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# A SYSTEMATIC REVIEW OF TPACK RESEARCH ON ENGLISH LANGUAGE TEACHING

## *UMA REVISÃO SISTEMÁTICA DA PESQUISA TPACK SOBRE ENSINO DA LÍNGUA INGLESA*

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**ABSTRACT**

Developments in the field of educational technology have accelerated research on Technological Pedagogical and Content Knowledge (TPACK). As the number of the TPACK studies has been burgeoning, the need for a categorization study of the past research has emerged. Therefore, the objective of this systematic review study is to present a categorization table of TPACK studies in three main themes, namely, understanding TPACK, measuring TPACK and developing TPACK. In the study, the distribution of the articles in terms of the publishing year, country, methodology and the participants were aimed to investigate. For this purpose, 39 journal articles which were browsed in the Web of Science index and published between the years of 2013 and 2024 were examined. The results revealed that the number of the TPACK studies decreased from the year of 2021 on, the United States of America was the leading country with the most TPACK studies, quantitative design was the most preferred research design, and the majority of the studies were conducted with pre-service teachers for developing their TPACK level.

**Keywords:** TPACK, technology integration, English Language Teaching (ELT), systematic review.

**RESUMO**

Os desenvolvimentos no campo da tecnologia educacional aceleraram a pesquisa em Conhecimento Tecnológico, Pedagógico e de Conteúdo (TPACK). À medida que o número de estudos TPACK tem aumentado, surgiu a necessidade de um estudo de categorização das pesquisas anteriores. Portanto, o objetivo deste estudo de revisão sistemática é apresentar uma tabela de categorização dos estudos TPACK em três temas principais, a saber, compreensão do TPACK, medição do TPACK e desenvolvimento do TPACK. No estudo, objetivou-se investigar a distribuição dos artigos quanto ao ano de publicação, país, metodologia e participantes. Para tanto, foram examinados 39 artigos de periódicos navegados no índice Web of Science e publicados entre os anos de 2013 e 2024. Os resultados revelaram que o número de estudos TPACK diminuiu a partir do ano de 2021, os Estados Unidos da América foram o país líder com o maior número de estudos TPACK, o desenho quantitativo foi o desenho de investigação preferido e a maioria dos estudos foram realizados com professores em formação para desenvolver seu nível TPACK.

**Palavras-chave:** TPACK, integração tecnológica, Ensino de Língua Inglesa (ELT), revisão sistemática.

## Introduction

The issue of technology integration has received considerable attention in the field of English language teaching. As technology use has become widespread, serious concerns over using the correct tool in an appropriate manner for language teaching purposes have increased. Researchers have attempted to develop models for technology integration and Technological Pedagogical and Content Knowledge (TPACK) framework is the result of such an endeavor. Built on Shulman's Pedagogical Content Knowledge (1986), TPACK framework was introduced to the scientific community in almost three decades ago by Mishra and Koehler. Initially the framework was made up of the acronyms of three core knowledge types as TPCK but later it was changed to TPACK as a 'Total PACKage' for effective teaching through technology (THOMPSON & MISHRA, 2007). As demonstrated in Figure 1, TPACK is made up of three basic knowledge domains and their integrations. Each knowledge type represented in the framework is explained briefly.

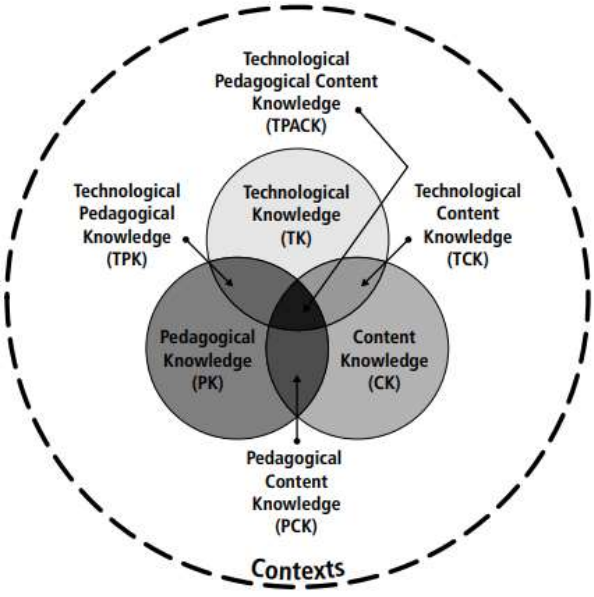
*Technological Knowledge (TK):* Even though TK simply refers to the knowledge about the technological tools, defining it precisely is rather a complex task on account of the continuously changing nature of the technology. Therefore, instead of the traditional computer literacy definition, having a deeper understanding of information processing, applying the knowledge in everyday

problem-solving tasks and adapting the rapid changes easily represent this domain better (KOEHLER, MISHRA & CAIN, 2013).

*Pedagogical Knowledge (PK):* PK is related to the answers of the questions that begin with 'how'. How does a student learn, how can I evaluate the student's learning, are among these questions. PK represents the knowledge of teaching methods and strategies, classroom management, lesson plan development and student assessment.

*Content Knowledge (CK):* CK represents the 'what' dimension. Simply it refers to the subject matter knowledge. Shulman (1986) extends the definition through giving the details such as knowledge about the concepts, theories, ideas, established practices and approaches. In the field of English language teaching, for example, content knowledge includes the knowledge about the direct method, relative clauses and phonetics alphabet.

Figure 1 – The TPACK Framework (Koehler, Mishra and Cain, 2013)




Source: Author.

Technological Pedagogical Knowledge (TPK): TPK refers to the knowledge about the pedagogical affordances and constraints of the tools in order to have the greatest benefits of them in educational settings. Therefore, TPK requires teachers

to broaden their horizons when selecting the technology and to consider its suitability for the target level, age and the needs.

Technological Content Knowledge (TCK): Technology and the subject matter has a reciprocal relationship. The selected technology can constrain or extend the content representations. For example, in language teaching utilizing a digital album increases the amount of the vocabulary to be taught. On the other hand, in some occasions the subject matter has the determining power on the technology selection. Conversation clubs for speaking skill, for example, require video conferencing tools. TCK refers to the understanding of this reciprocal relationship between the technology and the discipline area.

Pedagogical Content Knowledge (PCK): PCK refers to the deep understanding of what makes a particular content easy to teach, what strategies are best suited for the content representations and what direction is needed to take for teaching a specific information. Additionally, it requires knowledge of the target audience in terms of their background, interests and needs. Therefore, PCK is critical for teachers in order to ensure the success of instruction.

Technological Pedagogical and Content Knowledge (TPACK): Described as 'emergent' form of knowledge (Koehler, Mishra & Cain, 2013), TPACK is at the center of the framework. It refers to the ability of selecting and navigating the appropriate technology through employing robust strategies for achieving the objectives. The key aspect of TPACK is the harmony between the three core knowledge dimensions. Even though the TPACK framework was developed through the addition of technology dimension to Shulman's PCK, it is not the sole component of the framework. Neither is there a specific way of selecting a particular technology for achieving an objective. TPACK framework allows for flexibility when integrating technology into instruction therefore employing the correct combination of the seven dimensions is pivotal to the success of TPACK.

***Literature Review***

A detailed examination of existing literature on TPACK results in several review studies (CHAI, KOH, & TSAI, 2013; IRWANTO,2021; RODRIGUEZ MORENO ET AL., 2019; SOLER-COSTA ET AL. 2021; VOOGT, FISSER, ROBLIN, TONDEUR & VAN BRAAK, 2013; WILLERMARK, 2018; WU, 2013; TÜTÜNIŞ ET AL, 2022). While these studies differ in scope and sampling, all of them has a contribution to the understanding the theoretical basis of TPACK and its development over time.

To begin with, Chai et al. (2013) reviewed 74 journal publications and results showed that TPACK is a burgeoning area but the number of discipline-specific studies is limited and there are no studies conducted specifically for language learning. In the same year two more TPACK review studies were published. Wu (2013) reviewed 24 empirical studies published between 2002 and 2011 on SSCI database. Results indicated that the number of TPACK studies increased specifically after 2009. Another review was conducted by Voogt et al. (2013) and focused on the theoretical framework of TPACK in the studies published between 2005 and 2011. Results suggested that there were three different views regarding the TPACK construct: (*a) TPACK as a unique body of knowledge, (b) TPACK as an extension of Shulman's PCK* and *(c) TPACK as an intersection of content, pedagogy and technology.* Another conclusion drawn from the review was that the differences in the notion of TPACK impacted the TPACK measurement.

The review conducted by Willermark (2018) focused on teacher TPACK in empirical studies published between 2011 and 2016 on SSCI database. It was revealed that the number of the studies increased in 2013, student teachers were the most frequently employed study group, quantitative research design was the most frequently applied research design and science was the most studied discipline.

In a small scale review of 37 articles published between 2014 and 2017 and accessed on Web of Science and Scopus databases, the results suggested that quantitative design was the most preferred design, primary and higher education students were the most studied subject group (RODRIGUEZ MORENO ET AL., 2019). One more finding of the review was related to the fewer number of the longitudinal

empirical studies that investigate teachers' actions when they apply TPACK-based instruction.

Among the review studies, one of the largest scale bibliometric study was conducted by Soler-Costa and his colleagues in which 471 publications were analyzed (SOLER-COSTA ET AL., 2021). The results of their research show consistency with the earlier review studies which suggest the rising trend of TPACK. Besides, it was revealed that the United States was the nation with the most TPACK research (n=124) followed by Turkey (n=80), English language was the most preferred language (n=470), Educational research was the area with the most publications (n=471) and the most cited work (n=2238) belongs to Mishra and Koehler (2006).

The most recent review study intended to explore TPACK in the field of language teaching (TSENG ET AL.,2022). The review covered 51 studies published from 2011 to 2019. The results indicated that the number of TPACK research peaked in 2015 and most of the studies were conducted in Asia and the Middle East. One of the most striking findings was related to the interrelated relationship between the sub-components of the framework since the analysis of the TPACK- assessment research suggested that in most of the studies survey items were contextualized to make them more distinguishable. Accordingly, the researchers emphasized the need to apply discipline-specific strategies when determining the survey items.

Collectively, these studies outline the TPACK literature with regard to research areas, publication years and methodological perspective. The implications from the studies reviewed so far have assisted to the future researchers in shaping their research direction. The present study distinguishes from the existing reviews in terms of its aim for making a theme-based categorization. Even though several TPACK reviews have been conducted so far, none of them -to the researcher's best knowledge- investigated the TPACK literature with a lens for making a theme-based categorization. Only the critical review by Tseng and his colleagues (2022) organized the articles into four areas as (a) exploring TPACK, (b) assessing TPACK, (c) developing TPACK, and (d) applying TPACK. However, the review by Tseng et al. (2022) investigates the TPACK literature up to the year of 2019. When the

transforming effects of the Covid 19 outbreak in the field of educational technology in general and language teaching in particular are considered, having a closer look at the developments that occurred after 2020 is a necessity. Therefore, this study is significant for including the review of TPACK research from 2013 to 2024 and seeks to answer the following questions:

1. How can the TPACK studies be categorized in terms of publishing year, methodology, participants and the country?
2. What are the trending themes of TPACK studies in the 2013-2024 period?

## Method

### *Research Design*

In the study, a systematic review of literature was adopted as the research design. Systematic reviews have foremost been developed within medical science as a way to synthesize research findings in a systematic, transparent, and reproducible way and have been referred to as the gold standard among reviews (DAVIS ET AL., 2014).

### *Sampling and Data Collection*

The study specifically focused on TPACK researches conducted from 2013 to 2024 in the field of English language teaching accessible via Web of Science database, using the terms 'technological pedagogical content knowledge','technological pedagogical and content knowledge', 'TPCK' or 'TPACK'. In order to access the studies in the field of English language teaching, another search was done through filtering the studies that have the words 'language', 'English', 'EFL' or 'ESL' in the titles and the abstract. In addition, this search focused on merely the journal articles excluding conference papers, book chapters and dissertations. As a result, 39 papers were found.

***Data Analysis***

The obtained data were analyzed through thematic analysis which is defined simply as a method for identifying and analyzing patterns in qualitative data. The strength of thematic analysis is based on its flexibility for analyzing both small and large datasets from those about people's understandings of a phenomena to those about the representation or construction of meaning in a particular phenomenon (Clarke & Braun, 2013). Thematic analysis follows six recursive phases which are (a) familiarization with the data, (b) coding, (c) searching for themes, (d) defining themes and (e) reporting. These steps were applied in the analysis of data for determining the themes as the following:

a) familiarization with the data: The researcher read the articles for several times to get informed about the research aims.
b) coding: The key phrases in the research questions and research aim statements were underlined. For example, papers devoted to explore the impact of a particular interference on the TPACK level were coded as 'TPACK intervention'.
c) searching for themes: In this step, the codes determined in the previous step were grouped based on their similarity.
d) defining themes: Similar codes were categorized into one main theme. For example, the codes 'TPACK intervention' and 'TPACK-based instruction' were categorized under the theme of '*developing TPACK*'.
e) reporting: This step refers to the act of writing up the research.

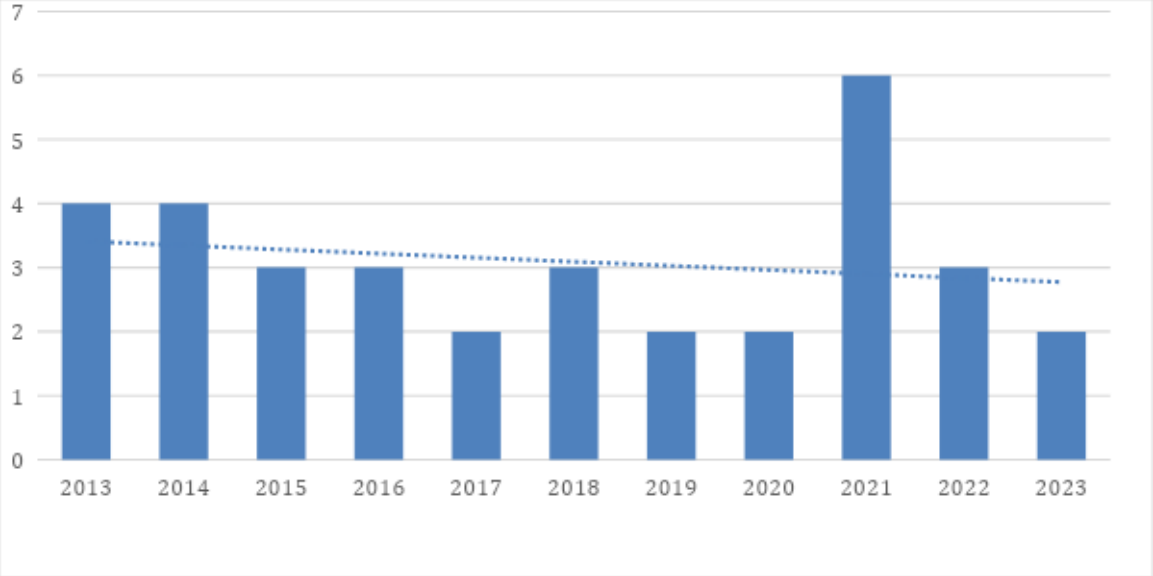
In order to promote coding reliability, another round of coding was performed one week after the first round of coding. The six steps were re-applied until complete match was ensured.

***Findings***

Findings of the study are presented referring to each research question as in the following.

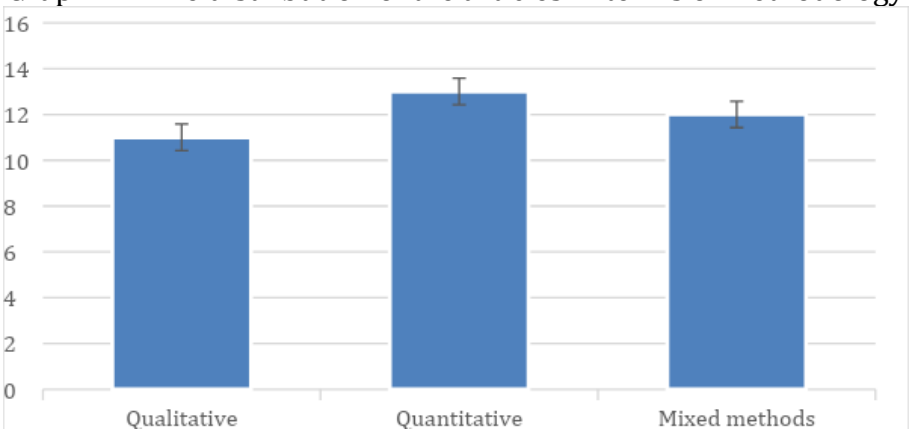
Findings for the first research question are presented in the Graphs I - V, which show the distribution of the articles in terms of the publishing year, methodology, participants and the country respectively.

Graph I – The distribution of the articles in terms of the publishing year



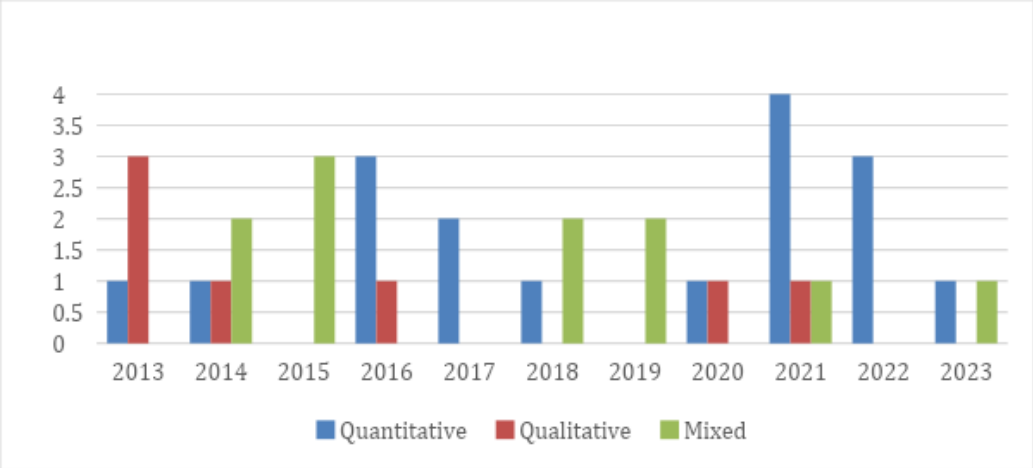

According to the information presented in Graph I, the number of TPACK research followed a balanced distribution with a total of 14 papers between the years 2013-2016. In the following years the number of the studies decreased to two for each year excluding the year of 2018. However, there is a sudden peak in the year 2021 with 6 (16 %) publications and what makes it more interesting is the finding that from different parts of the world the researchers contributed to the TPACK literature. However, the next year the number of TPACK studies decreased by half (n=3) and the two of them published in China. All in all, the findings regarding the distribution of the articles over the years indicate a downward trend.

Graph II – The distribution of the articles in terms of methodology



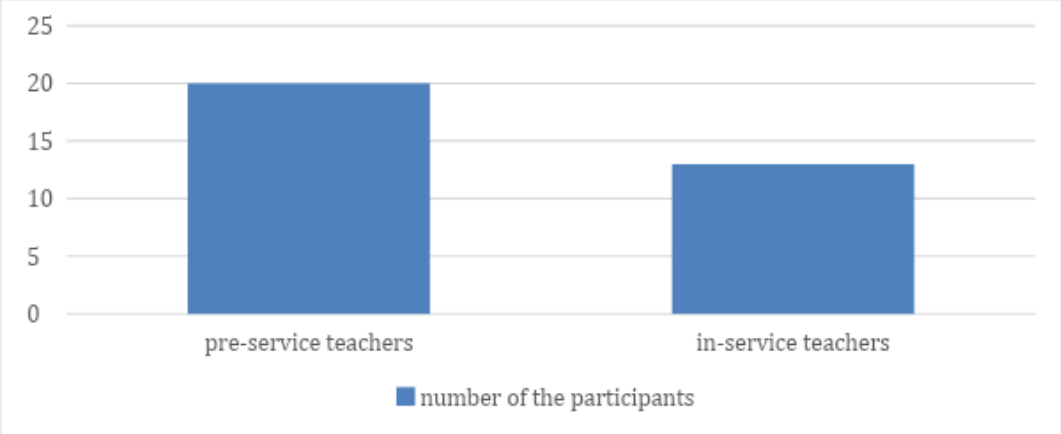
It is displayed in Graph II that quantitative research design is the most preferred framework (n=13) by a slight difference followed by mixed (n=12) and qualitative designs (n=11).

Graph III – The distribution of the articles in terms of methodology across the years



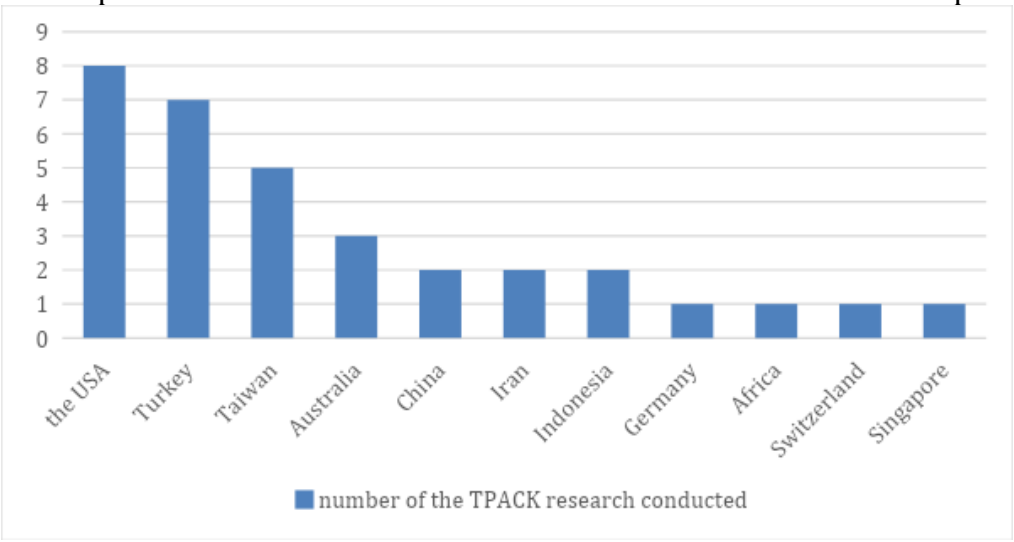

As indicated in Graph III, the methodological distribution of the articles fluctuates from year to year. For example, while there is not any mixed study in 2013, there are 2 studies with mixed design in 2014. The next year, it was found out that all of the studies employ mixed design but none of the studies employs mixed design in the years 2016, 2017, 2020 and 2022. The highest number of the studies (n=6) were found to be conducted in the year 2021 and four of them employ quantitative design. To sum up, findings suggest that methodological trends in TPACK research do not follow a linear pattern across the years and quantitative research design is the most preferred framework.

Graph IV – The distribution of the articles in terms of the participants




Analysis of the articles in terms of the participants indicates that 6 articles can be categorized as document reviews since they give theoretical information and historical development of the framework. Therefore, they are excluded from the analysis and the total number is determined to be 33. According to the information presented in Graph IV, 60 % (n=20) of all the articles employs pre service teachers and 40 % (n=13) of the reviews is conducted with in-service teachers.

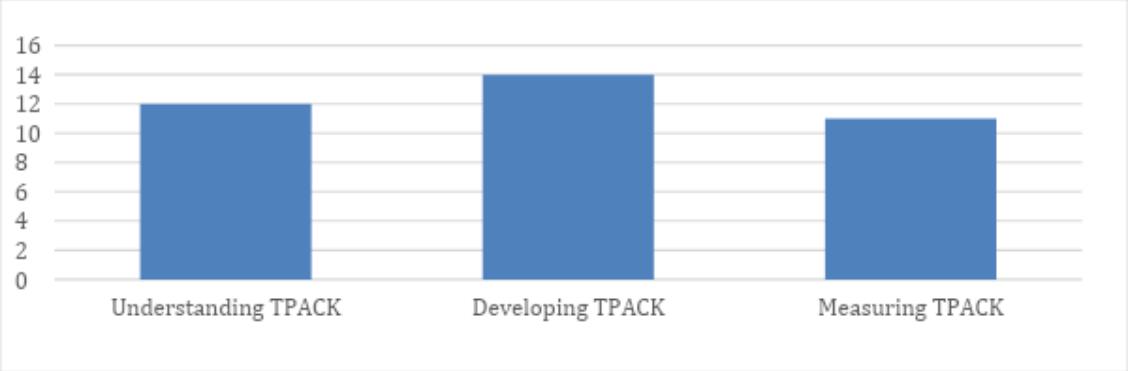
Graph V – The distribution of the articles in terms of the countries published




Graph V shows the findings regarding the analysis of the articles in terms of the countries where the research were conducted. As shown in the graph, the USA is the leading country with 8 TPACK studies followed by Turkey (n=7) and Taiwan (n=5).

Findings for the second research question, which aims to find out the trending themes in the field of TPACK, are presented in Graph VI. When the articles were analyzed in terms of the scope and the aim, three themes emerged as (*i) understanding TPACK, (ii) developing TPACK* and *(iii) measuring TPACK*.

Graph VI – The distribution of the articles in terms of the theme




From the distribution levels demonstrated in Graph VI, it is clearly seen that the number of the articles do not show a considerable difference in terms of the theme investigated. Developing TPACK is the most frequently researched theme with 14 papers and measuring TPACK is the least investigated theme with 11 papers.

The category of *developing TPACK* consists of articles that aim to develop the TPACK level of the participants through some intervention models such as TPACK-in-action model (e.g. Tai,2013), design-based learning principles (E.G. BARAN & UYGUN, 2016), subject specific TPACK modules (e.g. Lachner et al.,2021) and integrated course model (e.G. MOUZA, KARCHMER-KLEIN, NANDAKUMAR, OZDEN & HU; 2014).

To begin with, Koh and Divaharan (2013) applied a design-based research project in order to facilitate pre-service teachers' TPACK development. They implemented an instructional process which includes tutor modelling, hands-on exploration and group-based design. Having received theoretical underpinnings of ICT integration in a five-week-course, the student teachers were given the opportunity to explore the pedagogical uses of ICT tools in consultation of their tutor. First, the tutor models the pedagogical uses of a specific tool, then the

participants practice the technical functions of the selected tool, explore the lesson samples and finally design an ICT-integrated lesson. The study concluded that strategies such as tutor modelling and hands-on exploration fostered participants' TPACK development.

The aim of Tai (2015)'s study was to enhance the CALL competency of in service teachers through TPACK-in-Action Model. In this regard, a TPACK workshop was designed according to the five steps of TPACK-in-Action Model: a*) Modeling; b) Analyzing; c) Demonstrating; d) Application* and *e) Reflection.* In the workshop, the tutor introduced the selected tool and the participants analyzed the tool in terms of its affordances and limitations. Then, they developed lesson plans and reflected on the whole process. At the end of the study, the participants reported that the workshops helped them develop CALL integration skills and gave them opportunity to transform what they had learned into teaching activities.

A more recent study for developing the TPACK level of pre-service teachers was conducted by Lachner and his colleagues (LACHNER ET AL.,2021). In their quasi-experimental study, they developed TPACK modules and used the modules with the experiment group whereas the participants in the control group attended the courses without the TPACK module. From the findings it was concluded that technology-related self-efficacy and TPACK level of the pre-service teachers in the experiment group increased significantly.

The articles that present theoretical information about the TPACK framework, that aim to delineate the interactions between the knowledge dimensions and that explore TPACK in terms of some variables such as ICT usage, ICT competency etc. are categorized under the theme of *understanding TPACK* which is the second most popular category after *developing TPACK* (n=12). In this category, one of the most comprehensive works belongs to Koehler, Mishra and Cain (2013) which not only presents the theoretical basis of the TPACK framework but also discusses the latest developments in the field of TPACK with the aim of promoting the understanding. Together with some scholars, Koehler and Mishra published one more work in which theoretical, pedagogical and methodological issues related to TPACK are discussed (KOEHLER ET AL., 2014). The articles categorized under the

theme of understanding TPACK are not limited to the theoretical papers. In a study conducted with pre-service teachers in Taiwan, researchers aimed to decipher the ways of how the various forms of TPACK are enacted by the student teachers in their web-conferencing teaching environment (TSENG, CHENG AND YEH, 2019). The findings provide insights into how individual TPACK subdomains were reflected in an online teaching environment through design thinking.

With regard to the category of *measuring TPACK*, the research preferred varies in terms of the method undertaken such as self-report measures (surveys, questionnaires, and interviews), teaching artefacts (lesson plan, task design) and observation. Among them, the most widely used data collection tool is survey as it allows for accessing a large group of participants in a short time.

A closer analysis of the research on TPACK measurement displays that a number of surveys have been developed and utilized for TPACK measurement since the TPACK framework was announced to the academic field (E.G. ARCHAMBAULT, 2008; CHAI, KOH, TSAI, & TAN, 2011; KOH ET AL., 2010; SCHMIDT ET AL.,2009). However, some limitations have been detected and developing a TPACK survey which correctly addresses the seven knowledge domains and which can be used specifically in the field of English language teaching has been on the agenda of the researchers in the last decade. Pamuk et al. (2015), for example, developed an instrument which is composed of 38 items in seven knowledge domains and aims at delineating the relationship between the knowledge components. What stands out at the end of the study is that second-level knowledge types (TPK, TCK, and PCK) are more effective in predicting the TPACK development in comparison to the core knowledge types. Upon detecting the necessity of an instrument that addresses the subject-specific pedagogies and technologies, Baser, Kopcha & Ozden (2016) developed a 39-item TPACK-EFL survey for student teachers. However, it has been criticized for the overemphasis on technology for communication in the target language, especially for TCK and TPACK domains and a self-report questionnaire was developed (BOSTANCIOĞLU & HANDLEY, 2018). More recently, Schmid, Brienza and Petko (2020) raised some constrains of the existing instruments in terms of validity, reliability and practical applicability and developed a valid,

reliable, short questionnaire which they call TPACK.xs. An overview of research on TPACK surveys developed between the years of 2013-2024 indicates that progress has been made through identifying the limitations and developing instruments that address the constraints. Even though surveys are widely used for TPACK measurement, survey data is dependent on the self-measurement of the participants and does not always reflect the real situation. Therefore, majority of the researchers prefer to triangulate the survey data with data from teaching artefacts (CROSTHWAITE, LUCIANA & WIJAYA, 2023) and/or performance assessment (BRINKLEY-ETZKORN, 2018, MOUZA ET AL., 2014). For instance, in the research conducted by Mouza et al. (2014) the participants wrote reflective case reports which provide insights into the participants' planning, organizing, integrating and using technology in their projects. Another study which combines survey data with data from lesson plans and the researchers' field notes belongs to Lee and Kim (2014). Thus, tangible information regarding the TPACK development of the participants is gained. In summary, research on TPACK measurement varies in terms of the data collection method and majority of the studies provide data from multiple sources.

Overall, these results indicate that recent research in the field of TPACK mostly employs quantitative framework and aims to develop the TPACK level of the pre service teachers. The USA is the leading country with the highest number of the TPACK publications but there is a downward trend between the years 2013-2024.

## Discussion and Conclusions

In this study, the TPACK research conducted between the years of 2013-2024 and published on Web of Science database was reviewed in order to make a categorization in terms of the years and countries published, participants, research framework and the theme. The findings for the distribution of the articles in terms of the years show that TPACK research follows a downward trend excluding the year of 2021 when there was a peak with 6 (16 %) publications. A possible explanation for this might be the Covid outbreak during which online teaching gained popularity

and the importance of successful technology integration became evident. The finding regarding the sudden popularity of TPACK in the year of 2021 is supported by the findings of the most recent review in the TPACK literature. Irwanto (2021) reviewed 106 papers published between the years 2010-2021 and found that there were 10 TPACK publications on Springer database only in the year of 2021. Based on this finding, he predicted that there will be more publications in the future. Contrary to the predictions, the findings of the current review demonstrate that the number of the TPACK studies is on decrease for the last two years. It may be too early to draw conclusions about the long term popularity of TPACK but it is a reality that technology is a revolving phenomenon and as the advances in the educational technology continue more TPACK research will be needed.

With respect to the findings regarding the most preferred research design, quantitative design is the most preferred framework (n=13) and in all of the quantitative studies surveys are widely used to collect the data. This finding is echoed in previous literature, for example, in their review of 37 papers published between the years 2014-2017, Rodriguez Moreno et al. (2018) found that quantitative methodology was used in 43% of all the papers. Similarly, in her review of 107 papers published between the years 2011-2016, Willermark (2018) calculated that quantitative design was the most frequently applied (p=46 %) research design. In this review TPACK-EFL survey (Baser, Kopcha & Ozden, 2015) is the most preferred survey. The popularity of quantitative design can be attributed to its time-saving-nature in terms of collecting large amount of data in a short time. However, as indicated in the findings, mixed design is an emerging trend in recent years with a view to triangulate data. Therefore, mixed framework can be expected to take dominance in the future.

Findings for the analysis of the articles in terms of the participants indicate that 60% of the studies were conducted with pre service teachers. This finding is consistent with Willermark (2018)'s findings and is likely to be the outcome of increased focus on developing the ICT integration skills of pre-service teachers in teacher education institutions (Turgut, 2017). Since teacher education institutions are expected to provide the student teachers with the required skills to teach

through ICT, most of the universities updated their curriculum in a way to focus more on ICT integrated teaching. Therefore, the dominance of the pre-service teachers in the articles is quite an expected outcome.

As for the most productive countries in the field of TPACK research, the top three countries are the USA, Turkey and Taiwan. These findings are consistent with the findings of Irwanto (2021) who found that the US ranked first with 34 papers among 15 countries reviewed between the years 2010-2021. The same result was obtained in an earlier review study conducted by Chai et al. (2013). In their analysis of 74 papers reviewed between the years 2003- 2010, they found out that North America was the leading country with 49 papers. The popularity of TPACK research in the US can be attributed to the higher use of technology and the high amount of budget for research. Besides, the findings indicate that countries from all around the world have contributed to the TPACK literature, which indicates that TPACK has a wide spectrum of researchers worldwide.

On the question of the trending themes in TPACK research it was found that *developing TPACK* is the most popular theme. This finding can be attributed to the emphasis on digital teacher education and effective technology integration (TSENG, CHENG & YEH, 2019). The founders of the TPACK framework, Koehler and Mishra, describe teaching with technology as a complex and ill-structured task since it involves understanding the content, pedagogy, technology and their relationship with each other (KOEHLER & MISHRA, 2009). Therefore, the complex nature of TPACK requires the study of its development in authentic contexts as mentioned by Baran and Uygun (2016). The special focus on professional development programs and the necessity of having teachers who are competent in the seven knowledge domains result in the increase of the research conducted for TPACK development.

These findings have significant implications for the understanding of the research direction in the field of TPACK for the last decade. Looking at the decreasing trend in the field of TPACK, there appears an inconsistency between the theory and practice. In other words, gradual decrease in the number of TPACK articles contradicts with the developments in educational technology (SOLER-

COSTA ET AL., 2021). Suggestions for more TPACK investigation and the topics that need to be studied are given below.

***Suggestions***

The scope of this research was limited to research articles that were published in the Web of Science index between the years 2013-2024. Further research which is wider in scope need to be carried out in order to see the big picture. In terms of directions for future studies, more research need to be conducted with experienced teachers in order to measure their TPACK level and scrutinize the ways for promoting TPACK. Besides, the findings of the current review indicate the scarcity of TPACK research with a longitudinal point of view. Therefore, it would be interesting to track the TPACK level of student teachers until they reach ten years of teaching experience. Moreover, comparative study is needed to fully understand the impact of TPACK-based development modules. This review was conducted with the aim of making a categorization of the TPACK research. The categorization is believed to be of help to researchers who wish to take a snapshot of the recent literature. Taken together with the past review studies, the findings of this study will serve as a bridge from past to future of the TPACK research field.

**Acknowledgment**

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LACHNER, A., FABIAN, A., FRANKE, U., PREIß, J., JACOB, L., FÜHRER, C., & THOMAS, P. Fostering pre-service teachers' technological pedagogical content knowledge (TPACK): A quasi-experimental field study. **Computers & Education**, 174, 104304, 2021.

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**Appendix**

Categorization of the TPACK research

| TPACK Study | Country | Study Group | Methodology | Theme |
|---|---|---|---|---|
| Ngandeu, J. B. (2020). Dealing with barriers to the integration of computer-assisted language learning in an African low-tech context: is the TPACK framework enough? An analysis of ICT integration in a low-tech context Joseph Blaise Ngandeu University of KwaZulu-Natal. *Per Linguam: a Journal of Language Learning= Per Linguam: Tydskrif vir Taalaanleer*, *36*(2), 90-103. | Africa | pre-service teachers | Qualitative | Developing TPACK |
| Anderson, A., Barham, N., & Northcote, M. (2013). Using the TPACK framework to unite disciplines in online learning. *Australasian Journal of Educational Technology*, *29*(4). | Australia | lecturers | Qualitative | Understanding TPACK |
| Kabakci Yurdakul, I., & Çoklar, A. N. (2014). Modeling preservice teachers' TPACK competencies based on ICT usage. *Journal of Computer Assisted Learning*, *30*(4), 363-376. | Turkey | pre-service teachers | Quantitative | Developing TPACK |
| Baran, E., & Uygun, E. (2016). Putting technological, pedagogical, and content knowledge (TPACK) in action: An integrated TPACK-design-based learning (DBL) approach. *Australasian journal of educational technology*, *32*(2). | Turkey | pre-service teachers | Mixed | Developing TPACK |

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| Baser, D., Kopcha, T. J., & Ozden, M. Y. (2016). Developing a technological pedagogical content knowledge (TPACK) assessment for preservice teachers learning to teach English as a foreign language. *Computer Assisted Language Learning*, *29*(4), 749-764. | Turkey | pre-service teachers | Quantitative | Measuring TPACK |
| Tseng, J. J. (2016). Developing an instrument for assessing technological pedagogical content knowledge as perceived by EFL students. *Computer Assisted Language Learning*, *29*(2), 302-315. | China | pre-service teachers | Quantitative | Measuring TPACK |
| Pamuk, S., Ergun, M., Cakir, R., Yilmaz, H. B., & Ayas, C. (2015). Exploring relationships among TPACK components and development of the TPACK instrument. *Education and Information Technologies*, *20*, 241-263. | Turkey | pre-service teachers | Quantitative | Measuring TPACK |
| Bostancıoğlu, A., & Handley, Z. (2018). Developing and validating a questionnaire for evaluating the EFL 'Total PACKage': Technological Pedagogical Content Knowledge (TPACK) for English as a Foreign Language (EFL). *Computer assisted language learning*, *31*(5-6), 572-598. | Turkey | pre-service teachers | Quantitative | Measuring TPACK |
| Nazari, N., Nafissi, Z., Estaji, M., Marandi, S. S., & Wang, S. (2019). Evaluating novice and experienced EFL teachers' perceived TPACK for their professional development. Cogent Education, 6 (1). | Iran | teachers | Mixed | Measuring TPACK |
| Hsu, L. (2016). Examining EFL teachers' technological pedagogical content knowledge and the adoption of mobile-assisted language learning: A partial least square | Taiwan | teachers | Quantitative | Understanding TPACK |

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| approach. *Computer Assisted Language Learning*, *29*(8), 1287-1297. | | | | |
| 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. | Indonesia | pre-service teachers | Qualitative | Developing TPACK |
| Çam, Ş. S., & Erdamar Koç, G. (2021). A needs analysis study on technological pedagogical content knowledge of faculty members. *Education and Information Technologies*, *26*(5), 5337-5363. | Turkey | teachers | Qualitative | Measuring TPACK |
| Lachner, A., Fabian, A., Franke, U., Preiß, J., Jacob, L., Führer, C., ... & Thomas, P. (2021). Fostering pre-service teachers' technological pedagogical content knowledge (TPACK): A quasi-experimental field study. *Computers & Education*, *174*, 104304. | Germany | pre-service teachers | Mixed | Developing TPACK |
| Sointu, E., Valtonen, T., Kukkonen, J., Kärkkäinen, S., Koskela, T., Pöntinen, S., ... & Mäkitalo-Siegl, K. (2016, March). Quasi-experimental study for enhancing pre-service teachers' TPACK. In *Society for Information Technology & Teacher Education International Conference* (pp. 3067-3074). Association for the Advancement of Computing in Education (AACE). | The USA | pre-service teachers | Mixed | Developing TPACK |
| Tseng, J. J., Cheng, Y. S., & Yeh, H. N. (2019). How pre-service English teachers enact TPACK in the context of | Taiwan | pre-service teachers | Mixed | Understanding TPACK |

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| web-conferencing teaching: A design thinking approach. *Computers & Education*, *128*, 171-182. | | | | |
| Yeh, Y. F., Chan, K. K. H., & Hsu, Y. S. (2021). Toward a framework that connects individual TPACK and collective TPACK: A systematic review of TPACK studies investigating teacher collaborative discourse in the learning by design process. *Computers & Education*, *171*, 104238. | Taiwan | teachers | Qualitative | Understanding TPACK |
| Mouza, C., Karchmer-Klein, R., Nandakumar, R., Ozden, S. Y., & Hu, L. (2014). Investigating the impact of an integrated approach to the development of preservice teachers' technological pedagogical content knowledge (TPACK). *Computers & Education*, *71*, 206-221. | The USA | Pre-service teachers | Mixed | Developing TPACK |
| Zhang, M., & Chen, S. (2022). Modeling dichotomous technology use among university EFL teachers in China: The roles of TPACK, affective and evaluative attitudes towards technology. *Cogent Education*, *9*(1), 2013396. | China | teachers | Quantitative | Understanding TPACK |
| Tømte, C., Enochsson, A. B., Buskqvist, U., & Kårstein, A. (2015). Educating online student teachers to master professional digital competence: The TPACK-framework goes online. *Computers & Education*, *84*, 26-35. | Norway | Pre-service teachers | Mixed | Developing TPACK |
| Celik, I., Sahin, I., & Akturk, A. O. (2014). Analysis of the relations among the components of technological pedagogical and content knowledge (TPACK): A structural equation model. *Journal of educational computing research*, *51*(1), 1-22. | Turkey | Pre-service teachers | Quantitative | Understanding TPACK |

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| Schmid, M., Brianza, E., & Petko, D. (2020). Developing a short assessment instrument for Technological Pedagogical Content Knowledge (TPACK. xs) and comparing the factor structure of an integrative and a transformative model. *Computers & Education*, *157*, 103967. | Switzerland | Pre-service teachers | Quantitative | Measuring TPACK |
| Schmid, M., Brianza, E., & Petko, D. (2021). Self-reported technological pedagogical content knowledge (TPACK) of pre-service teachers in relation to digital technology use in lesson plans. *Computers in Human Behavior*, *115*, 106586. | Switzerland | Pre-service teachers | Quantitative | Understanding TPACK |
| Liu, T., Zhang, Z., & Gao, X. (2023). Pedagogical Design in Technology-Enhanced Language Education Research: A Scoping Review. *Sustainability*, *15*(7), 6069. | Australia | Pre-service teachers | Quantitative | Understanding TPACK |
| Brinkley-Etzkorn, K. E. (2018). Learning to teach online: Measuring the influence of faculty development training on teaching effectiveness through a TPACK lens. *The Internet and Higher Education*, *38*, 28-35. | The USA | teachers | Mixed | Developing TPACK |
| Bibi, S., & Khan, S. H. (2017). TPACK in action: A study of a teacher educator's thoughts when planning to use ICT. *Australasian Journal of Educational Technology*, *33*(4). | Australia | teachers | Qualitative | Understanding TPACK |
| Santos, J. M., & Castro, R. D. (2021). Technological Pedagogical content knowledge (TPACK) in action: Application of learning in the classroom by pre-service teachers (PST). *Social Sciences & Humanities Open*, *3*(1), 100110. | Philippines | Pre-service teachers | Mixed | Developing TPACK |

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| Ansyari, M. F. (2015). Designing and evaluating a professional development programme for basic technology integration in English as a foreign language (EFL) classrooms. *Australasian Journal of Educational Technology*, *31*(6). | Indonesia | Teachers | Mixed | Developing TPACK |
| Wang, A. Y. (2022). Understanding levels of technology integration: A TPACK scale for EFL teachers to promote 21st-century learning. *Education and Information Technologies*, *27*(7), 9935-9952. | China | Teachers | Quantitative | Measuring TPACK |
| Tai, S.-J. D. (2015). From TPACK-in-action workshops to classrooms: CALL competency developed and integrated. Language Learning & Technology, 19(1), 139–164. Retrieved from http://llt.msu.edu/issues/february2015/tai.pdf | Taiwan | Teachers | Mixed | Developing TPACK |
| Lee, C. J., & Kim, C. (2014). An implementation study of a TPACK-based instructional design model in a technology integration course. *Educational Technology Research and Development*, *62*, 437-460. | The USA | Pre-service teachers | Mixed | Developing TPACK |
| Muslimin, A. I., Mukminatien, N., & Ivone, F. M. (2023). TPACK-SAMR digital literacy competence, technostress, and teaching performance: Correlational study among EFL lecturers. Contemporary Educational Technology, 15(2), ep409. https://doi.org/10.30935/cedtech/12921 | Indonesia | Teachers | Mixed | Understanding TPACK |
| Lee, C. J., & Kim, C. (2017). A technological pedagogical content knowledge based instructional design model: a third version implementation study in a technology | The USA | Pre-service teachers | Qualitative | Developing TPACK |

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| integration course. *Educational Technology Research and Development*, *65*, 1627-1654. | | | | |
| Koh, J. H. L., & Divaharan, S. (2013). Towards a TPACK-fostering ICT instructional process for teachers: Lessons from the implementation of interactive whiteboard instruction. *Australasian Journal of Educational Technology*, *29*(2). | Singapore | Pre-service teachers | Qualitative | Developing TPACK |