
Analyzing TPACK Research in Teacher Education: A Systematic Literature Review from 2014-2023

Kaushik Sarkar

Ph.D. Research Scholar, Department of Education, Sikkim University, Gangtok, Sikkim

Email- kaushiksarkar018@gmail.com

Dr. Aabriti Sharma

Assistant Professor, Department of Education, Sikkim University, Gangtok, Sikkim

Email- asharma@cus.ac.in

DOI : <https://doi.org/10.5281/zenodo.16778538>

ARTICLE DETAILS

Research Paper

Accepted: 15-07-2025

Published: 10-08-2025

Keywords:

*Emerging Research Trends,
Teacher Education,
Technological Pedagogical
Content Knowledge,
Technology Integration in
the Classroom, Systematic
Literature Review*

ABSTRACT

The importance of integrating technology into educational settings has grown over the years. When technology is incorporated into a traditional learning environment, meaningful learning experiences are fostered, and positive attitudes towards and relationships with technology are encouraged. To prepare teachers for modern classrooms, it is increasingly essential to include technology in teacher education programmes. TPACK has become a key focus in discussions about effective teaching in the digital age, as it is a framework based on the idea that teachers who want to integrate technology into their teaching must be competent in all three domains: content knowledge, pedagogical knowledge, and technological knowledge. This paper aims to explore emerging trends in TPACK research within teacher education and to offer researchers and educators potential avenues for future studies through a comprehensive systematic review of relevant literature. To this end, 109 peer-reviewed journal articles published



between 2014 and 2023 were selected from the ERIC database. An attempt was made to synthesise the main findings and conclusions from this research, including the implementation or application of TPACK in the classroom, approaches or strategies to develop teachers' TPACK, the relationship between TPACK and other components, the development or validation of instruments or scales for TPACK, and the measurement of teachers' perceptions and opinions regarding TPACK and its components

1.0 Introduction

The concept of pedagogical content knowledge (PCK), first introduced by Schulman in 1986, serves as the foundation for the technological pedagogical content knowledge (TPACK) framework, also known as TPCK at first. Technology was added to the TPACK framework in response to the quick development and impact of information and communication technology (ICT), which is known to improve students' twenty-first-century skills (Mishra and Koehler, 2006). Notably, since its inception, TPACK has consistently garnered significant attention from educators and evolved into a focal point for teacher professional development (Voogt et al., 2012, as cited in Irwanto, 2021). This study will provide a solid methodological base and insightful information for further research on the subject. Thus, researchers and educators may find it easier to plan for future studies if they have access to information on research trends and potential directions in TPACK research. To achieve this aim, journal articles published through the ERIC database between January 2014 and October 2023 were identified. The systematic review then started with the following research questions.

1. What are the research approaches in the TPACK research published from 2014 to 2023?
2. What are the emerging themes that appear in the reviewed studies from 2014 to 2023?
3. What are the trends of findings in TPACK research?

2.0 Methodology

A manual search of documents was conducted by examining journals associated with TPACK. Keywords or a set of key terms were established to systematically search for literature in electronic databases.



The keywords that were selected were “TPCK”, “TPACK”, “Technological pedagogical content knowledge” and “Technological pedagogical and content knowledge” and publication periods ranging from 2014 to 2023. The initial inquiry on the ERIC database yielded 239 results. Following the elimination of duplicate entries derived from the keyword search across ERIC databases, the total number of distinct articles narrowed down to 136. The selection process began with a careful evaluation of the titles, proceeded with a detailed examination of the abstracts, and concluded with an in-depth review of the full texts to decide which articles would be included in the study. A total of 109 articles were ultimately selected for the study through this process.

Table 1: Search Equations and Filters

Database Search	Search equation	Applied filters
ERIC	“TPCK”	Publication status: final.
	“TPACK”	Type of document: article.
	“Technological Pedagogical and Content Knowledge”	Open Access.
	“Technological Pedagogical Content Knowledge”	From 2014 to 2023.

Source: Own elaboration

Table 2: Criteria of inclusion

<i>Inclusion criteria</i>
The title, abstract, or keywords must include the acronym TPACK.
The research had to be developed, either totally or partially, with pre-service & in-service teachers.
The studies ought to be empirical research articles.
Papers published between 2014 and 2023.

Source: Own elaboration

Articles that didn't meet the specified criteria weren't considered.

3.0 Findings

The results of examining selected papers from the ERIC database between 2014 and 2023 are presented in this section. Three sections comprise the findings, which include the various research approaches and



methodology used in TPACK studies, the emergent themes seen in the examined papers, and the patterns found in TPACK study findings.

3.1 Approaches and Methodologies Distribution Across Research

Table 3: *The adopted research approaches*

Approaches	Number of articles
Quantitative	61
Qualitative	24
Mixed-method research	24

A predominant 61 out of 109 studies, accounting for 55.96% numerically, opted for a quantitative research approach. Conversely, both qualitative and mixed-method approaches were used by 24 studies each. Within the quantitative domain, 20 studies were characterized by descriptive research, followed by 6 experimental research. Additionally, there were 5 studies utilizing quasi-experimental methods, 4 studies were constructing and validating the tools, 4 engaging in correlational studies. Among the qualitative studies, a substantial majority, constituting 11 out of 24 studies or 45.83% in numerical terms, embraced the case study methodology. Following this both content analysis & thematic analysis and phenomenological research employed 2 studies each. Within the domain of mixed-method approaches, a total of 19 studies were conducted, and notably, explanatory mixed-method research emerged as the predominant research method that is 9 out of 24 studies.

3.2 The emerging themes identified in the studies reviewed

The emerging themes in TPACK research emphasize the critical role of role models and practical, real-world applications in fostering effective technology integration among pre-service teachers. Research indicates that analyzing the disparity between teachers perceived and actual TPACK competencies, as highlighted by Baert (2014), can promote reflective practices that are essential for advancing TPACK development (Lu, 2014). Additionally, digital storytelling is recommended as an impactful method to enhance TPACK, with Sancar-Tokmak et al. (2014) advocating for studies involving larger participant groups and experimental methodologies to validate this approach. Akman and Guven (2015) highlight the necessity of creating and validating TPACK surveys to enhance insight into teachers' self-efficacy beliefs, whereas Oz (2015) highlights the importance of further investigating gender differences in TPACK skills between pre-service and in-service teachers. In summary, these topics emphasize the



changing nature of TPACK research and the need for innovative methods and thorough assessments to enhance technology integration within teacher education programs.

Recent studies have continued to highlight the necessity for diverse and innovative strategies to boost techno-pedagogical skills in pre-service teachers. Senturk (2019) suggests exploring the relationship between these skills and lifelong learning tendencies across various demographic variables and competencies. The use of technology within specific subject areas is crucial, as Simsek and Yazar (2019) emphasize that self-efficacy differs across disciplines, making it important to growth a range of assessment methods.

Moreover, Bergeson and Beschorner (2020) suggest investigating the Technology Integration Planning Cycle (TIPC) framework's effectiveness in providing modeling, scaffolding, and guided practice for pre-service teachers. Esposito and Moroney (2020) emphasize assessing how components of innovative educational technology master's programs contribute to TPACK development, while Gunbas (2020) focuses on creating technology-based teaching materials, such as mathematics stories, to improve prospective teachers' TPACK. Especially in light of issues like COVID-19, Inpeng and Nomnian (2020) emphasise the potential of social media, especially Facebook, and online learning technologies in augmenting blended English language education. Irdalisa et al. (2020) advocate for exploring technology-based guided inquiry as a means to enhance technological literacy among prospective teachers, and Karabuz and Ogan-Bekiroglu (2020) point out the significance of contextual factors like classroom environment and resources in TPACK development.

Love (2020) examines how teacher trainees view the incorporation of tools and platforms in education, suggesting the use of both quantitative and qualitative approaches for a thorough analysis. Ormanci et al. (2020) call for extended training to boost pre-service teachers' self-efficacy in science teaching and TPACK, while Ozgen and Narli (2020) propose the use of sophisticated data analysis methods, including Rough Set Analysis, to identify connections among TPACK constructs. Peng (2020) is in favor of formal evaluations for technology teaching assistantship programs and emphasizes the importance of professional developmental activities for educators. Rahmadi et al. (2020) propose comparative studies on TPACK confidence levels across different course modes and cultural contexts, while Setiawan and Phillipson (2020) recommend cross-cultural comparisons to identify the influence of cultural factors on TPACK development through social media use.



Torun (2020) and Ulusoy (2020) suggest exploring teachers' and prospective teachers' attitudes, academic achievements, and competence perceptions regarding various instructional technology tools and digital storytelling. Unal and Yelken (2020) emphasize the importance of exploring how the long-term preparation of vocabulary materials by pre-service English language teachers, guided by web-supported situated learning models, influences their academic success and their TPACK development. These themes illustrate the evolving landscape of TPACK research, highlighting the need for innovative approaches, comprehensive assessments, and a focus on contextual and demographic variables to enhance technology integration in teacher education.

In summary, the emerging themes in recent TPACK studies stress the importance of diverse, context-specific strategies to improve pre-service teachers' techno-pedagogical skills. These studies highlight the importance of cross-cultural comparisons, experimental and longitudinal research, and the creation of novel instruments and techniques for TPACK competency assessment and improvement.

3.3 The trends of findings in TPACK research

The analysis of the reviewed articles for trends of findings in TPACK research have been summarized in the sub-sections below.

3.3.1 Analyzing and determining teacher's level TPACK and its components

Many of the studies examined primarily concentrated on evaluating teachers' TPACK levels (karaca, 2015; Apeanti, 2016; Turgut, 2017; Esposito & Moroney, 2020; Li, 2021; Karatas & Basol, 2021; Tafli, 2021; Choi & Park, 2022; Eshelman & Hogue, 2023), opinions (Mailybayeva et al., 2022; Kazu & Erten, 2014), beliefs (Gunes & Bahcivan, 2016; Adalar, 2021; Confidence (Gozum & Demir, 2021; Suzuk & Akinci, 2021), and assessing (Kartal & Afacan, 2017; Basaran, 2020; Kara, 2021; Kacar, 2022; Kartal, 2022; Saralar-aras & Birgili, 2022; Yildiz & Gokcek, 2017), concerning their TPACK levels and the associated sub-dimensions.

3.3.2 TPACK and Supplementary Components

The idea of TPACK is intricately connected to various elements of technology integration, particularly regarding teachers' beliefs in their ability to successfully integrate technology into their instructional practices (Sensory & Yildirim, 2018; Wright & Akgunduz, 2018, Simsek & Yazar, 2019; Yildiz 2022) and self-efficacy beliefs regarding Web 2.0 tools (Kul et al. 2019). The interconnection encompasses



academic achievements (Ekrem & Recep, 2014), occupational anxiety (Kaya-Uyanik et al. 2019), thinking styles (Canbolat et al., 2016), anxiety related to teaching mathematics (Unveren Bilgic, 2022), social media usage (Setiawan & Phillipson, 2020), technology acceptance of preservice teachers and various personality traits (Thohir et al. 2021) and substantial structural correlation between preservice teachers' adoption of technology and their understanding of web pedagogical content (Akar & Guzin, 2019).

3.3.3 Strategies for enhancing teachers' TPACK

Strengthening teachers' TPACK is essential for successfully integrating technology into education. Reviewing research studies reveals a variety of strategies that help pre-service and in-service teachers develop and improve their TPACK.

Baert (2014) underlined the value of role modelling in the Physical Education Teacher Education (PETE) program, pointing out that a variety of technological tools, such as computer programs, devices for tracking physical activity, and video feedback, were used to improve pre-service teachers' understanding of TPACK. Similarly, hands-on engagement with technology in educational settings is essential. Examples of activities that have been demonstrated to improve both technological and pedagogical content knowledge include the use of dynamic geometry software (Ozcakir, 2019) and the creation of digital storytelling (Ulusoy, 2020). Reflective journaling helped pre-service teachers become more aware of TPACK (Lu, 2024). Deeper consideration of how to combine technology and subject-matter expertise is necessary for more substantial advancements, though. It has been acknowledged that incorporating a variety of thought processes into instructional design is crucial to supporting the development of TPACK.

Moreover, technology-enhanced learning environments, including online case methods (Saltan, 2017) and flipped classrooms (Piotrowski & Witte, 2016), have been found to significantly improve TPACK components like Technological Content Knowledge (TCK) and Technological Knowledge (TK). Belief systems and perspectives on technology are crucial factors in shaping the growth of TPACK. Karakus (2018) demonstrated that beliefs about computer technology use in mathematics instruction are significant predictors of TPACK, while Kartal and Cinar (2018) observed that workshops and field experiences can shift these beliefs and enhance TPACK.

Content-specific TPACK development is another critical area, with studies such as those by Mutlu et al. (2019) and Akar & Guzin (2019) showing that approaches tailored to specific subjects, like using comics



in history teaching or the T-TAM model in language education, significantly enhance TPACK. Furthermore, educators can examine and enhance their digital competencies with the use of self-assessment tools like DiKoLAN (Kotzebue et al., 2021), which promotes focused professional development.

Furthermore, it has been demonstrated that collaborative methods and project-based learning (PjBL) greatly increase TPACK by promoting knowledge exchange, practical problem solving, and technology integration cooperation (Erviana et al., 2022).

Finally, sustaining and improving TPACK over time requires ongoing professional development. Peng (2020) emphasised the necessity of continuous professional development programs that enable teachers to incorporate technology into their lesson plans and keep abreast of the most recent advancements in the field of education. According to Durdu and Dag (2017), well-structured teaching strategies greatly enhanced TPACK, leading to notable improvements in Technological Pedagogical Knowledge, Technological Content Knowledge, and Technology Knowledge. Similarly, Onal and Alemdag (2018) showed that the learning-by-design approach increased pre-service teachers' understanding of the key components of digital teaching resources while simultaneously advancing TPACK.

To sum up, improving teachers' TPACK requires a multifaceted strategy that includes content-specific development, technology-enhanced learning environments, reflective practices, role modelling, collaborative learning, self-assessment tools, and resolving infrastructure issues. Maintaining long-term TPACK growth also requires ongoing professional development.

3.3.4 Applied TPACK: Practical Approaches Employed by Teachers in Classroom Settings

This finding highlights the applications of TPACK in various educational settings. Integrating technology into science courses (Felton, 2021) and science teaching (Karakas & Basol, 2021), particularly through flipped classroom (Kusuma, 2022) and the seamless integration of Technological Pedagogical and Content Knowledge (TPACK) for teachers is made possible by flipped learning models (Widyasari et al., 2022). By employing observational protocol practices (Rakes et al., 2021), a structured and evidence-driven approach is established for integrating technology effectively. ICT-based courses (Habibi et al., 2022) and creative activities (Laura et al., 2022) support pre-service teachers in thoughtfully and strategically embedding TPACK into their teaching practices. Ethical use of digital resources (Gomez-Trigueros, 2023) emphasizes responsible and principled technology integration. Additionally, gaming



activities, coupled with micro-teaching sessions (Acikgul, 2020) and literacy lesson plans (Arya et al., 2020) that incorporate digital texts or tools offer a comprehensive way to embed TPACK seamlessly into the fabric of classroom instruction.

3.3.5 Developing and validating tools for TPACK

Several sources emphasize the creation of different tools; for instance, a study by Kiray in 2016 introduces a self-efficacy scale grounded in the TPACK framework, tailored specifically for preservice science teachers. In a different study, Nordin and Ariffin (2016) investigated the usefulness of a TPACK tool designed to help secondary school teachers successfully integrate ICT. A study (Cetin & Erdogan, 2018) looks into the validation and utilization of the TPACK framework to enhance the efficient ICT in secondary education. A different study examines the dependability and accuracy of a scale developed to assess TPACK in the framework of Turkish culture (Mustafa, 2021).

4.0 Conclusion

In conclusion, the systematic literature review of TPACK research conducted between 2014 and 2023 highlights notable progress and emerging trends in integrating technology into teacher education. The research highlights the significance of enhancing Technological Pedagogical Content Knowledge (TPACK) for teachers, whether they are in training or currently practicing. Diverse strategies and approaches are being investigated to augment this competency. Although qualitative and mixed-method approaches also made significant contributions, quantitative research still held a dominant position in the field. Emphasizing the importance of practical applications, real-world integration, and the creation of innovative tools and strategies, the research underscores the fluid and progressive characteristics of TPACK in enhancing techno-pedagogical skills. Additionally, the findings underscore the importance of continuous professional development, cross-cultural analysis, and tailored approaches in enhancing TPACK. A thorough exploration of TPACK is crucial for preparing teachers to successfully incorporate digital tools into their instruction, which will enhance student performance, as technology continues to be a core element of education.

References

- Adalar, H. (2021). Social Studies Teacher Candidates' Self-Efficacy Beliefs for Technological Pedagogical Content Knowledge (TPACK). *International Journal of Education and Literacy Studies*, 9(3), 169–183. <https://doi.org/10.7575/aiac.ijels.v.9n.3p.169>



- Akar, M., & Güzin, S. (2019). A Structural Model for Relationship between Web Pedagogic Content Knowledge and Technology Acceptance of Preservice Teachers. *Malaysian Online Journal of Educational Technology*, 7(1), 1–14. <https://doi.org/10.17220/mojet.2019.01.001>
- Akman, O., & Guven, C. (2014). TPACK Survey Development Study for Social Sciences Teachers and Teacher Candidates. *International Journal of Research in Education and Science*, 1(1), 1–10. <https://doi.org/10.21890/ijres.97007>
- Apeanti, W. O. (2015). Contributing Factors to Pre-service Mathematics Teachers' e-readiness for ICT Integration. *International Journal of Research in Education and Science*, 2(1), 223–238. <https://doi.org/10.21890/ijres.29797>
- Baert, H., & Stewart, A. (2014). The Effects of Role Modeling on Technology Integration within Physical Education Teacher Education. *JTRM in Kinesiology*, 1–26. <https://files.eric.ed.gov/fulltext/EJ1053415.pdf>
- Bergeson, K., & Beschorner, B. (2020). Modeling and Scaffolding the Technology Integration Planning Cycle for Pre-service Teachers: A Case Study. *International Journal of Education in Mathematics, Science and Technology*, 8(4), 330–341. <https://doi.org/10.46328/ijemst.v8i4.1031>
- Çetin, İ., & Erdoğan, A. (2018). Development, Validity and Reliability Study of Technological Pedagogical Content Knowledge (TPACK) Efficiency Scale for Mathematics Teacher Candidates. *International Journal of Contemporary Educational Research*, 5(1), 50–62. <https://files.eric.ed.gov/fulltext/EJ1207506.pdf>
- Choi, Y., & Park, N. (2022). The Improvement of Attitudes toward Convergence of Preservice Teachers: Blended Learning versus Online Learning in Science Teaching Method Courses. *Journal of Curriculum and Teaching*, 11(5), 87–94. <https://doi.org/10.5430/jct.v11n5p87>
- Durdu, L., & Dag, F. (2017). Pre-Service Teachers' TPACK Development and Conceptions through a TPACK-Based Course. *Australian Journal of Teacher Education*, 42(11), 150–171. <https://doi.org/10.14221/ajte.2017v42n11.10>
- Ekrem, S., & Recep, Ç. (2014). Examining Preservice EFL Teachers' TPACK Competencies in Turkey. *Journal of Educators Online*, 11(2). <https://files.eric.ed.gov/fulltext/EJ1033263.pdf>
- Erviana, V. Y., Sintawati, M., Bhattacharyya, E., Habil, H., & Fatmawati, L. (2022). The effect of project-based learning on technological pedagogical content knowledge among elementary school pre-service teacher. *Pegem Journal of Education and Instruction*, 12(2), 151–156. <https://doi.org/10.47750/pegegog.12.02.15>



- Eshelman, T. C., & Hogue, M. (2023). Pre-Service Teacher Perceptions on Tpack Instructional Design Micro-Course: A Case Study in the Northeastern United States. *The Turkish Online Journal of Educational Technology*, 22(1), 161–180. <https://files.eric.ed.gov/fulltext/EJ1375570.pdf>
- Esposito, M., & Moroney, R. (2020). Technology and student-centered learning in higher education: Issues and practices. *Journal of Computing in Higher Education*, 12(1), 3–30. <https://doi.org/10.1007/BF03032712>
- Fenton, D. (2021). Preparing Elementary Preservice Teachers to Integrate Technology: Examining the Effects of a New Science Course Sequence with Technology Infusion. *International Consortium for Research in Science & Mathematics Education*, 26(1), 23–32. <https://files.eric.ed.gov/fulltext/EJ1344104.pdf>
- Gómez-Trigueros, I. M. (2023). Digital skills and ethical knowledge of teachers with TPACK in higher education. *Contemporary Educational Technology*, 15(2), 1–8. <https://doi.org/10.30935/cedtech/12874>
- Gozum, A. İ. C., & Demir, Ö. (2021). Technological pedagogical content knowledge self-confidence of prospective pre-school teachers for Science Education during the COVID-19 period: A Structural Equational Modelling. *International Journal of Curriculum and Instruction*, 13(1), 712–742. <https://files.eric.ed.gov/fulltext/EJ1285807.pdf>
- Gunbas, N. (2020). Pre-service Mathematics Teachers Created Animated Stories to Improve their Technological Pedagogical Content Knowledge. *International Journal of Psychology and Educational Studies*, 7(3), 209–222. <https://doi.org/10.17220/ijpes.2020.03.018>
- Güneş, E., & Bahçivan, E. (2016). A Multiple Case Study of Preservice Science Teachers' TPACK: Embedded in a Comprehensive Belief System. *INTERNATIONAL JOURNAL OF ENVIRONMENTAL & SCIENCE EDUCATION*, 11(15), 8040–8054. <https://files.eric.ed.gov/fulltext/EJ1118367.pdf>
- Habibi, A., Razak, R. A., Yusop, F. D., Muhaimin, M., Asrial, A., Mukminin, A., & Jamila, A. (2022). Exploring the factors affecting pre-service science teachers' actual use of technology during teaching practice. *South African Journal of Education*, 42(1), 1–11. <https://doi.org/10.15700/saje.v42n1a1955>



- 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. <https://files.eric.ed.gov/fulltext/EJ1258789.pdf>
- Irdalisa, Paidi, & Djukri. (2020). Implementation of Technology-based Guided Inquiry to Improve TPACK among Prospective Biology Teachers. *International Journal of Instruction*, 13(2), 33–44. <https://doi.org/10.29333/iji.2020.1323a>
- Irwanto, I. (2021). Research Trends in Technological Pedagogical Content Knowledge (TPACK): A Systematic Literature Review from 2010 to 2021. *European Journal of Educational Research*, 10(4), 2045–2054. <https://doi.org/10.12973/eu-jer.10.4.2045>
- Karakus, F. (2018). An Examination of Pre-Service Teachers' Technological Pedagogical Content Knowledge and Beliefs Using Computer Technology in Mathematics Instruction. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, 3, 1-13. <http://files.eric.ed.gov/fulltext/EJ1199683.pdf>
- 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(3–4), 107–130. <https://files.eric.ed.gov/fulltext/EJ1367618.pdf>
- Kara, S. (2021). An Investigation of Technological Pedagogical and Content Knowledge (TPACK) Competencies of Pre-Service Visual Arts Teachers. *International Journal of Technology in Education*, 4(3), 527–541. <https://doi.org/10.46328/ijte.184>
- Karabuz, O., & Ogan-Bekiroglu, F. (2020). Pre-Service Teachers' Technological Pedagogical Content Knowledge (TPCK) Related to Calculator-Based Laboratory and Contextual Factors Influencing Their TPCK. *Journal of Curriculum and Teaching*, 9(3), 57–75. <https://doi.org/10.5430/jct.v9n3p57>
- Karaca, F. (2015). An Investigation of Preservice Teachers' Technological Pedagogical Content Knowledge Based on a Variety of Characteristics. *International Journal of Higher Education*, 4(4), 128–136. <https://doi.org/10.5430/ijhe.v4n4p128>
- Karakus, F. (2018). An Examination of Pre-Service Teachers' Technological Pedagogical Content Knowledge and Beliefs Using Computer Technology in Mathematics Instruction. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, 3., 3. <http://files.eric.ed.gov/fulltext/EJ1199683.pdf>



- Karataş, T. Ö., & Başol, H. Ç. (2021). What Techno-effective Teachers Mean for Preservice Teachers of English: A Socio-Constructivist Study. *PASAA: Journal of Language Teaching and Learning in Thailand*, 62, 204–235. <https://files.eric.ed.gov/fulltext/EJ1334990.pdf>
- Kartal, B. (2022). Examining Preservice Mathematics Teachers' Technological Pedagogical Content Knowledge Development in The Natural Setting of A Teacher Preparation Program. *I.e.: Inquiry in Education i*, 14(2), 1–26. <https://files.eric.ed.gov/fulltext/EJ1379140.pdf>
- Kartal, B., & Çinar, C. (2018). Examining Pre-Service Mathematics Teachers' Beliefs of TPACK during a Method Course and Field Experience. *Malaysian Online Journal of Educational Technology*, 6(3), 11–37. <http://dx.doi.org/10.17220/mojet.2018.03.002>
- Kartal, T., & Afacan, O. (2017). Examining Turkish Pre-service Science Teachers' Technological Pedagogical Content Knowledge (TPACK) Based on Demographic Variables. *Journal of Turkish Science Education.*, 14(1), 1–22. <https://files.eric.ed.gov/fulltext/EJ1344309.pdf>
- Kaya-Uyanik, G., Gur-Erdogan, D., & Canan-Gungoren, O. (2019). Examination of the Relationship between Prospective Teachers' Occupational Anxiety and Technological Pedagogical Content Knowledge by Canonical Correlation. *International Journal of Educational Methodology*, 5(3), 407–420. <https://doi.org/10.12973/ijem.5.3.407>
- Kazu, I. Y., & Erten, P. (2014). Teachers' Technological Pedagogical Content Knowledge Self-Efficacies. *Journal of Education and Training Studies*, 2(2), 126–144. <https://doi.org/10.11114/jets.v2i2.261>
- Kiray, S. A. (2016). Development of a TPACK Self-efficacy Scale for Preservice Science Teachers. *International Journal of Research in Education and Science*, 2(2), 527–541. <https://doi.org/10.21890/ijres.64750>
- Kotzebue, L. V., Meier, M., Finger, A., Kremser, E., Huwer, J., Thoms, L.-J., Becker, S., Bruckermann, T., & Thyssen, C. (2021). The Framework DiKoLAN (Digital Competencies for Teaching in Science Education) as Basis for the Self-Assessment Tool DiKoLAN-Grid. *Education Sciences*, 11(12), 1–23. <https://doi.org/10.3390/educsci11120775>
- Kul, U., Aksu, Z., & Birisci, S. (2019). The Relationship between Technological Pedagogical Content Knowledge and Web 2.0 Self-Efficacy Beliefs. *International Online Journal of Educational Sciences*, 11(1), 198–213. <https://doi.org/10.15345/iojes.2019.01.014>



- Kusuma, I. P. 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. <https://files.eric.ed.gov/fulltext/EJ1358700.pdf>
- Laura, T., Akgul, Z., Balazhanova, K., Sholpan, T., Sholpan, S., & Saule, B. (2022). Development of readiness of future teachers of preschool organisations to innovative activity. *Cypriot Journal of Educational Sciences*, 17(6), 1972–1982. <https://doi.org/10.18844/cjes.v17i6.7547>
- Li, L. (2021). Learning Together Online: Insights into Knowledge Construction of Language Teachers in a CSCL Environment. *Iranian Journal of Language Teaching Research*, 9(3), 39–62. <https://doi.org/10.30466/ijltr.2021.121075>
- Love, M. (2020). How EFL Teacher Trainees in a Tesol Graduate Program Integrate Tools and Platforms into Teaching Eap. *Teaching English With Technology*, 20(5), 38–65. <https://files.eric.ed.gov/fulltext/EJ1281551.pdf>
- Lu, L. (2014). Cultivating Reflective Practitioners in Technology Preparation: Constructing TPACK through Reflection. *Education Sciences*, 4(1), 13–35. <https://doi.org/10.3390/educsci4010013>
- Mailybayeva, Z. S., Kurmanbayev, M. R., & Yermentayeva, A. R. (2022). Group psychological and pedagogical technologies for developing the narrative ability in future specialists. *Cypriot Journal of Educational Sciences*, 17(7), 2371–2382. <https://doi.org/10.18844/cjes.v17i7.7688>
- Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record: The Voice of Scholarship in Education*, 108(6), 1017–1054. <https://doi.org/10.1111/j.1467-9620.2006.00684.x>
- Mustafa, A. M., Ulubey, Ö., & Ata, R. (2021). Adaptation of Technological Pedagogical Content Knowledge Scale into Turkish Culture within the Scope of 21st Century Skills. *Psycho-Educational Research Reviews*, 10(1), 77–91. <http://files.eric.ed.gov/fulltext/EJ1300203.pdf>
- Mutlu, Y., Polat, S., & Alan, S. (2019). Development of Preservice Mathematics Teachers' TPACK through Micro Teaching: Teaching the VuStat Program. *International Journal of Technology in Education and Science*, 3(2), 107–118. <https://files.eric.ed.gov/fulltext/EJ1227053.pdf>



- Nordin, H., & Tengku Ariffin, T. F. (2016). Validation of a Technological Pedagogical Content Knowledge Instrument in a Malaysian Secondary School Context. *Malaysian Journal of Learning and Instruction*, 13(1), 1–24. <https://doi.org/10.32890/mjli2016.13.1.1>
- Önal, N., & Alemdağ, E. (2018). Educational Website Design Process: Changes in TPACK Competencies and Experiences. *International Journal of Progressive Education*, 14(1), 88–104. <https://doi.org/10.29329/ijpe.2018.129.7>
- Oz, H. (2015). Assessing Pre-service English as a Foreign Language Teachers' Technological Pedagogical Content Knowledge. *International Education Studies*, 8(5), 119–130. <https://doi.org/10.5539/ies.v8n5p119>
- Özçakir, B. (2019). Prospective Mathematics Teachers' Technology Usages: A Case for Dynamic Geometry Software. *Acta Didactica Napocensia*, 12(1), 1–16. <https://doi.org/10.24193/adn.12.1.1>
- Özgen, K., & Narlı, S. (2019). Intelligent Data Analysis of Interactions and Relationships among Technological Pedagogical Content Knowledge Constructs via Rough Set Analysis. *Contemporary Educational Technology*, 11(1), 77–98. <https://doi.org/10.30935/cet.646769>
- Peng, L. (2020). Practice-Based Technology Teaching Assistantship Program: Preparing Teacher Educators to Support Teacher Candidates' Integration of Technological, Pedagogical, and Content Knowledge. *The Excellence in Education Journal*, 9(1), 85–103. <http://files.eric.ed.gov/fulltext/EJ1246800.pdf>
- 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. <https://files.eric.ed.gov/fulltext/EJ1213368.pdf>
- Rakes, C. R., Stites, M. L., Ronau, R. N., Bush, S. B., Fisher, M. H., Safi, F., Desai, S., Schmidt, A., Andreasen, J. B., Saderholm, J., Amick, L., Mohr-Schroeder, M. J., & Viera, J. (2022). Teaching Mathematics with Technology: TPACK and Effective Teaching Practices. *Education Sciences*, 12(2), 1–16. <https://doi.org/10.3390/educsci12020133>
- Saltan, F. (2017). Online Case-based Learning Design for Facilitating Classroom Teachers' Development of Technological, Pedagogical, and Content Knowledge. *European Journal of Contemporary Education*, 6(2), 308–316. <https://doi.org/10.13187/ejced.2017.2.308>
- Saralar-Aras, İ., & BiRgiLi, B. (2022). An Assessment of Pre-Service Mathematics Teachers' Techno-Pedagogical Content Knowledge regarding Geometry. *International Journal of*



Psychology and Educational Studies, 9(4), 1307–1327.
<https://doi.org/10.52380/ijpes.2022.9.4.920>

- Sensoy, O., & Yildirim, H. I. (2018). Impact of Technological Pedagogical Content Knowledge Based Education Applications on Prospective Teachers' Self-Efficacy Belief Levels Toward Science Education. *Journal of Education and Training Studies*, 6(10), 29–38. <https://doi.org/10.11114/jets.v6i10.3433>
- Şentürk, Ş. (2019). Investigation of Pre-service Teachers' Techno-pedagogical Skills and Lifelong Learning Tendencies. *Participatory Educational Research*, 6(2), 78–92. <https://doi.org/10.17275/per.19.14.6.2>
- Setiawan, H., & Phillipson, S. (2020). The Correlation Between Social Media Usage in Academic Context and Self-Efficacy Towards TPACK of Prospective Science Teachers in Indonesia. *Journal of Science Learning*, 3(2), 106–116. <https://doi.org/10.17509/jsl.v3i2.22242>
- Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14. <https://doi.org/10.3102/0013189x015002004>
- Simsek, O., & Yazar, T. (2019). Examining the Self-Efficacy of Prospective Teachers in Technology Integration According to their Subject Areas: The Case of Turkey. *Contemporary Educational Technology*, 10(3), 289–308. <https://doi.org/10.30935/cet.590105>
- Süzük, E., & Akinci, T. (2021). Comparing Pre-Service Teachers' Self-Confidence Levels in Technological Pedagogical Content Knowledge in Terms of Several Variables. *Journal of Education and Learning*, 10(1), 82–93. <https://doi.org/10.5539/jel.v10n1p82>
- Taflı, T. (2021). A comparative study on TPACK self-efficacy of prospective Biology teachers from the faculties of education & science. *International Journal of Curriculum and Instruction*, 13(3), 2957–2980. <https://files.eric.ed.gov/fulltext/EJ1312866.pdf>
- Thohir, M. A., Yuliati, L., Ahdhianto, E., Untari, E., & Yanti, F. A. (2021). Exploring the Relationship Between Personality Traits and TPACK-Web of Pre-service Teacher. *Contemporary Educational Technology*, 13(4), 1–16. <https://doi.org/10.30935/cedtech/11128>
- Torun, F. (2020). The Effect of a Textbook Preparation Process Supported by Instructional Technology Tools on the TPACK Self-Confidence levels of Prospective Social Studies Teachers. *Review of International Geographical Education Online*, 10(2), 115–140. <https://doi.org/10.33403/rigeo.691943>



- Turgut, Y. (2017). A comparison of pre-service, in-service and formation program for teachers' perceptions of technological pedagogical content knowledge (TPACK) in English language teaching (ELT). *Educational Research and Reviews*, 12(22), 1091–1106. <https://doi.org/10.5897/ERR2017.3311>
- Ulusoy, M. (2020). Pre-Service Teachers as Creators and Students as Viewers of Children's Literature-Related Digital Stories: A Formative Experiment. *International Journal of Progressive Education*, 16(6), 365–389. <https://doi.org/10.29329/ijpe.2020.280.23>
- Ünal, K., & Yelken, T. Y. (2020). The Effects of Pre-service English Language Teachers' Making Vocabulary Learning Materials in Web-Supported Situated Learning Environment on Their Vocabulary Learning. *English Language Teaching*, 13(4), 52–75. <https://doi.org/10.5539/elt.v13n4p52>
- Ünveren BiLgiÇ, E. N. (2022). The relationship between technological pedagogical content knowledge of mathematics teacher candidates and teaching mathematics anxiety. *Journal of Educational Technology and Online Learning*, 5(3), 619–635. <https://doi.org/10.31681/jetol.1115994>
- Widayarsi, F., Masykuri, M., Mahardiani, L., Saputro, S., & Yamtinah, S. (2022). Measuring the Effect of Subject-Specific Pedagogy on TPACK through Flipped Learning in E-Learning Classroom. *International Journal of Instruction*, 15(3), 1007–1030. <https://doi.org/10.29333/iji.2022.15354a>
- Wright, B., & Akgunduz, D. (2018). The relationship between technological pedagogical content knowledge (TPACK) self-efficacy belief levels and the usage of Web 2.0 applications of pre-service science teachers. *World Journal on Educational Technology: Current Issues*, 10(1), 52–69. <https://doi.org/10.18844/wjet.v10i1.3187>
- Yildiz, A. (2017). The Factors Affecting Techno-Pedagogical Competencies and Critical Thinking Skills of Preservice Mathematics Teachers. *Malaysian Online Journal of Educational Sciences*, 5(2), 66–81. <https://files.eric.ed.gov/fulltext/EJ1142510.pdf>
- Yildiz, H., & Gokcek, T. (2017). The Development Process of a Mathematic Teacher's Technological Pedagogical Content Knowledge. *European Journal of Educational Research*, 7(1), 9–29. <https://doi.org/10.12973/eu-jer.7.1.9>