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The Technological Pedagogical Content Knowledge (TPACK) model in primary education: A literature review

Il modello TPACK (Technological Pedagogical Content Knowledge) nell'istruzione primaria: una revisione della letteratura

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ABSTRACT This article presents the results of a systematic literature review conducted on the research works of doctoral students concerning the TPACK model in primary education and considering multiple roles, including those of teachers, students, and of the educational community. The procedure used was the one proposed by Kitchenham (2004). The selection of 15 doctoral theses was carried out after a search in the repositories TESEO, DIALNET, Doctoral Dissertations on the Net (TDR), Open theses, and Theses and dissertations (OATD), considering the period from the publication of the model by Mishra and Koehler (2006) until April 2020. The review was carried out analyzing open access, full text doctoral theses focusing on primary education. It is concluded that only 6,52% of the total number of theses about TPACK available on the data bases concerns primary education. Furthermore, 53,3% of the research related to the TPACK model in primary education is focused on teachers. These results are in line with those of a previous literature review carried out on the same topic that did not consider this type of literature (Paidicán & Arredondo, 2022b). It is recommended that research on TPACK be expanded, focusing on aspects related to educational management, initial education, and its articulation with primary education.

KEYWORDS Teachers' Competence; Educational Technology; Technological Pedagogical Content Knowledge (TPACK); Primary School Teachers; Teacher Training; Integration of Technology.

SOMMARIO Questo articolo presenta i risultati di una revisione sistematica della letteratura scientifica limitata a lavori di dottorato e associata al modello TPACK nell'istruzione primaria, che considera il ruolo degli insegnanti, degli studenti e della comunità educativa. La procedura utilizzata è quella proposta da Kitchenham (2004). La selezione di 15 tesi di dottorato è stata effettuata a partire da una ricerca negli archivi online TESEO, DIALNET, Doctoral Dissertations on the Net (TDR), Open theses, and Theses and Dissertations (OATD), considerando il periodo dalla pubblicazione del modello da parte di Mishra e Koehler (2006) fino ad aprile 2020. I criteri di inclusione erano: accesso aperto, testo completo, tesi di dottorato incentrate sull'istruzione primaria. Si è concluso che solo il 6,52% del numero totale di tesi sul TPACK disponibili nelle banche dati riguarda l'istruzione primaria. Inoltre, il 53,3% delle ricerche relative al modello TPACK nell'istruzione primaria è incentrato sugli insegnanti. Questi risultati sono in linea con quelli di una precedente revisione della letteratura condotta sullo stesso

argomento ma che non includeva lavori di dottorato (Paidicán & Arredondo, 2022b). Si raccomanda di ampliare la ricerca sul TPACK, concentrandosi sugli aspetti legati alla gestione dell'istruzione, alla formazione iniziale e alla sua articolazione con l'istruzione primaria.

PAROLE CHIAVE Competenze degli Insegnanti; Tecnologie Educative; Conoscenza dei Contenuti Pedagogici Tecnologici (TPACK); Insegnanti della Scuola Primaria; Formazione degli Insegnanti; Integrazione della Tecnologia.

1. Introduction

Teachers need a series of competencies to successfully design and conduct the teaching and learning process. The technological, pedagogical, and content knowledge model (TPACK), which proposes a way to look at the interaction between pedagogical, technological, and content teachers' competence, supplies a solid construct for integrating technology in the classroom (Koh & Chai, 2011; Koehler, Shin & Mishra, 2012; Mishra & Koehler, 2006). In TPACK, three central dimensions can be distinguished and the intersection between them allows for the identification of four others, as shown in Figure 1.

1) Technological Knowledge (TK): These are the skills needed to use ICT tools such as computers, projectors, cameras, digital video, whiteboards, the internet, and the skills needed to use different software programs (Koehler, Mishra, Kereluik, Shin, & Graham, 2014; Munyengabe, Yiyi, Haiyan, & Hitimana, 2017).
2) Content Knowledge (CK): These are skills related to the content to be taught. It should be noted that teaching and learning processes are enhanced if teachers are able to present knowledge in meaningful contexts (Mishra & Koehler, 2006; Munyengabe et al., 2017).

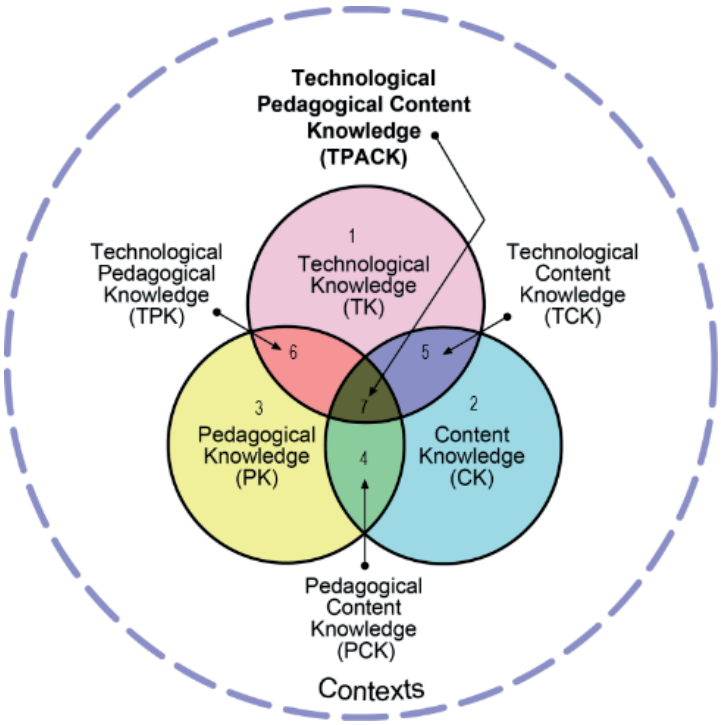

Figure 1. TPACK Model. Reproduced by permission of the publisher, © 2012 by tpack.org.

3) Pedagogical knowledge (PK): Teachers need knowledge of teaching and learning processes, which should include classroom management, planning, and evaluation of teaching and learning processes (Munyengabe et al., 2017; Schmidt et al., 2009).
4) Pedagogical Content Knowledge (PCK): Occurs at the intersection of CK and PK, as PCK prepares CK for the teaching process (Munyengabe et al., 2017; Koehler et al., 2014; Shulman, 1986).
5) Technological Content Knowledge (TCK): The result of the combination of TK and CK, TCK relates to how technology depicts specific content (Koehler et al., 2014; Munyengabe et al., 2017; Schmidt et al., 2009).
6) Technological Pedagogical Knowledge (TPK): The result of the combination of TK and PK, TPK refers to how various technologies can be used in education (Mishra & Koehler, 2006; Munyengabe et al., 2017; Schmidt et al., 2009).
7) Technological Pedagogical Content Knowledge (TPACK): It corresponds to the result of the intersection of CK, PK, and TK, which teachers must have to integrate ICT in the teaching and learning process (Koehler et al., 2014; Munyengabe et al., 2017; Schmidt et al., 2009).

Over the last few years, the TPACK model has consolidated its importance in educational research by presenting theoretical and practical guidance on teacher education in the field of technologies (Erdoğan & Sahin, 2010; Graham, 2011; Jang & Tsai, 2012; Lescano, 2013; Lye, 2013; Nordin, Davis, & Tengku, 2013; Voogt, Pieters, & Handelzalts, 2016; Wang, Schmidt-Crawford, & Jin, 2018). As suggested by Mishra and Koehler (2006) and So and Kim (2009), TPACK is the pedagogical way of knowing how to teach a certain content using the most proper technology. Other authors, such as Kim, Kim, Lee, Spector and De-Meester (2013), Lin, Tsai, Chai, and Lee. (2013), and Koh and Chai (2014) underline that the usefulness of the TPACK model lies in favouring the integration of ICT, considering teachers' feelings as a guide for the development of the process.

So far, systematic reviews of TPACK in primary school address aspects related to the application of the model, learning designs, and the development of professional training programs, but they cover the topic only partially, and usually regard different educational levels rather than look into the specificities of primary level (Rodríguez, Agreda, & Ortiz, 2019; Voogt et al., 2016; Yeh, Chan, & Hsu, 2021). The exception is Paidicán and Arredondo (2022b) whose systematic literature review (SLR) focuses specifically on primary school, although it analyses only a few databases such as: ERIC (Educational Resources Information Center), Google Scholar, SCOPUS and WoS (Web of Science) and hence does not cover PhD theses. The above SLR analyses 19 articles (3.05%) of the total selection (622), covering the period from the presentation of the model to May 2019. The results of the SLR show that most of the studies are oriented toward teachers, and self-assessment of teachers' knowledge is the most studied topic (42,8%). There are also studies focused on students and educational communities, incorporating students' families. It should be considered that there are no studies of the TPACK model in Latin America.

Aim of this study is to extend the results of the above SLR by covering databases of PhD thesis, in the belief that this type of work is an important component of state-of-the-art research trends. It should be noted that the present SLR is developed as part of the doctoral research of the "Education and Society" program at the University of Barcelona.

This study aims to examine the recent PhD works related to the TPACK model focused on primary education, considering the following research questions:

- Question 1 (RQ1): What are the characteristics of the PhD thesis on the TPACK model in primary education?

- Question 2 (RQ2): What approaches describe studies on the TPACK model in primary school focusing on teachers, students, and the educational community?
- Question 3 (RQ3): What recommendations do the PhD theses suggest for the TPACK model in primary education focusing on teachers, students, and the educational community?
- Question 4 (RQ4): To what extent are the results of this review in line with those obtained by its complementary study, by Paidicán and Arredondo (2022b)?

2. Methods and materials

Systematic literature reviews aim to evaluate the scientific literature using critical and structured protocols to limit bias (Petticrew & Roberts, 2008). The present study is carried out using the steps defined by Kitchenham (2004), whose protocol is widely used in the social sciences, as described in Table 1.

Table 1. Stages described in this SLR.

Stages	Activities
Stage 1: Planning the SLR	Activity 1.1: Identifying the rationale of the SLR Activity 1.2: Developing a protocol for the SLR
Stage 2: Conducting the SLR	Activity 2.1: Identifying the purpose of the SLR Activity 2.2: Selecting primary study sources Activity 2.3: Evaluating the quality of study sources Activity 2.4: Data collection and monitoring Activity 2.5: Data synthesis
Stage 3: Reporting the SLR	Communicating results of the SLR

2.1. Planning and conducting the SLR

As a preliminary stage for the SLR, a search was carried out in Google scholar, SCOPUS and WoS databases to identify previous SLR related to the TPACK model in primary education. The string used was (technological AND pedagogical AND content AND knowledge) OR TPACK. The string was adapted to the format required by the different databases.

A total of 15 SLR were obtained, only three of which partially met the established requirements. The study by Paidicán and Arredondo (2022b) deals entirely with studies of the TPACK model in primary education. In addition, two SLR partially address this educational level, Yeh et al. (2021) consider 27,2% of the articles, and Rodríguez et al. (2019) include 35,3% of the publications on this educational level. It should be noted that the three SLRs preferentially select WoS, SCOPUS, ERIC, and Google scholar databases.

Given the above background, it was established that our review is different and complementary to previous reviews related to TPACK. It addresses doctoral theses, considering usually less selected repositories for SLR. Moreover, it allows us to obtain a broader view of the development of TPACK. According to Caballero, Torres-Salinas and López-Cozar (2011), studying doctoral theses is advantageous as it reflects the trends, lines of research, and potential of universities. It is also a suitable way to analyse the evolution of a specific area. Therefore, we conducted a SLR in the repositories TESEO,

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Table 2. Summary of the papers analysed by extant SLR on TPACK.

Author	Period of years	Article numbers	Databases consulted	Research focus
Abbitt (2011)	2005-2010	20 publications	EBSCO Academic Search Premier, ERIC and EDITLib.org	Instruments and methods used to measure TPACK and potential purposes and uses for TPACK-based assessment.
Wu (2013)	2002-2022	24 articles	WoS Social Science Citation Index (SSCI)	Review empirical studies on TPACK, including samples, methods, and thematic areas.
Chai, Koh and Tsai (2013)	Start in May 2011	74 articles	WoS, SCOPUS, Education Research Complete and ERIC (EBSCOhost).	ICT integration from the TPACK framework, according to place of study, publication medium and research methods.
Voogt et al. (2013)	2005 to September 2011	55 articles and books	ERIC, WoS, SCOPUS and PsychINFO	Theoretical basis of TPACK, concepts, specific subject areas, and teaching beliefs.
Rosenberg and Koehler (2015)	2005-2013	74 articles	ERIC, PsychINFO and Electronic Sources	The TPACK model and its development context (micro, meso, and macro)
Willermark (2018)	2011-2016	107 articles	ERIC, SCOPUS and SSCI	General aspects of TPACK, research design and methods, research samples, subject areas, etc. In the context of teachers.
Wang et al. (2018)	January 2006 to September 2015	88 articles	ERIC, PsycINFO and Mendeley (Grupo de investigación TPACK)	Types of methodologies, development, and results in TPACK studies
Voogt et al. (2011)	1988-2009	9 articles	SCOPUS, WoS and ERIC.	TPACK teacher training programme design teams.
Voogt et al. (2016)	2009-2015	14 doctoral theses	No data	The effects of teachers' participation in vocational training programme design and development teams
Malik, Rohendi and Widiaty (2019)	2008-2018	30 articles	SCOPUS, ScienceDirect, SAGE Journal and Taylor & Francis	A new ICT integration model based on TPACK.
Paidicán and Arredondo. (2022b)	Since 2006 May 2019	19 articules primary	SCOPUS, WoS, ERIC and Google scholar	Analyze the scientific literature related to TPACK in primary education.
Rodríguez et al. (2019)	2014-2017	37 articles 13 de primary (35,3%)	WoS and SCOPUS	Current vision of the application of the TPACK model in education.
Young (2016)	2002-2015	65 articles	JSTOR, ERIC, EBSCO, Pych INFO and ProQuest	Characterising the effectiveness of technology in the mathematics classroom using TPACK.
Yalçın and Yayla. (2016)	2009-2015	543 papers	Wos and SCOPUS	Reveal the scholarly communication of the researchers, to specify the documents and authors efficient in the field and to reveal extensive conclusions in the context of document and author by examining the researches that are conducted about TPACK.
Yeh et al. (2021)	Until 13 February 2020	11 articles, 3 primary (27.2%)	WoS and SCOPUS	Learning by design

DIALNET, Doctoral Theses in Network (TDR), Open Theses and Theses and Dissertations (OATD) to find scientific documentation related to the TPACK model for primary education.

This SLR analysed doctoral theses from the presentation of the model until April 2020. Keywords were checked in the ERIC and UNESCO thesauri before searching. Table 3 shows the protocol used in the search in each database.

Table 3. Specific keyword protocol in each repository.

Repository	Keyword protocol
TESEO	Modelo TPACK
DIALNET	Modelo TPACK
Tesis doctorales en red (TDR)	TPACK
Open Thesis	"Technological Pedagogical Content Knowledge" or "tpack"
Theses and dissertations (AOTD)	(Technological AND Pedagogical AND Content AND Knowledge) AND ("tpack")

The search equation only considers the term TPACK and not TPCK, because according to Mishra and Koehler (2006) and De Rossi and Trevisan (2018), the acronym TPACK depicts an integrative perspective, avoiding focusing on one or two components of the model. In addition, the term primary education is excluded to be able to access a broader body of research. Inclusion criteria are the following: open access, full text, doctoral theses focused on primary education. The exclusion criteria set out restricted access, abstracts only, editorials, press releases, conference papers, reports, dissertations, bachelor's and master's research, and other educational levels.

Figure 2 shows that 230 doctoral theses were found, with the largest number in Theses and Dissertations (AOTD) 171 (74,3%), followed by Doctoral Dissertations on the Net (TDR) 31 (13,4%). Titles, keywords, and abstracts are reviewed according to the inclusion criteria. In some cases, it was necessary to read the full text.

Fifteen doctoral theses were studied, 11 (73,3%) found in Theses and Dissertations, 2 in DIALNET, and 2 in TDR (13,3%) respectively. It should be noted that the theses were reviewed by systematically obtaining information related to the previously defined research questions. Table 4 shows the list of selected studies.

3. Results

Initially, theses were analysed in relation to year of publication, geographical distribution, university of origin of the research, type and design of research and instruments used. Secondly, the studies on the TPACK model were analysed according to the focus of the studies, on teachers, students, and the educational community.

3.1. Characteristics of the thesis about the TPACK model in primary education

The first part of the analysis is organised according to the first research question (RQ1). It is observed that there are no publications between the start of the TPACK model and 2012 and during

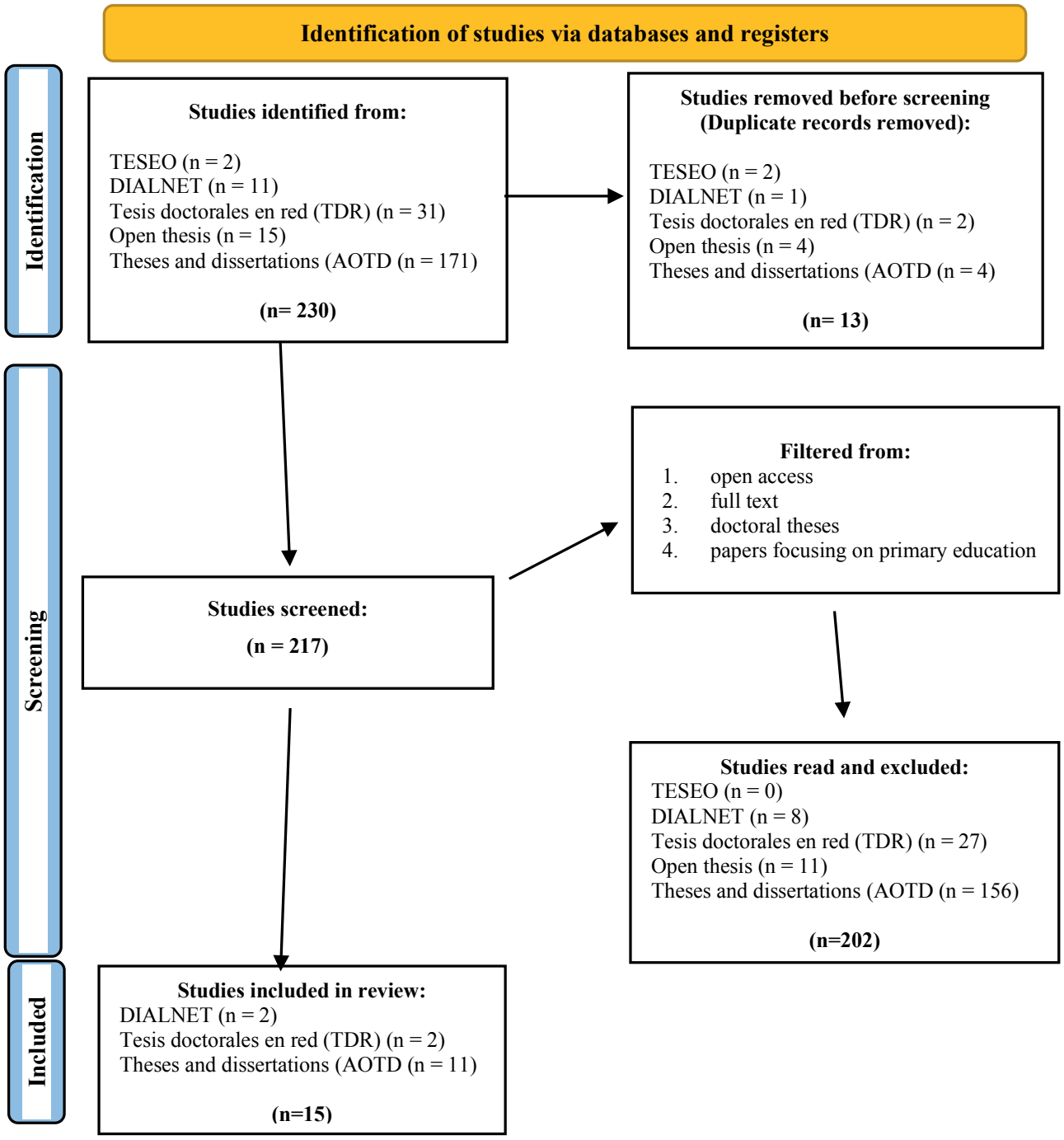

Figure 2. Summary diagram of selected doctoral theses.

2018 and 2019. In addition, year 2016 presents the highest production, 6 theses (40%), followed by 2017 (20%), see Figure 3.

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Table 4. Doctoral thesis included in the SLR.

Nº	Author	University	Country	Type of study	Research design	Sample	Instruments	Working area
1	Mañas (2017)	Alicante	Spain	Mixed	Case study	255 students	Questionnaire	Music
2	Martínez (2016)	Murcia	Spain	Mixed	Quasi experimental	53 students, 16 teachers and 49 families	Questionnaires and Field Diary	Spanish Language
3	Ufartes (2016)	Autónoma de Barcelona	Spain	Qualitative	Case study	28 students	Interview, participant observation, field diary, individual recordings and focus group discussions.	Music
4	Masdeu (2015)	Lleida	Spain	Mixed	Descriptive	16 experts and 1.371 experts	Questionnaire and Interview	Music
5	McCann (2015)	Hawái	USA	Qualitative	Case study	1 teacher	Interview	English language and literature, mathematics, science and social sciences
6	Ontiveros-Karr (2017)	Liberty	USA	Qualitative	Phenomenology and hermeneutics	9 teachers	Interviews, reflections and representations	Not stated
7	Monroe-Ossi (2016)	North Florida	USA	Quantitative	SEM (structural equation modelling)	42 school principals and 75 teachers.	Questionnaire	Not stated
8	Alqallaf (2016)	Northern Colorado	USA	Mixed	Descriptive	562 teachers	TPACK-based questionnaire (mathematics) and interview	Mathematics
9	Woodward (2016)	Iowa State	USA	Qualitative	Verbal reporting methodology	58 students and 3 teachers	Verbal reports	English language
10	Mallernee (2017)	North Central	USA	Quantitative	Case study	82 teachers	Questionnaire	Technology education
11	Mishne (2012)	Pepperdine	USA	Mixed	Ex post facto	44 teachers	TPACK-based questionnaire	Not stated
12	Montes (2016)	Houston	USA	Qualitative	Caso study	3 teachers	Observations and interviews	Technology education
13	Perry (2018)	Yeungstown State	USA	Mixed	Regression analysis	49 professionals	Observation	Technology education
14	Fanni (2014)	Dellas Svizzera	Italy	Mixed	Case study	218 teachers	TPACK Questionnaire	Not stated
15	Jones (2012)	Texas	USA	Qualitative	Case study	72 teachers	Interviews, lesson plans, group meetings, field diaries and focus groups.	Not stated

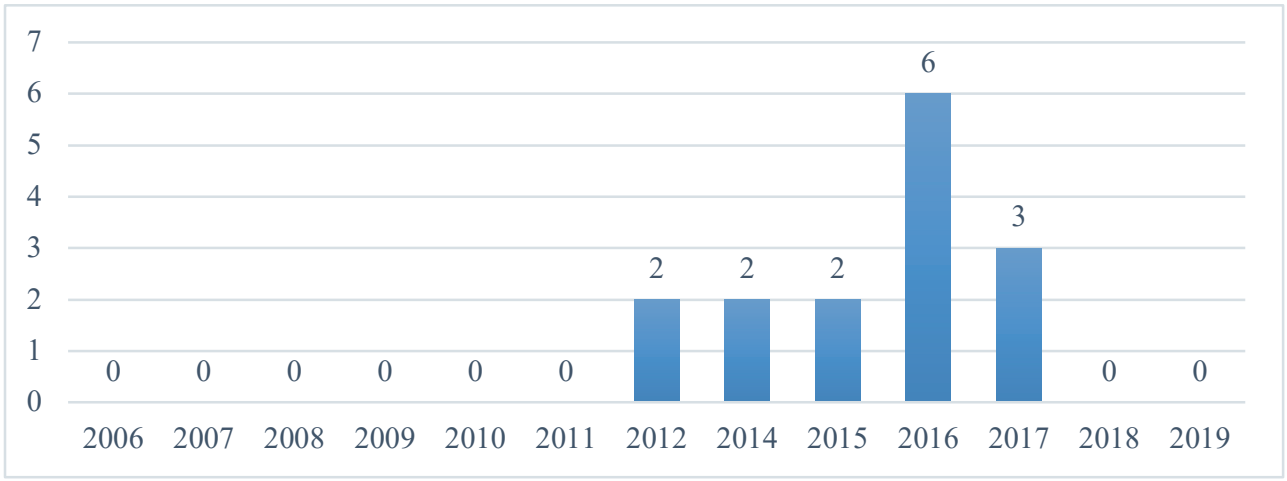

Figure 3. Doctoral theses on TPACK by year of publication according to SLR.

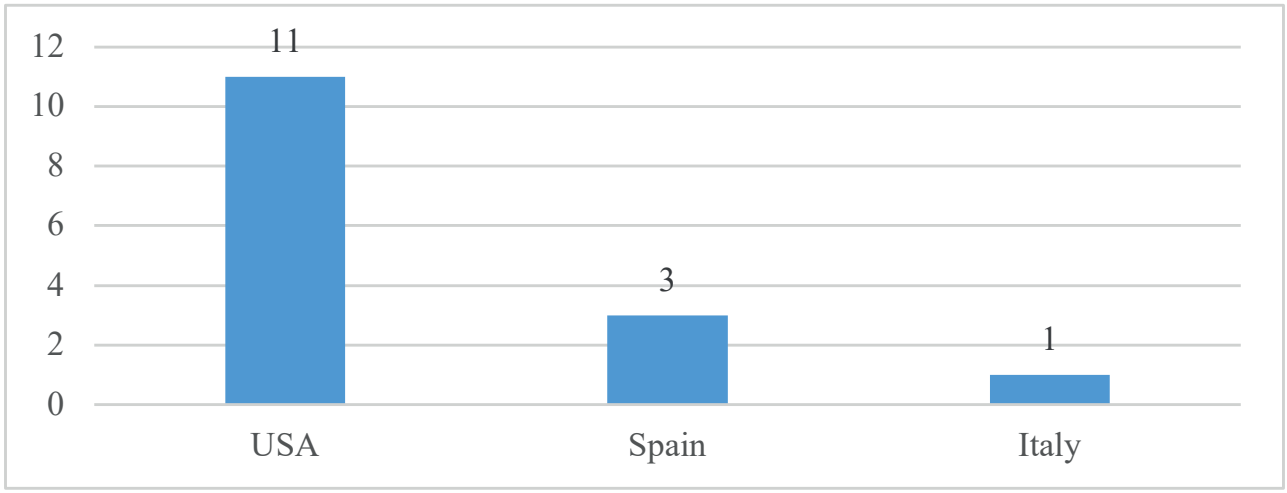

Figure 4. Geographical distribution of selected publications.

In terms of geographical distribution, the largest number of doctoral theses were published in the United States 11 (66.6%), followed at lower rates by Spain 3 (20%) and Italy with 1 (13.3%), as shown in Figure 4.

When referring to the type of research, 7 (46,6%) are mixed studies, 6 (40%) are qualitative and, 2 (13,3%) are quantitative, as shown in Figure 5.

Within the seven (45,1%) case studies, two (13,3%) descriptive investigations were found. Other studies, such as quasi-experimental, phenomenological, and hermeneutic, SEM (structural equation modelling), verbal report, ex post facto, and regression analysis, were observed with one, respectively: 29 instruments were used, including questionnaires (8), interviews (7), field diaries (3), and observations (3). In addition, recordings, discussion groups, reflections, representations, reports, lesson plans, meetings, and focus groups were used, with one each.

In terms of samples, they vary between one and 1.371 cases. The largest samples of Masdeu (2015) with 1.371 experts, Alqallaf (2016) with 562 teachers, and Mañas Pérez (2017) with 255 students stand

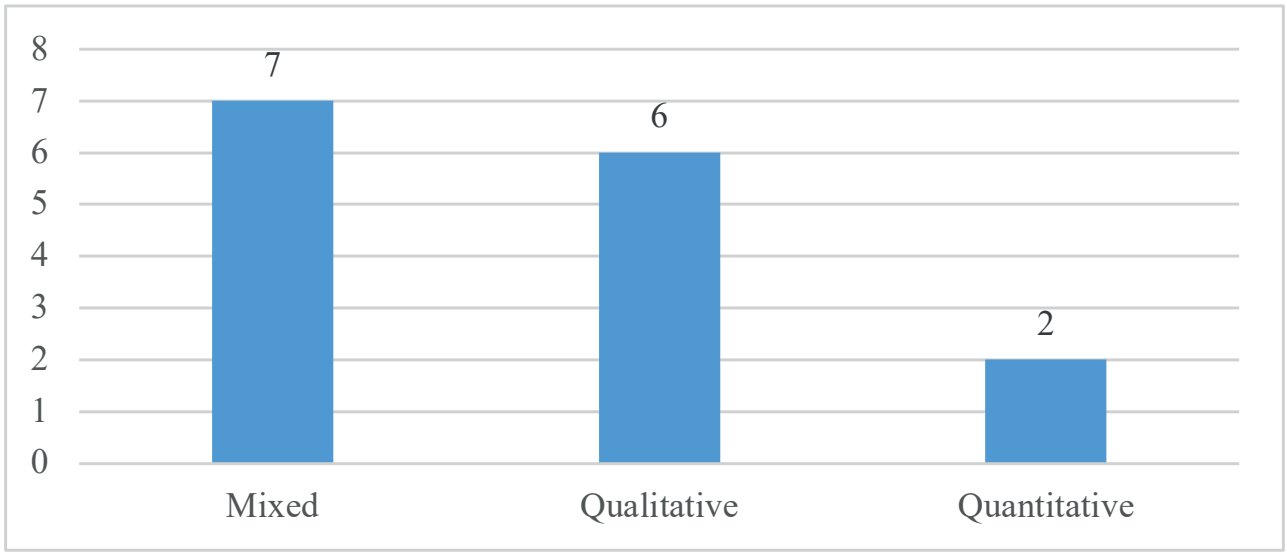

Figure 5. Types of research found in this SLR.

out. In addition, the study by Martínez (2016) considers the participation of 53 students, 16 teachers, and 49 families.

3.2. The TPACK model in primary education by the targets of the studies

The second part of the analysis addresses the research questions 2, 3 and 4 and is organized taking into consideration elements of the study classifications of Paidicán and Arredondo (2022b), Wang and colleagues, (2018), and Willermark (2018), namely according to the focus of the studies (teachers, students, and the community).

3.2.1. Teacher-centred studies of the TPACK model

Among the selected doctoral theses, 8 (53,3%) studies focus on teachers, classified in self-report of knowledge, training, experience, and development of TK and their TPACK relationship, as shown in Table 5.

As far as the methodological approach (RQ2), the studies focusing on teachers were mostly qualitative and mixed. The samples, that are mostly non-probability samples, ranged from one (McCann,

Table 5. Teacher-centred approach to TPACK research.

TPACK perspective	Authors	Quantity/ percentage
Self-reporting of teachers' technological, pedagogical, and content knowledge (TPACK)	Ontiveros-Karr (2017), Alqallaf (2016), Mallernee (2017) Mishne (2012), Fanni (2014)	5 (62,5%)
TPACK teacher training	Jones (2012)	1 (12,5%)
TPACK teaching experiences	Montes (2016)	1 (12,5%)
TK development and its relationship with TPACK	McCann (2015)	1 (12,5%)

2015) to 562 teachers (Alqallaf, 2016). When referring to the research instruments, reflections, task representations, field notes, focus groups, planning, interviews, and questionnaires were used, the latter two being the most frequently used.

In the self-reporting approach, Ontiveros-Karr (2017) conducted a qualitative, phenomenological, and hermeneutic research study, whose aim is to describe the attitudes of teachers in integrating ICT in the framework of TPACK. The results show that teachers with more experience in CK and PK increase their confidence, and this allows them to increase their TK. In addition, teachers report they use ICTs for communication and training over teaching and learning processes.

Alqallaf (2016) conducts a mixed and descriptive study, aiming to examine teachers' feelings on integrating teaching practices in an M-learning environment. The results show confidence in integrating ICTs through YouTube and Instagram. They say that there are difficulties in integrating ICTs if there is no clear model for their integration.

Mallernee (2017) develops a quantitative case study, which aims to explore the effects of teacher professional development on integrating iPads. The results show that 72,6% of teachers have above-average scores on the TPACK. However, there is no correlation between the development of training seminars and teachers' TPACK knowledge.

Mishne (2012) conducts a mixed, ex post facto investigation, the aim of which is to examine whether teacher self-efficacy, knowledge, and experience influence levels of technology integration. The results show that teachers with higher TK also report higher ICT use and higher digital competencies. Moreover, an elevated level of teacher TPACK requires more than just supplying access to ICT tools and resources.

Fanni (2014) develops a mixed case study, which aims to investigate the relationship between teachers' self-efficacy and their use of ICT. About the results, the use of TPACK positively predicts teachers' self-efficacy and ICT use. In addition, experienced teachers report less confidence when using ICTs. Teachers who have taken part in extensive training processes report higher levels of self-efficacy.

About teacher education with TPACK, Jones (2012) carried out a qualitative study. The aim is to understand how teachers in a lesson study professional development (LSPD) with technology change their beliefs and practices. The results show teachers feel confident to use ICTs, however, their use is limited by lack of PK and CK. In addition, the use of technology is affected by the limited availability of technology in the classroom.

Referring to teaching experiences with TPACK, Montes (2016), carried out a qualitative case study, which aims to examine the decisions taken by teachers when planning the integration of portable technology. The results show that effective ICT implementation requires effective planning and that teachers have increased their technological, pedagogical, and content knowledge (TPACK). It is found that the regular use of ICT does not imply that it is planned by teachers.

Regarding the development of TK and its relationship with TPACK, McCann (2015), conducted a qualitative study, which aims to study the support that teacher's TPACK can give in designing and delivering instruction based on the UDL.

As far as RQ3, namely recommendations deriving from studies, self-report research on teachers' knowledge recommends the development of qualitative, mixed, and longitudinal studies (Fanni, 2014; Ontiveros-Karr, 2017; Mishne, 2012). In addition, the use of various data collection tools is recommended, such as interviews, reflective diaries over time, observations, and analysis of curriculum documents, in secondary and adult education contexts and different subjects (Alqallaf, 2016; Ontiveros-Karr, 2017). It is also recommended to investigate aspects related to curriculum-ICT alignment and

contextual factors affecting ICT use (Alqallaf, 2016; Mallernee, 2017). Finally, it is recommended feelings, motivations, and influence of teaching behaviors when using ICT need to be explored and understood (Fanni, 2014; Mishne, 2012).

Jones' study (2012) related to teacher training recommends understanding the motivations behind teachers' resistance to the use of ICTs, exploring the role of parents and guardians and the support of the educational community.

Likewise, research led by Montes (2016), which was focused on teachers' experiences, recommends exploring and understanding TPACK levels and teachers' beliefs during planning in different contexts, to understand the strengths and weaknesses when integrating ICT.

McCann's (2015) research, based on the development of TK and its relationship with TPACK, recommends that, in consideration of increasing numbers of students with special educational needs, TPACK development should be complemented with UDL in order to collaborate transdisciplinary.

3.2.2. Student-centred approaches to the TPACK model

Regarding the methodology adopted in the studies, of the two studies (13,3%) focusing on students retrieved, one uses mixed methods while the other is qualitative. The samples range from 28 to 255 cases, with the participation of students from fourth to the sixth grade being the most representative sample (Mañas Pérez, 2017). Both studies were conducted about music. The data collection instruments were questionnaires, interviews, participant observation through a field diary, individual recordings, and discussion group, and the study by Ufartes (2016), which used various instruments, stands out.

Mañas Pérez (2017) conducts mixed research through the observation method. Its aim is to improve the quality of music education with the creation of an interactive musicogram. The results show that teachers and pupils have a positive view of the incorporation of interactive activities in music education.

Ufartes (2016), develops qualitative and interpretative research, its aim is to analyze the implications that the adoption of mobile devices in music education has on the didactic process. The results show teachers require training and the exchange of experiences related to mobile devices. In addition, the didactic proposal has shown the change of roles between teachers and students, with the latter being the true protagonist of the teaching and learning process.

As far as RQ3, the research focused on students recommend the development of mixed studies, which would lead to the deepening of the theoretical framework of TPACK, including the exploration of international experiences (Mañas Pérez, 2017; Ufartes, 2016). Furthermore, it is recommended the use of research as a feedback tool (Mañas, 2017).

3.2.3. Approaches to the TPACK model with a focus on the school community

There are five studies (33,3%) focused on the school community, including the participation of teachers, students, school principals, families, educational administrators, schools, and external experts, see table seven.

The research on the school community was mixed, quantitative, qualitative, and quasi-experimental. All the samples are non-experimental, the sample being representative (Masdeu, 2015). The research work is carried out in the subjects of the Spanish language, English, technology, and music. Different instruments were used for data collection, with the questionnaire being the most used.

Table 6. School community participation in TPACK studies.

Authors	STU	TEA	DE	FA	EA	SC	EE
Martínez (2016)	53	16		49			
Monroe-Ossi (2016)		75	42				
Woodward (2016)	58	3					
Perry (2018)		49			N/D (*)		
Masdeu (2015)						1.371	16

Note: STU (students), TEA (teachers), DE (educational directors), FA (family), EA (educational administrators), SC (schools) EE (external experts). (*) There is participation of education administrators, but no specification of the number of education administrators.

Martínez (2016), develops a mixed and quasi-experimental study, whose aim is to incorporate enriched e-books in an integrated model of education to improve the understanding of information and the development of a critical attitude. The results allowed Martínez to state that incorporating TPACK as a complement to the e-book increases linguistic communication by 82%.

Monroe-Ossi (2016) carried out a quantitative, which aims to examine in-service teachers' beliefs about how they use ICT in the classroom. The results suggest positive predictive relationships between technological leadership support and the development of technological skills. Thus, a technology leader has the opportunity and responsibility to communicate a positive view of ICT.

Woodward (2016) conducted qualitative research and verbal report, the aim of which is to examine the processes used by teachers when planning the integration of ICT. The results show that teachers' incorporation of ICT strengthens certain instructions, despite the lack of clarity of purpose. Teachers do not need to be experts to use certain ICT tools.

Perry (2018) conducts mixed research with regression analysis, which aims to Measure the factors that influence ICT integration. The results show that the complementation of SMART and TPACK confirms that teachers effectively implement ICT. Sometimes, teachers obtain results that are on the upper scale of SMART. In addition, science teachers show a higher frequency of ICT use.

About the development of TK and its relationship with TPACK, Masdeu (2015), develops mixed, descriptive research with the interpretative paradigm, to study the digitization of music classrooms in public schools in Catalonia. The results show that teachers need to consciously incorporate ICT and understand that technologies support digital literacy, and in no case are they a replacement for traditional teaching practices.

Research, based on the school community, recommends the development of comparative, mixed, longitudinal, and case studies, to collect more information on ICT-mediated learning environments (Masdeu, 2015; Monroe-Ossi, 2016). Besides, studies focusing on professional development and sustainability over time are recommended (Perry, 2018) as well as studies examining teachers' beliefs when integrating ICT and the decision-making process when planning instruction (Monroe-Ossi, 2016; Woodward, 2016). Finally, Martínez (2016) recommend the creation of a bank of free ICT tools to adapt to the student needs.

Finally, in relation to the results obtained in the present SLR and its complement with the previous study by Paidicán and Arredondo (2022b) (RQ4), it can be affirmed that both SLRs present a greater scientific production between 2015 and 2017. In relation to geographical distribution, the United States and Spain have the highest scientific production, in both SLR. It should be noted that this result

depends largely on the databases selected for SLR, as some of them deal only with national research. With regards to the type of research, there is agreement on the existence of mixed, quantitative and qualitative studies in both SLR. Moreover, mixed studies are the majority in this SLR and allow access to a broad and complementary view of the TPACK model. About research instruments, there is a noticeable trend in the use of questionnaires and interviews. In this regard, it can be noticed that the use of the TPACK questionnaire by Schmidt et al. (2009) is widely observed in both the SLR, for its application in the original form but also for the adaptation and creation of new questionnaires.

In terms of samples, both SLR retrieved studies involving mainly teachers; the largest studies include 881 and 662 teachers, respectively (Alqallaf, 2016; Magen-Nagar & Peled, 2013). On the other hand, the studies involving students present similar sample sizes; the largest include 255 and 259, respectively (Mañas Pérez, 2017; Wong, Chai, Zhang, & King, 2014).

About subjects of the studies, there is a greater development of research focused on teachers, with values between 68.14% and 53.3%. At the same time, the majority are self-report studies of TPACK with the former SLR (Paidicán & Arredondo, 2022b) presenting 35.29% and the present one reaching over 60%. In the case of the studies focused on students, both SLR consider participation from first to sixth grade, being higher in fourth-grade students (Angeli, et al., 2016; Lye, Wee, Kwek, Abas, & Tay, 2014; Mañas Pérez, 2017; Sáez & Cózar (2017); Ufartes, 2016; Wong et al., 2014). In addition, the studies include different subjects, including music education, computer science, social sciences, and the Chinese language. Considering studies based on educational communities, the present SLR has greater teacher, student, and family participation. Besides, this SLR is complemented by the inclusion of studies involving school principals and external experts. Likewise, there is a coincidence in the subjects addressed in the research, among them: Spanish language, English, music education, and technology education.

4. Discussion

The scientific production about the TPACK model has advanced in recent years. However, in primary education does not present the same development (Paidicán & Arredondo, 2022b; Rodríguez et al., 2019; Yeh et al., 2021). For Margerum-Leys and Marx (2002) the cause lies in the focus of studies on secondary and university levels of education over primary education.

Previous SLR on the TPACK model in primary schools address specific topics such as the vision of the TPACK model in education, the effects of teacher participation in the design and development of training programs and learning by design (Rodríguez et al., 2019; Yeh et al., 2021). Although Paidicán and Arredondo (2022b) address TPACK in primary school in general, the selection only considers a few databases, making it impossible to obtain a broad view of TPACK at this educational level.

This SLR shows that most teacher-centred research on TPACK uses self-report to measure teachers' knowledge of ICTs use, as argued by Bingimlas (2018), Chen and Jang (2013), Kazu and Erten (2014), Magen-Nagar and Peled (2013), Paidicán and Arredondo (2019; 2022a; 2022c). Furthermore, the preferred instrument is the five-level Likert-type questionnaire, the construction of which considers Schmidt et al. (2009) as well as Cabero Almenara, Roig-Villa, and Mengual-Andrés (2017) and Roig-Vila, Mengual-Andrès and Quinto-Medrano (2015), as main references.

As for studies on students, both have been conducted in the field of music education. It should be noted that the importance of developing student-centred teaching processes lies in the fact that they promote the achievement of greater learning by students, as stated by Harris and Hofer (2011), Koehler and Mishra (2005; 2009), Hughes (2005), Niess (2005) and Yeh et al. (2021).

Concerning the studies involving the school community, they include the participation of various educational agents such as students, teachers, principals, family, educational administrators, and external experts. Furthermore, the research is developed considering different subjects such as Spanish language, English, technology, and music, which is in line with previous studies by Angeli et al. (2016), Chen and Jang (2013), Hansen, Mavrikis, and Geraniou (2016), Liu (2013), Lye et al. (2014), Maboe, Smith, Banoobhai and Makgatho (2018), Paneru (2018) and Tai (2015).

When referring to the recommendations, there is agreement in studies on the need for comparative, mixed, and longitudinal research, to deepen theoretical and methodological aspects, incorporating various instruments that facilitate the triangulation of data.

About teachers, it is recommended investigating feelings, motivations, and contextual factors presented by teachers when using ICT. In addition, curricular, contextual, and planning aspects of ICT-mediated instruction should be addressed. Concerning students, it is recommended using research as a feedback tool within schools. Likewise, the educational community needs a bank of free ICT resources.

Considering the contribution of the TPACK model in the integration of technologies, the research focused on the educational community suggests the development of studies to explore the beliefs of the school community about the integration of technology, investigate teachers' planning decisions and their impact on student learning, and develop models of lifelong learning to determine the long-term benefits.

5. Conclusions

On the basis of the results obtained, it can be concluded that the scientific production about the TPACK model in primary education is lower than at other educational levels, such as university education. The present SLR only obtains 15 doctoral theses analysed, out of a total of 230, representing 6,52%, none of which are carried out in Latin America. Moreover, the doctoral theses are published for a limited period between 2012 and 2017. Regarding the geographical distribution, almost two-thirds were published in the United States.

In addition, the existence of different research approaches related to the TPACK model is confirmed, highlighting aspects related to students and the school community, in mostly mixed and qualitative studies.

The use of the TPACK framework to analyse ICTs integration in different pedagogical contexts as Montessori, the substitution augmentation modification redefinition (SAMR) model, and Universal Design for Learning (UDL) stand out. About Montessori, Jones' research (2012) concludes that the use of ICT under this method is limited by teachers' levels of knowledge of PK and CK and not by their levels of confidence in ICT.

On the other hand, Perry's research (2018) through SAMR and TPACK allows us to affirm that their use together facilitates the implementation of ICT, where teachers reach levels of redefinition, the highest of SAMR. McCann's (2015) study related to UDL reveals the complexity of ICT integration through TPACK in inclusive contexts; however, the author concludes that teachers with high levels of TPACK have access to technologies and strategies to serve students from diverse backgrounds.

In addition, the use of TPACK is presented in seven different subjects with a prevalence of music and technology. TPACK has proven to be a useful framework for integrating new technologies as a complement to traditional classes. There is a clear need to incorporate TPACK studies related to school management teams and to address issues of educational management.

The present SLR has added value, reflected in the incorporation of samples with students between first and sixth grade, new studies focused on the school community, including the participation of school principals and external experts, and a greater variety of topics such as music education and technology education.

The literature review provides a different view of TPACK research, although there are limitations that should be considered. For example, other types of analysis, focused on the characteristics of the research instruments, the subjects considered, and the student characteristics, among others, could be considered for future reviews. Finally, searching new databases such as DIALNET, SCIELO, REDALYC, Yök National Thesis Center and CNKI (China National Knowledge Infrastructure) among others could provide insight into how TPACK is being studied in different contexts.

6. References

Abbitt, J. T. (2011). Measuring technological pedagogical content knowledge in preservice teacher education: A review of current methods and instruments. *Journal of Research on Technology in Education*, *43*(4), 281-300. doi: 10.1080/15391523.2011.10782573

Alqallaf, N. (2016). *Mathematical teachers' perception: Mobile learning and constructing 21 st century collaborative cloud-computing environments in elementary public schools in the State of Kuwait*. [Doctoral dissertation, University of Northern Colorado, US]. Retrieved from https://www.proquest.com/docview/1795084735

Angeli, C., Voogt, J., Fluck, A., Webb, M., Cox, M., Malyn-Smith, J., & Zagami, J. (2016). A K-6 computational thinking curriculum framework: Implications for teacher knowledge. *Journal of Educational Technology & Society*, *19*(3). Retrieved from http://ecite.utas.edu.au/110032

Bingimlas, K. (2018). Investigating the level of teachers' Knowledge in Technology, Pedagogy, and Content (TPACK) in Saudi Arabia. *South African Journal of Education*, *38*(3). Retrieved from https://is.gd/BbbCqk

Caballero, R. R., Torres-Salinas, D., & López-Cozar, E. D. (2011). Análisis bibliométrico y de redes sociales en tesis doctorales españolas sobre televisión: (1976/2007). *Comunicar: Revista Científica Iberoamericana de Comunicación y Educación*, *37*, 151-159. doi: 10.3916/C37-2011-03-07

Cabero Almenara, J., Roig-Vila, R., & Mengual Andrés, S. (2017). Conocimientos tecnológicos, pedagógicos y disciplinares de los futuros docentes según el modelo TPACK. *Digital Education Review, 32,* 85-96. Retrieved from http://hdl.handle.net/11441/69058

Chai, C. S, Koh, J. H. L, & Tsai, C. C. (2013). A review of technological pedagogical content knowledge. *Journal of Educational Technology & Society*, *16*(2), 31-51. Retrieved from http://www.jstor.org/stable/jeductechsoci.16.2.31

Chen, H. Y, & Jang, S. J. (2013). Exploring the reasons for using electric books and technologic pedagogical and content knowledge of Taiwanese elementary mathematics and science teachers. *Turkish Online Journal of Educational Technology - TOJET*, *12*(2), 131-141. Retrieved from https://eric.ed.gov/?id=EJ1015403

De Rossi, M., & Trevisan, O. (2018). Technological Pedagogical Content Knowledge in the literature: How TPCK is defined and implemented in initial teacher education. *Italian Journal of Educational Technology*, *26*(1), 7-23. doi: 10.17471/2499-4324/988

Erdoğan, A, & Sahin, I. (2010). Relationship between math teacher candidates' technological pedagogical and content knowledge (TPACK) and achievement levels. *Procedia-Social and Behavioral Sciences*, *2*(2), 2707-2711. doi: 10.1016/j.sbspro.2010.03.400

Fanni, F. (2014). Confidence in technology use: The development and validation of a technological, pedagogical, and content self-efficacy scale for teachers. [Doctoral dissertation, Università della Svizzera italiana]. Retrieved from https://susi.usi.ch/usi/documents/318679

Graham, C. R. (2011). Theorical considerations for understanding Technological Pedagogical Content Knowledge (TPACK). *Computers & Education*, *57*, 1953-1960. doi: 10.1016/j.compedu.2011.04.010

Hansen, A., Mavrikis, M., & Geraniou, E. (2016). Supporting teachers' technological pedagogical content knowledge of fractions through co-designing a virtual manipulative. *Journal of Mathematics Teacher Education*, *19*(2-3), 205-226. doi: 10.1007/s10857-016-9344-0

Harris, J. B., & Hofer, M. J. (2011). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education*, *43*(3), 211-229. doi: 10.1080/15391523.2011.10782570

Hughes, J. (2005). The role of teacher knowledge and learning experiences in forming technology-integrated pedagogy. *Journal of Technology and Teacher Education, 13*(2), 277-302. Retrieved from https://www.learntechlib.org/primary/p/26105/

Jang, S. J, & Tsai, M. F. (2012). Exploring the TPACK of Taiwanese elementary mathematics and science teachers with respect to use of interactive whiteboards. *Computers & Education*, *597*, 327-338. doi: 10.1016/j.compedu.2012.02.003

Jones, S. J. (2012). *Teachers' experiences in a technology-infused lesson study professional development* [Doctoral dissertation, The University of Texas at Austin, TX, US]. Retrieved from http://hdl.handle.net/2152/ETD-UT-2012-05-5518

Kazu, I. Y., & Erten, P. (2014). Teachers' Technological Pedagogical Content Knowledge self-efficacies. *Journal of Education and Training Studies*, *2*(2), 126-144. Retrieved from https://eric.ed.gov/?id=EJ1055505

Kim, C., Kim, M. K., Lee, C., Spector, J. M., & De-Meester, K. (2013). Teacher beliefs and technology integration. *Teaching and Teacher Education*, *29*, 76-85. doi: 10.1016/j.tate.2012.08.005

Kitchenham, B. (2004). Procedures for performing systematic reviews. *Keele University Technical Report TR/SE-0401*, *33*, 1-26. Retrieved from https://people.ucalgary.ca/~medlibr/kitchenham_2004.pdf

Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of Technological Pedagogical Content Knowledge. *Journal of Educational Computing Research*, *32*(2), 131-152. doi: 10.2190/0EW7-01WB-BKHL-QDYV

Koehler, M., & Mishra, P. (2009). What is Technological Pedagogical Content Knowledge (TPACK)?. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60-70. Retrieved from https://www.learntechlib.org/primary/p/29544/

Koehler, M. J., Shin, T. S., & Mishra, P. (2012). How do we measure TPACK? Let me count the ways. *In Educational technology, teacher knowledge, and classroom impact: A research handbook on frameworks and approaches* (pp. 16-31). Hershey, PA, US: IGI Global. Retrieved from https://bit.ly/3zZ9WAt

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). The Technological Pedagogical Content Knowledge framework. *In Handbook of Research on Educational Communications and Technology* (pp. 101-111). New York, NY, US: Springer. Retrieved from https://bit.ly/3HUxHN0

Koh, J. H. L., & Chai, C. S. (2011). Modeling pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) perceptions: The influence of demographic factors and TPACK constructs. In *Australasian Society for Computers in Learning in Tertiary Education (ASCILITE) Conference* (Hobart, Australia, 4-7 December 2011). Retrieved from https://bit.ly/3r7LatQ

Koh, J. H. L., & Chai, C .S. (2014). Teacher clusters and their perceptions of Technological Pedagogical Content Knowledge (TPACK) Development through ICT lesson design. *Computers & Education*, *70*, 22-232. doi: 10.1016/j.compedu.2013.08.017

Lescano, M. Y. (2013). Experiencias de la aplicación de la metodología TPACK usando recursos de la web 2.0 en un colegio técnico secundario. *TE & ET*, *10*, 45-52. Retrieved from http://hdl.handle.net/10915/27732

Lin, T. C., Tsai, C. C., Chai, C. S., & Lee, M. H. (2013). Identifying science teachers' perceptions of Technological Pedagogical and Content Knowledge (TPACK*). Journal of Science Education and Technology 22*, 325-336. doi: 10.1007/s10956-012-9396-6

Liu, S. H. (2013). Exploring the instructional strategies of elementary school teachers when developing Technological, Pedagogical, and Content Knowledge via a collaborative professional development program. *International Education Studies*, *6*(11), 58-68. doi: 10.5539/ies.v6n11p58

Lye, L. T. (2013). Opportunities and challenges faced by private higher education institution using the TPACK model in Malasya. *Procedia-Social Behavioral Sciences*, *91*, 294-305. doi: 10.1016/j.sbspro.2013.08.426

Lye, S. Y, Wee, L. K, Kwek, Y. C, Abas, S, & Tay, L. Y. (2014). Design, customization and implementation of energy simulation with 5E model in elementary classroom. *Journal of Educational Technology & Society*, *17*(3), 121-137. Retrieved from https://is.gd/DtiN47

Maboe, E., Smith, C. G., Banoobhai, M., & Makgatho, M. (2018). Implementing tablets to teach reading in grade 5. *Reading & Writing*, *9*(1), 1-10. Retrieved from https://is.gd/DuDnVk

Magen-Nagar, N, & Peled, B. (2013). Characteristics of Israeli school teachers in computer-based learning environments. *Journal of Educators Online*, *10*(1), 1-34. Retrieved from https://www.learntechlib.org/p/114392/

Malik, S, Rohendi, D, & Widiaty, I. (2019). Technological Pedagogical Content Knowledge (TPACK) with information and communication technology (ICT) integration: A literature review. In *5th UPI International Conference on Technical and Vocational Education and Training*. doi: 10.2991/ictvet-18.2019.114

Mallernee, N. (2017). *Exploring the use of ipads for literacy instruction in the 1: 1 K-6 classroom*. [Doctoral dissertation, North Central University, San Diego, CA, US]. Retrieved from https://is.gd/UOCeNu

Mañas Pérez, A. (2017). *De la audición musical activa a la audición musical interactiva*. [Doctoral Thesis, Universidad de Alicante]. Retrieved from https://is.gd/gv8xo1

Margerum-Leys, J., & Marx, R. W. (2002). Teacher knowledge of educational technology: A case study of student/mentor teacher pairs. *Journal of Educational Computing Research, 26*(4), 427-462. doi: 10.2190/JXBR-2G0G-1E4T-7T4M

Martínez, B. J. (2016). *La educación para los medios integración del e-book enriquecido en educación primaria*. [Doctoral Thesis, Universidad de Murcia]. Retrieved from https://www.tdx.cat/handle/10803/399231

Masdeu Y. E. (2015). *The digitalisation of music classrooms in schools in Catalonia: study of and proposal for a general framework for integrating technology in music education* [Doctoral dissertation, Universitat de Lleida]. Retrieved from http://hdl.handle.net/10803/300305

McCann, K. (2015*). Using Technological-Pedagogical-and-Content Knowledge (TPACK) to support universal design for learning: A case study*. [Doctoral dissertation, University of Hawaii, Manoa, US]. Retrieved from http://hdl.handle.net/10125/50998

Mishne, J. (2012). *An investigation of the relationships between technology use and teachers' self-efficacy, knowledge and experience*. [Doctoral dissertation, Pepperdine University, Malibu, CA, US]. Retrieved from https://bit.ly/3Fg5Chf

Mishra, P, & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: a framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017-1054. Retrieved from https://is.gd/15lZvT

Monroe-Ossi, H. M. (2016). *Complexities of Technology Integration in the Elementary Classroom Context: A Structural Equation Model Study*. [Doctoral dissertation, University of North Florida, FL, US]. Retrieved from https://digitalcommons.unf.edu/etd/622

Montes, S. T. (2016). *Integrating one-to-one technology in the classroom: Three different approaches*. [Doctoral dissertation, University of Houston, TX, US]. Retrieved from http://hdl.handle.net/10657/1723

Munyengabe, S, Yiyi, Z, Haiyan, H, & Hitimana, S. (2017). Primary teachers' perceptions on ICT integration for enhancing teaching and learning through the implementation of one laptop per child program in primary schools of Rwanda. *Eurasia Journal of Mathematics, Science, and Technology Education*, *13*(11), 7193-7204. doi: 10.12973/ejmste/79044

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education*, *21*(5), 509-523. doi: 10.1016/j.tate.2005.03.006

Nordin, H, Davis, N, & Tengku, T. F. (2013). A case study of secondary pre-service teachers' Technological Pedagogical and Content Knowledge mastery level. *Procedia-Social Behavioral Sciences*, *103*, 1-9. doi: 10.1016/j.sbspro.2013.10.300

Ontiveros-Karr, K. (2017). *A phenomenological study of first-career millennial novice elementary school teachers' use of technology* [Doctoral dissertation. University Liberty, Lynchburg, VA, US]. Retrived from https://digitalcommons.liberty.edu/doctoral/1542

Paidicán, M. A., & Arredondo, P. A. (2019, June 19). El modelo TPACK como herramienta de gestión educativa, experiencia colegio de educación primaria. In *I Congreso Internacional Tecnologías Emergentes en Educación* (Malaga, Spain). doi: 10.5281/zenodo.3522395

Paidicán, M. A., & Arredondo, P. A. (2022a). Conocimientos tecnopedagógicos y disciplinares en los docentes de primaria y los factores demográficos. *Mendive Revista de Educación, 20*(3), 906-916. Retrieved from https://mendive.upr.edu.cu/index.php/MendiveUPR/article/view/2949

Paidicán, M. A., & Arredondo, P. A. (2022b). The Technological-Pedagogical Knowledge for in-service teachers in primary education: A systematic literature review. *Contemporary Educational Technology*, *14*(3). doi: 10.30935/cedtech/11813

Paidicán, M. A., & Arredondo, P. A. (2022c). Evaluación de la validez y fiabilidad del cuestionario de conocimiento tecnológico pedagógico del contenido (TPACK) para docentes de primaria. *Revista Innova Educación*, *5*(1), 38–58. doi: 10.35622/j.rie.2023.05.003

Paneru, D. (2018). Information communication technologies in teaching English as a foreign language: analysing EFL teachers' TPACK in Czech elementary schools. *Center for Educational Policy Studies Journal*, *8*(3), 141-163. doi: 10.26529/cepsj.499

Perry, N. D. (2018). *Teacher attitudes and beliefs about successfully integrating technology in their classroom during a 1: 1 Technology initiative and the factors that lead to adaptations in their instructional practice and possible influence on standardized test achievement*. [Doctoral dissertation, Youngstown State University, OH, US]. Retrieved from http://rave.ohiolink.edu/etdc/view?acc_num=ysu1522233676292274

Petticrew, M., & Roberts, H. (2008). Systematic reviews in the social sciences: A practical guide. New York NY, US: John Wiley & Sons.

Rodríguez M. J, Agreda M. M, & Ortiz C. A. (2019). Changes in teacher training within the TPACK model framework: a systematic review. *Sustainability*, *11*(7), 1870. doi: 10.3390/su11071870

Roig-Villa, R., Mengual-Andrés, S., & Quinto-Medrano, P. (2015). Primary teachers' technological, pedagogical and content knowledge. *Comunicar*, *23*(45). doi: 10.3916/C45-2015-16

Rosenberg, J. M., & Koehler, M. J. (2015). Context and technological pedagogical content knowledge (TPACK): A systematic review. *Journal of Research on Technology in Education, 47*(3), 186-210. doi: 10.1080/15391523.2015.1052663

Sáez, L. J., & Cózar, G. R. (2016). Programación visual por bloques en educación primaria: Aprendiendo y creando contenidos en ciencias sociales. *Revista Complutense de Educación*, *28*(2), 409-426. doi: 10.5209/rev_RCED.2017.v28.n2.49381

Schmidt, D. A., Baran E., Thompson A. D., Mishra P., Koehler M. J., & Shin T. S. (2009). Technological Pedagogical Content Knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education*, *42*, 123-150. doi: 10.1080/15391523.2009.10782544

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14. doi: 10.2307/1175860

So, H. J., & Kim, B. (2009). Learning about problem-based learning: Student teachers integrating Technology, Pedagogy, and Content Knowledge. *Australasian Journal of Educational Technology*, *25*(1). doi: 10.14742/ajet.1183

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 https://eric.ed.gov/?id=EJ1051726

Ufartes Ollé, G. (2016). *l'IPAD a l'àrea de música. Disseny, aplicació i anàlisi d'una propsota didàctica a l'educació primària*. [Doctoral dissertation, Autonomous University of Barcelona]. Retrieved from https://bit.ly/38HC3r6

Voogt, J., Fisser, P., Pareja Roblin, N. N., Tondeur, J., & van Braak, J. (2013). Technological Pedagogical Content Knowledge-a review of the literature. *Journal of Computer Assisted Learning, 29*(2), 109-121. doi: 10.1111/j.1365-2729.2012.00487.x

Voogt, J., Westbroek, H., Handelzalts, A., Walraven, A., McKenney, S., Pieters, J., & De Vries, B. (2011). Teacher learning in collaborative curriculum design. *Teaching and Teacher Education, 27*(8), 1235–1244. doi:10.1016/j.tate.2011.07.003

Voogt, J. M., Pieters, J. M., & Handelzalts, A. (2016). Teacher collaboration in curriculum design teams: Effects, mechanisms, and conditions. *Educational Research and Evaluation, 22*(3–4), 121–140. doi: 10.1080/13803611.2016.1247725

Wang, W, Schmidt-Crawford, D, & Jin, Y. (2018). Preservice teachers' TPACK development: A review of literature. *Journal of Digital Learning in Teacher Education*, *34*(4), 234–258. doi: 10.1080/21532974.2018.1498039

Willermark, S. (2018). Technological pedagogical and content knowledge: A review of empirical studies published from 2011 to 2016. *Journal of Educational Computing Research*, *56*(3), 315-343. doi: 10.1177/0735633117713114

Wong, L. H., Chai, C. S., Zhang, X., & King, R. B. (2014). Employing the TPACK framework for researcher-teacher co-design of a mobile-assisted seamless language learning environment. *IEEE Transactions on Learning Technologies*, *8*(1), 31-42. doi: 10.1109/TLT.2014.2354038

Woodward, L. (2016). *An examination of teachers' planning processes as they seek to integrate technology into literacy instruction*. [Doctoral dissertation, University Iowa State]. Retrieved from https://bit.ly/32YhAPH

Wu, Y. T. (2013). Research trends in technological pedagogical content knowledge (TPACK) research: A review of empirical studies published in selected journals from 2002 to 2011. *British Journal of Educational Technology*, *44*(3). doi: 10.1111/j.1467-8535.2012.01349.x

Yalçın, H., & Yayla, K. (2016). Scientometric analysis of the researches about Technological Pedagogical Content Knowledge and scholarly communication. *Education & Science/Egitim ve Bilim*, *41*(188). doi: 10.15390/EB.2016.6746

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. doi: 10.1016/j.compedu.2021.104238

Young, J. R. (2016). Unpacking TPACK in Mathematics education research: A systematic review of meta-analyses. *International Journal of Educational Methodology*, *2*(1), 19-29. doi: 10.1016/j.compedu.2021.104238