.36663/joes.v2i2.272

[30] Arslan, A., 2020. Reliability and Validity of Instruments Measuring English Teachers' TPACK. International Journal of Assessment Tools in Education. 7(3), 343–360. DOI: https://doi.org/10.21449/ijate.679876

[31] Genç, G., Dülger, R., 2024. Examining the Technological Pedagogical Content Knowledge (TPACK) of Turkish Preservice English as a Foreign Language Teachers. International Journal of Educational Reform. DOI: https://doi.org/10.1177/10567879241228258

[32] Darsih, E., Agustiana, V., Rahmatunisa, W., 2023. Exploring the Integration of Technological Pedagogical Content Knowledge (TPACK) in Online Teaching Among EFL Lecturers. English Review: Journal of English Education. 11(2), 561–570. DOI: https://doi.org/10.25134/erjee.v11i2.7570

[33] Kusuma, I., 2022. How Does a TPACK-Related Program Support EFL Pre-Service Teachers' Flipped Classrooms?. LEARN Journal: Language Education and Acquisition Research Network. 15(2), 300–325. Available from: https://eric.ed.gov/?id=EJ1358700 (cited

15 September 2024).

[34] Inpeng, S., Nomnian, S., 2020. The Use of Facebook in a TEFL Program Based on the TPACK Framework. LEARN Journal: Language Education and Acquisition Research Network Journal. 13(2), 369–393. Available from: https://eric.ed.gov/?id=EJ1258789 (cited 15 September 2024).

[35] Muslimin, A.I., Mukminatien, N., Ivone, F.M., 2022. The Effect of Technology Based Instruction Lesson Plan on EFL Pre-Service Teachers' TPACK Self-Efficacy. World Journal of English Language. 12(6), 304–314. DOI: https://doi.org/10.5430/wjel.v12n6p 304

[36] Ma, Q., Lee, H.T.H., Gao, X., et al., 2024. Learning by design: Enhancing online collaboration in developing pre-service TESOL teachers' TPACK for teaching with corpus technology. British Journal of Educational Technology. DOI: https://doi.org/10.1111/bjet.13458

[37] Linnenluecke, M.K., Marrone, M., Singh, A.K., 2020. Conducting systematic literature reviews and bibliometric analyses. Australian Journal of Management. 45(2), 175–194. DOI: https://doi.org/10.1177/0312896219877678

[38] Moher, D., Liberati, A., Tetzlaff, J., et al., 2010. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. International Journal of Surgery. 8(5), 336–341. DOI: https://doi.org/10.1016/j.ijsu.2010.02.007

[39] Page, M.J., McKenzie, J.E., Bossuyt, P.M., et al., 2021. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. Bmj. 372. DOI: https://doi.org/10.1136/bmj.n71

[40] Criollo-C, S., Guerrero-Arias, A., Guaña-Moya, J., et al., 2024. Towards Sustainable Education with the Use of Mobile Augmented Reality in Early Childhood and Primary Education: A Systematic Mapping. Sustainability. 16(3), 1192. DOI: https://doi.org/10.3390/su 16031192

[41] Clarke, V., Braun, V., 2017. Thematic analysis. The Journal of Positive Psychology. 12(3), 297–298. DOI: https://doi.org/10.1080/17439760.2016.1262613

[42] Creswell, J.W., Creswell, J.D., 2017. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (Fifth Edition). Sage publications: Los Angeles, CA, USA. pp. 267–272.

[43] Cresswell, J., 2013. Qualitative inquiry & research design: Choosing among five approaches. Sage publications: Los Angeles, CA, USA. pp. 243–272.

[44] Asenahabi, B.M., Busula, A.O., Ronoh, R., 2019. A choice dilemma in selecting an appropriate research design. International Journal of Advanced Research in Computer Engineering & Technology. 8(8), 348–356. Available from: http://41.89.205.12/handle /123456789/1314 (cited 15 September 2024).

[45] Maggetti, M., 2020. Mixed-methods designs. Handbuch Methoden Der Politikwissenschaft. 193–210. DOI: https://doi.org/10.1007/978-3-658-16936-7_12

[46] Morrison, G.R., Ross, S.M., Morrison, J.R., Kalman, H. K. 2019. Designing effective instruction, 8th ed. Wiley: Hoboken, NJ, USA. pp. 9–10.

[47] Asik, A., Ince, B., Vural, A., 2018. Investigating Learning Technology by Design Approach in Pre-Service Language Teacher Education: Collaborative and Reflective Experiences. Journal of Qualitative Research in Education-Egitimde Nitel Arastirmalar Dergisi. 6(1), 37–53. DOI: https://doi.org/10.14689/issn.2148-2624. 1.6c1s2m

[48] Adipat, S., 2021. Developing Technological Pedagogical Content Knowledge (TPACK) through Technology-Enhanced Content and Language-Integrated Learning (T-CLIL) Instruction. Education and Information Technologies. 26(5), 6461–6477. DOI: https://doi.org/10. 1007/s10639-021-10648-3

[49] Kaçar, I.G., 2022. Pre-Service EFL Teachers as Digital Material Designers: A Case Study into the TPACK Development in the Turkish Context. Teaching English with Technology. 22, 107–130. Available from: https://www.ceeol.com/search/article-detail?id =1080610 (cited 15 September 2024).

[50] Kulaksiz, T., 2023. Does Individual Innovativeness Influence TPACK Development?: The Case of Pre-Service EFL Teachers in Türkiye. Australian Journal of Teacher Education. 48(3), 37–50. Available from: https://search.informit.org/doi/10.3316/inform it.T2024030500008301419279142

[51] Kulaksiz, T., 2023. Praxeological learning approach in the development of pre-service EFL teachers' TPACK and online information-seeking strategies. International Journal of Educational Technology in Higher Education. 20(1). DOI: https://doi.org/10.1186/ s41239-023-00421-6

[52] Tseng, J.-J., Cheng, Y.-S., Yeh, H.-N., 2019. How pre-service English teachers enact TPACK in the context of web-conferencing teaching: A design thinking approach. Computers & Education. 128, 171–182. DOI: https://doi.org/10.1016/j.compedu.2018.09.022

[53] Piotrowski, A., Witte, S., 2016. Flipped Learning and TPACK Construction in English Education. International Journal of Technology in Teaching and Learning. 12(1), 33–46. Available from: https://eric.ed.gov/?id= EJ1213368 (cited 15 September 2024).

[54] Chien, C.-W., 2022. Analysis of English Majors' Construction of Technological Pedagogical Content Knowledge in the Format of TED Talk. Journal of Interactive Learning Research. 33(1), 5–28. Available from: https://www.learntechlib.org/primary/p/215692/ (cited 15 September 2024).

[55] Syamdianita, S., Cahyono, B.Y., 2021. The EFL pre-service teachers' experiences and challenges in designing teaching materials using TPACK framework. Stud-

ies in English Language and Education. 8(2), 561–577. DOI: https://doi.org/10.24815/siele.v8i2.19202

[56] Bueno-Alastuey, M., Villarreal, I., Esteban, S., 2018. Can telecollaboration contribute to the TPACK development of pre-service teachers? Technology Pedagogy and Education. 27(3), 367–380. DOI: https://doi.org/10.1080/1475939X.2018.1471000

[57] Cengiz, B.C., Kaçar, I.G., 2024. Pre-Service EFL Teachers' Online Language Teaching and Their TPACK Development. Novitas-ROYAL (Research on Youth and Language). 18(1), 48–67. DOI: http://doi.org/10.5281/zenodo.10972972

[58] Tseng, S.-S., Yeh, H.-C., 2019. Fostering EFL teachers' CALL competencies through project-based learning. Educational Technology and Society. 22(1), 94–105. Available from: https://www.jstor.org/stable/26558831 (cited 15 September 2024).

[59] Zhang, D., Wang, W., 2023. The current status and development of pre-service language teachers' TLLT competence in a PjBL classroom. Cogent Education. 10(2). DOI: https://doi.org/10.1080/2331186X.2023.2273174

[60] Ersanli, C.Y., 2016. Improving Technological Pedagogical Content Knowledge (TPACK) of Pre-Service English Language Teachers. International Education Studies. 9(5), 18–27. DOI: http://doi.org/10.5539/ies.v9n5p18

[61] Lachner, A., Fabian, A., Franke, U., et al., 2021. Fostering pre-service teachers' technological pedagogical content knowledge (TPACK): A quasi-experimental field study. Computers & Education. 174, 104304. DOI: https://doi.org/10.1016/j.compedu.2021.104304

[62] Lisa, A., Faridi, A., Bharati, D.A. L., et al., 2021. A TPACK-in Practice Model for Enhancing EFL Students' Readiness to Teach with Ed-Tech Apps. International Journal of Interactive Mobile Technologies. 15(17), 156–176. DOI: https://doi.org/10.3991/ijim.v15i17.23465

[63] Dargan, S., Bansal, S., Kumar, M., et al., 2023. Augmented reality: A comprehensive review. Archives of Computational Methods in Engineering. 30(2), 1057–1080. DOI: https://doi.org/10.1007/s11831-022-09831-7

[64] Khoshnevisan, B., 2019. Teacher education meets emerging technologies: Augmented Reality (AR). TEIS Newsletter—TESOL International Association. Available from: https://www.researchgate.net/publication/334222867_Teacher_Education_Meets_Emerging_Technologies_Augmented_Reality_AR (cited 15 September 2024).

[65] Belda-Medina, J., 2022. Using Augmented Reality (AR) as an Authoring Tool in EFL through Mobile Computer-Supported Collaborative Learning. Teaching English with Technology. 22(2), 115–135. Available from: http://www.tewtjournal.org (cited 15 September

2024).

[66] Belda-Medina, J., Calvo-Ferrer, J.R., 2022. Integrating augmented reality in language learning: Pre-service teachers' digital competence and attitudes through the TPACK framework. Education and Information Technologies. 27(9), 12123–12146. DOI: https://doi.org/10.1007/s10639-022-11123-3

[67] Templeton, J., Timmis, I., 2023. A flexible framework for integrating data-driven learning. In Demystifying corpus linguistics for English language teaching. Springer: New York, NY, USA. pp. 39–58.

[68] Crosthwaite, P., Luciana, Wijaya, D., 2023. Exploring language teachers' lesson planning for corpus-based language teaching: A focus on developing TPACK for corpora and DDL. Computer Assisted Language Learning. 36(7), 1392–1420. DOI: https://doi.org/10.1080/09588221.2021.1995001

[69] Robin, B.R., 2008. Digital storytelling: A powerful technology tool for the 21st century classroom. Theory into Practice. 47(3), 220–228. DOI: https://doi.org/10.1080/00405840802153916

[70] Çetin, E., 2021. Digital storytelling in teacher education and its effect on the digital literacy of pre-service teachers. Thinking Skills and Creativity. 39, 100760. DOI: https://doi.org/10.1016/j.tsc.2020.100760

[71] Sancar-Tokmak, H., Yanpar-Yelken, T., 2015. Effects of creating digital stories on foreign language education pre-service teachers' TPACK self-confidence. EDUCATIONAL STUDIES, 41(4), 444–461. DOI: https://doi.org/10.1080/03055698.2015.1043978

[72] Asik, A., 2016. Digital Storytelling and Its Tools for Language Teaching: Perceptions and Reflections of Pre-Service Teachers. International Journal of Computer-Assisted Language Learning and Teaching. 6(1), 55–68. DOI: https://doi.org/10.4018/IJCALLT.2016010104

[73] Sobaih, A.E.E., Hasanein, A.M., Abu Elnasr, A.E., 2020. Responses to COVID-19 in higher education: Social media usage for sustaining formal academic communication in developing countries. Sustainability. 12(16), 6520. DOI: https://doi.org/10.3390/su12166520

[74] Kaplan, A.M., Haenlein, M., 2010. Users of the world, unite! The challenges and opportunities of social media. Business Horizons. 53(1), 59–68. DOI: https://doi.org/10.1016/j.bushor.2009.09.003

[75] Umara, K., Singh, I., Singh, A., 2024. Technological Adoption and Social Media Usage Among Undergraduate Students in Public Universities in Rivers State. Journal of Research Administration. 6(1), 1140–1168. Available from: https://journlra.org/index.php/jra/article/view/1239 (cited 15 September 2024).

[76] Lee Mei, K., Abdul Aziz, A., 2022. Students' Perception on Using Tiktok Application as An English Learning Tool. International Journal of Academic Re-

search in Progressive Education and Development. 11(4), 166–190. DOI: https://doi.org/10.6007/IJAR PED/v11-i4/15403

[77] Lau, W.W.F., 2018. Relationships between Pre-service Teachers' Social Media Usage in Informal Settings and Technological Pedagogical Content Knowledge. Eurasia Journal of Mathematics, Science and Technology Education. 14(12). DOI: https://doi.org/10.29333/ej mste/94228

[78] Spatioti, A.G., Kazanidis, I., Pange, J., 2022. A comparative study of the ADDIE instructional design model in distance education. Information. 13(9), 402. DOI: https://doi.org/10.3390/info13090402

[79] Looi, C.-K., Wong, L.-H., Song, Y., 2013. Mobile computer-supported collaborative learning. In The international handbook of collaborative learning. Routledge: New York, NY, USA. pp. 420–436.

[80] Niess, M.L., 2013. Central component descriptors for levels of technological pedagogical content knowledge. Journal of Educational Computing Research. 48(2), 173–198. DOI: https://doi.org/10.2190/EC.48.2.d

[81] Tondeur, J., Van Braak, J., Sang, G., et al., 2012. Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. Computers & Education. 59(1), 134–144. DOI: https://doi.org/10.1016/j.compedu.2011.10.009

[82] Puentedura, R.R., 2006. Transformation, technology, and education in the state of Maine. Available from: http://hippasus.com/blog/archives/18 (cited 15 September 2024).

[83] Romrell, D., Kidder, L., Wood, E., 2014. The SAMR model as a framework for evaluating mLearning. Online Learning Journal. 18(2). Available from: https://www.learntechlib.org/p/183753/ (cited 15 September 2024).

[84] Abuhassna, H., Alnawajha, S., 2023. Instructional design made easy! Instructional design models, categories, frameworks, educational context, and recommendations for future work. European Journal of Investigation in Health, Psychology and Education. 13(4), 715–735. DOI: https://doi.org/10.3390/ejihpe 13040054

[85] Kale, U., Roy, A., Yuan, J., 2020. To design or to integrate? Instructional design versus technology integration in developing learning interventions. Educational Technology Research and Development. 68(5), 2473–2504. DOI: https://doi.org/10.1007/s11423-020-09771-8

[86] Amelia, P., Rukmini, D., Mujiyanto, J., et al., 2021. Investigating the Development of Teachers' TPACK and the Adoption of Digital Storytelling: A Case Study of Teaching English in Elementary School. Journal of Asia TEFL, 18(2), 701. DOI: http://dx.doi.org/10.18823/as iatefl.2021.18.2.25.701

[87] Tan, L., Thomson, R., Koh, J.H. L., et al., 2023. Teaching multimodal literacies with digital technologies and augmented reality: A cluster analysis of Australian teachers' TPACK. Sustainability. 15(13), 10190. DOI: https://doi.org/10.3390/su151310190

[88] Ruiz-Rojas, L.I., Acosta-Vargas, P., De-Moreta-Llovet, J., et al., 2023. Empowering Education with Generative Artificial Intelligence Tools: Approach with an Instructional Design Matrix. Sustainability. 15(15), 11524. DOI: https://doi.org/10.3390/su151511524

[89] Tan, S., 2023. Harnessing Artificial Intelligence for innovation in education. In Learning intelligence: Innovative and digital transformative learning strategies: Cultural and social engineering perspectives. Springer: New York, NY, USA. pp. 335–363. DOI: https://doi.org/10.1007/978-981-19-9201-8_8

[90] Ch'ng, L.K., 2023. How AI Makes Its Mark on Instructional Design. Asian Journal of Distance Education. 12(2), 32–41. Available from: https://asianjde.c om/ojs/index.php/AsianJDE/article/view/740 (cited 15 September 2024).

[91] Handrianto, C., Jusoh, A.J., Goh, P.S.C., et al., 2021. Using ADDIE model for designing instructional strategies to improve teaching competency of secondary school's teachers. Proceeding Webinar Konvensyen Kaunseling Kebangsaan Kali Ke. 22, 361–371. Available from: https://www.researchgate.net/publication /352863787

[92] Almelhi, A.M., 2021. Effectiveness of the ADDIE Model within an E-Learning Environment in Developing Creative Writing in EFL Students. English Language Teaching. 14(2), 20. DOI: https://doi.org/10.5539/elt.v14n2p20

[93] Yu, B., Wang, W., 2024. Transforming English Pre-service Teachers Through a Digital Adventure: Developing Digital Literacy and Pedagogical Skills. In: Lee, J.S., Zou, D., Gu, M.M. (Eds.), Technology and English Language Teaching in a Changing World. Springer International Publishing: New York, NY, USA. pp. 125–142. DOI: https://doi.org/10.1007/978-3-031-51540-8_10

[94] Tütüniş, B., Ünal, K., Babanoğlu, P., 2022. Teacher Training on ICT (Web Tools) for English Language Teaching in Primary Schools: TPACK Framework and Usage. International Journal of Education. 2(1), 95–107. DOI: https://doi.org/10.1016/j.caeai.2022.100117

[95] Weng, X., Chiu, T.K.F., 2023. Instructional design and learning outcomes of intelligent computer assisted language learning: Systematic review in the field. Computers and Education: Artificial Intelligence. 4, 100117. DOI: https://doi.org/10.1016/j.caeai.2022.100117

[96] Mishra, P., Oster, N., Henriksen, D., 2024. Generative AI, Teacher Knowledge and Educational Research: Bridging Short- and Long-Term Perspectives. TechTrends. 68(2), 205–210. DOI: https://doi.org/10.

1007/s11528-024-00938-1

[97] Syafryadin, S., Pratiwi, V.U., Wardhana, D.E.C., 2021. Pre-service English teachers' experience with various CALL applications: Hindrances and reflection. Studies in English Language and Education. 8(1), 99–114. DOI: https://doi.org/10.24815/siele.v8i1.17609

[98] Taghizadeh, M., Basirat, M., 2022. Investigating pre-service EFL teachers' attitudes and challenges of online teaching. Computer Assisted Language Learning. 1–38. DOI: https://doi.org/10.1080/09588221.2022.2136201

[99] Fathi, J., Ebadi, S., 2020. Exploring EFL pre-service teachers' adoption of technology in a CALL program: Obstacles, motivators, and maintenance. Education and Information Technologies. 25(5), 3897–3917. DOI: https://doi.org/10.1007/s10639-020-10146-y

[100] Essam, R., 2021. Exploring the needs of teachers in a Middle East university using TPACK: A case study. Studies in Technology Enhanced Learning. 1(2). DOI: https://doi.org/10.21428/8c225f6e.b9366ecd

[101] Loi, N.V., 2021. Vietnamese High-School Teachers' Perceptions of TPACK in Teaching English as a Foreign Language. European Journal of Education Studies. 8(4), 183–198. DOI: https://doi.org/10.46827/ejes.v8i4.3693

[102] Kim, S., Raza, M., Seidman, E., 2019. Improving 21st-century teaching skills: The key to effective 21st-century learners. Research in Comparative and International Education. 14(1), 99–117. DOI: https://doi.org/10.1177/1745499919829214