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TECHNICAL PEDAGOGICAL CONTENT LNOWLEDGE (TPACK) IN SPECIAL EDUCATION: A LITERATURE REVIEW.

CONHECIMENTO TÉCNICO PEDAGÓGICO DO CONTEÚDO (TPACK) NA EDUCAÇÃO ESPECIAL: UMA REVISÃO DA LITERATURA.

CONOCIMIENTO TÉCNICO PEDAGÓGICO DEL CONTENIDO (TPACK) EN EDUCACIÓN ESPECIAL: UNA REVISIÓN BIBLIOGRÁFICA.

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Abstract: This article is the result of a systematic literature review that aimed to examine the TPACK model from its scientific production in special education contexts. The 16 papers were selected from DIALNET, ERIC, JSTOR, PsycINFO, Redalyc, SCOPUS and WoS databases. The search period was from the inception of the model in 2006 to December 2023 and included open access, full text, social science related and special education related articles. It was concluded that there is a limited development of TPACK in special education by obtaining only 5,59% of the documents reviewed, between 2014 and 2023, more than 50% of the research was developed in higher education, with the United States being the country with the highest production. The diversification of instruments arising from the TPACK model stands out, allowing a broader conceptual vision to be obtained. It is recommended to develop professional teacher training processes that include pedagogical, technological and disciplinary knowledge.
Keywords: Teacher knowledge; Technological Pedagogical Content Knowledge (TPACK); Educational technology; Education special.

Resumo: Este artigo é o resultado de uma revisão de literatura que teve como objetivo examinar o modelo TPACK a partir de sua produção científica em contextos de educação especial. Os 16 artigos foram selecionados a partir das bases de dados DIALNET, ERIC, JSTOR, PsycINFO, Redalyc, SCOPUS e WoS. O período de pesquisa foi desde o início do modelo em 2006 até dezembro de 2023 e incluiu artigos de acesso livre, texto integral, relacionados com as ciências sociais e com a educação especial. Concluiu-se que há um desenvolvimento limitado do TPACK na educação especial ao obter apenas 5,59% dos documentos analisados, entre 2014 e 2023, mais de 50% das pesquisas foram desenvolvidas no ensino superior, sendo os United States o país com maior produção. Destaca-se a diversificação de instrumentos decorrentes do modelo TPACK, permitindo a obtenção de uma visão conceitual mais ampla. Recomenda-se o desenvolvimento de processos de formação profissional docente que incluam conhecimentos pedagógicos, tecnológicos e disciplinares.

Palavras-chave: Conhecimento didático; Conhecimento Técnico Pedagógico do Conteúdo (TPACK); Tecnologia educativa; Educação especial.

Resumen: El presente artículo es el resultado de una revisión de literatura que tuvo como objetivo examinar el modelo TPACK desde su producción científica en contextos de educación especial. Los 16 documentos fueron seleccionados en las bases de datos DIALNET, ERIC, JSTOR, PsycINFO, Redalyc, SCOPUS y WoS. El período de búsqueda incluyó desde el inicio del modelo, en 2006, hasta diciembre 2023. Se incluyeron artículos de acceso abierto, texto completo, relacionado con las ciencias sociales y referido con la educación especial. Se concluyó que existe un acotado desarrollo del TPACK en educación especial al obtener solo 5,59 % de los documentos revisados, entre los años 2014 y 2023, más de 50 % de las investigaciones se desarrollaron en la educación superior, siendo Estados Unidos el país con mayor producción. Se destaca la diversificación de instrumentos surgidos del modelo TPACK, permitiendo obtener una visión conceptual más amplia. Se recomienda desarrollar procesos de formación profesional docente que incluyen los conocimientos pedagógicos, tecnológicos y disciplinares.
Palabras claves: Conocimiento docente; Conocimiento Técnico Pedagógico del Contenido (TPACK); Tecnología educativa; Educación especial.

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1. INTRODUCTION

The trends of the 21st century demand the constant development of the teacher training process, especially in aspects related to the use of technology. Furthermore, according to authors such as Paidicán (2018) and Van Leendert et al. (2022), professional development spaces need adequate instances of reflection as a way of facilitating the teaching and learning processes of students.

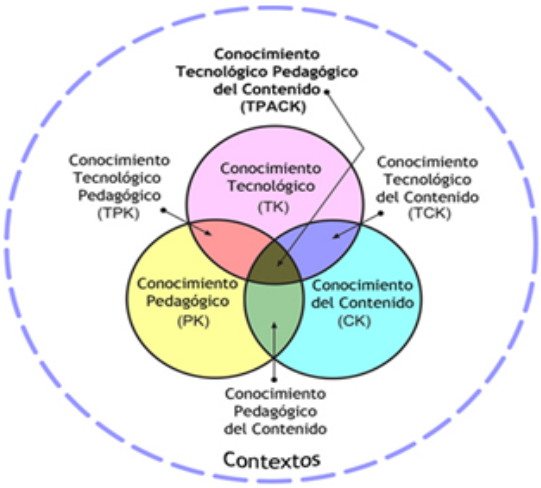
In 2006, the technological, pedagogical, and content knowledge (TPACK) model emerged and has gained considerable popularity among educational technology researchers. According to data obtained through Harzing's Publish and Perish program, the original work by Mishra and Koehler (2006) entitled "Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge", presents 17,498 citations (Google Scholar, March 2024), corroborating the above.

TPACK in its genesis is composed of three central dimensions: technological, pedagogical, and disciplinary knowledge. In addition, four dimensions emerge from the intersection of these dimensions. Figure 1 shows each element, described below.

1. Technological knowledge (TK): Corresponds to the knowledge and skills required for using technological tools (Mishra and Koehler, 2006; Angeli and Valanides, 2009; Koehler et al., 2014).
2. Content knowledge (CK): Corresponds to the knowledge and skills necessary for incorporating teaching and learning methods, approaches, and processes (Mishra and Koehler, 2006; Munyengabe et al., 2017).
3. Pedagogical knowledge (PK): Corresponds to knowledge related to a discipline, incorporating elements related to classroom management, planning, and evaluation of teaching and learning processes (Schmidt et al., 2009; Munyengabe et al., 2017).

4. Pedagogical content knowledge (PCK): Corresponds to the intersection between CK and PK, where it aims to focus the teaching process of content on the learner (Shulman, 1986; Mishra and Koehler, 2006; Koehler et al., 2014).
5. Technological content knowledge (TCK): Corresponding to the intersection between TK and CK, it aims to relate content-specific learning to the effective use of technology (Mishra and Koehler, 2006; Schmidt et al., 2009; Koehler et al., 2014).
6. Technological pedagogical knowledge (TPK): Corresponds to the intersection between TK and PK, it aims to use technology with a focus on pedagogical aspects, including strengths and weaknesses (Mishra and Koehler, 2006; Schmidt et al., 2009; Terpstra, 2015).
7. Technological pedagogical content knowledge (TPACK): Corresponding to the intersection between CK, PK, and TK, it aims to integrate students' prior knowledge and possible learning difficulties (Mishra and Koehler, 2006; Schmidt et al., 2009; Koehler et al., 2014).

Figure 1.
TPACK Model.



Source: Reproduced by permission of the publisher, © 2012 by tpack.org.

About the use of the TPACK model, its solid guidelines for the development of educational processes related to ICT stand out (Ortiz et al., 2023; Wang et al., 2018). In addition, authors such as Redmond and Peled (2019) and Schmid et al. (2021) consider TPACK as a fundamental guide for developing ICT-mediated curriculum experiences.

As of 2019, the TPACK model incorporates the concept of contextual knowledge, where teachers must include the realities of the context in their decision-making (Mishra, 2019; Monsalve-Suárez et al., 2024). For authors such as Akyuz (2023), Byrne-Cohen (2020), and Fives and Buehl (2014), contexts are unique and must include beliefs, knowledge, and constraints, including the different actors in schools.

The latest research related to TPACK includes rapidly expanding topics such as Artificial Intelligence (AI). The study by Saz-Perez et al. (2024), validates a generative AI self-report questionnaire, obtaining a valid and reliable tool for the assessment of PK, CK and TK knowledge. In addition, Kong et al. (2024), which addresses the design of STEM activities focused on the Internet of Things (IoT) and AI components, suggests that teacher-centred training processes favour the development of students' competences

through problem solving. Other studies develop professional training processes related to TPACK and AI, revealing the existence of significant knowledge gaps in the TK domain (Yue et al., 2024).

Regarding special education, the studies by Jenny et al. (2020) and Neece et al. (2020) highlight the need to develop TPACK studies to support students with Special Educational Needs (SEN) and intellectual disabilities, favoring the social participation of students and their families. A search for systematic literature review (SLR), scientometrics, and/or bibliometrics of the TPACK model and special education did not reveal the existence of this type of research; this procedure is described in subsequent sections. Considering the previous background, this research aims to examine the TPACK model from its scientific production in special education contexts, the following questions are included:

Question 1 (RQ1): What types of studies are derived from the scientific literature on the TPACK model in special education?

Question 2 (RQ2): What are the methodological orientations obtained in the studies of the TPACK model in special education?

Question 3 (RQ3): What results were obtained in studies of the TPACK model in special education?

Question 4 (RQ4): What are the recommendations of the studies of the TPACK model in special education?

2. METHODOLOGY

The SLR was conducted considering the stages proposed by Kitchenham (2004), widely used in the social sciences, see Table 1. Furthermore, this SLR aims to develop a research process according to critical and structured protocols (Petticrew & Roberts, 2006).

Table 1.
Stages described in this SLR.

Stage	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

Source: Based on Kitchenham (2004).

2.1. Planning and implementation of SLR

In the preliminary phase, a scoping search was carried out, by the guidelines of Robinson et al. (2014), to identify SLR, bibliometrics, and/or scientometrics of the TPACK, from 2020 onwards. The following databases and/or repositories were included: Dialnet, Google Scholar, Scientific Journals of Latin America and the Caribbean, Spain and Portugal (REDALYC), Semantic Scholar, and Scientific Electronic Library Online (SciELO). The keywords included in the search were "technological AND pedagogical

AND content AND knowledge AND TPACK" and adaptation according to the particularities of each database. Thirty-six researches were obtained, and the scientific production is preferentially concentrated in the year 2023 with 55,55% of the total. The most popular databases and/or repositories are SCOPUS, Google Scholar, Web of Science (WoS), and Education Resources Information Center (ERIC). To the subjects addressed, there are studies related to the subjects of mathematics, science, English, and geography and other subjects specific to local realities such as China, Indonesia, and Ibero-America. Finally, the topics of e-learning, Science, Technology, Engineering, and Mathematics (STEM), teacher training, and primary education stand out, see Table 5, Appendix.

In consideration of the previous background, an SLR was developed including the following databases and/or repositories: DIALNET, ERIC, JSTOR, PsycINFO, REDALYC, SCOPUS, and WoS. Keywords were checked in the ERIC and UNESCO thesauri. The search equation included the term TPACK, as it provides a broader view, avoiding focusing on one or two components (Mishra and Koehler, 2006; De Rossi and Trevisan, 2018), see Table 2. The search period covered was from the inception of the model 2006 to October 2023.

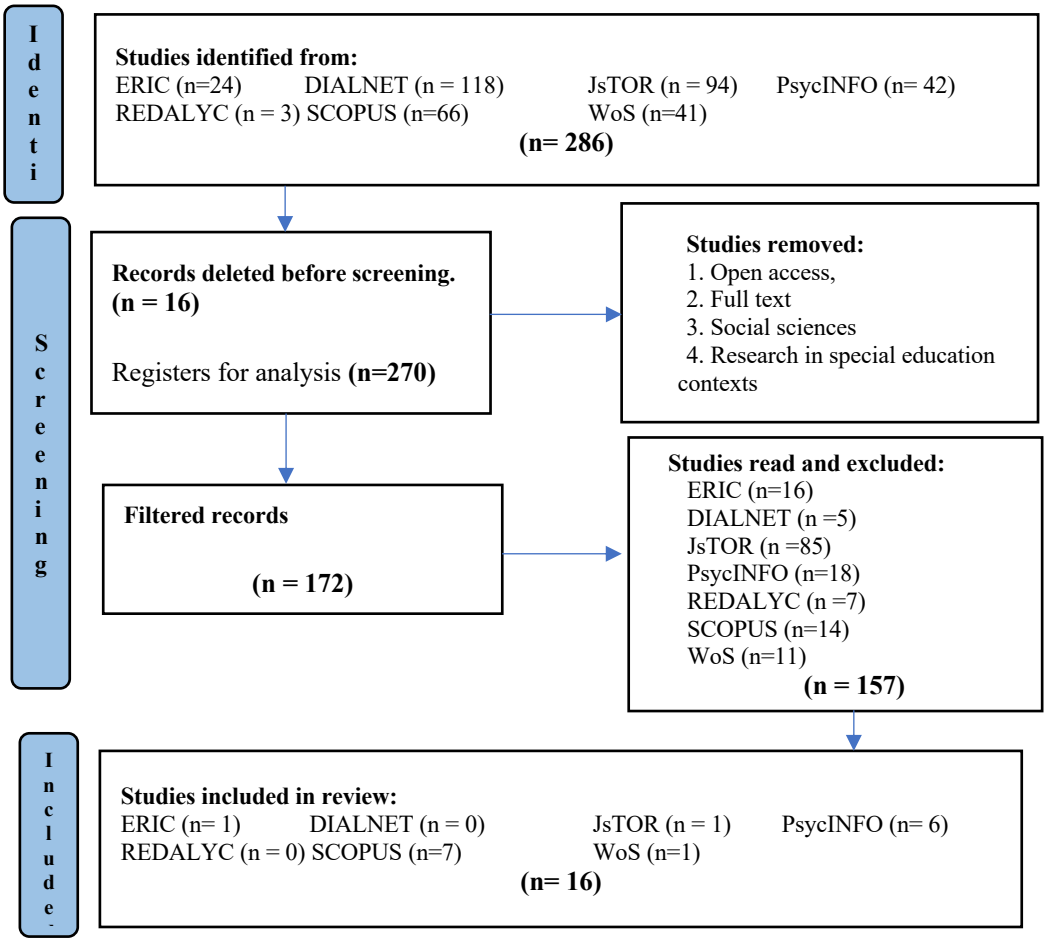
Table 2
Specific keyword protocol in each repository.

Repository	Keyword protocol
ERIC	"modelo TPACK" AND "educación especial"
DIALNET	“modelo TPACK AND "educación especial"
JSTOR	(((technological AND pedagogical AND content AND knowledge) AND (TPACK)) AND (education special))
PsycINFO	(Any Field: technological AND Any Field: pedagogical AND Any Field: content AND Any Field: knowledge) AND (Any Field: TPACK) AND (Any Field: education special)
SCOPUS	(TITLE-ABS-KEY Technological AND pedagogical AND content AND knowledge) OR TITLE-ABS-KEY (tpack) AND TITLE-ABS-KEY (education AND special)))
REDALYC	"modelo TPACK" AND "educación especial"
WoS	TS= (technological AND pedagogical AND content AND knowledge) AND TS=(tpack) AND (special education)

Source: Own elaboration.

Inclusion criteria were: articles, open access, full text, social sciences, and research developed in special education contexts. Exclusion criteria included: abstracts, editorials, press releases, conference papers, master's and doctoral dissertations and theses, areas other than social sciences, and research that did not consider special school contexts.

Figure 2
Summary outline of selected articles



Source: Own elaboration.

Figure 2 shows 286 documents documents were obtained in the identification stage, the largest number corresponding to DIALNET (44,02%), followed by JsTOR (35,07%). The articles were reviewed according to titles, keywords, and abstracts, by the inclusion criteria. In addition, in some cases, access to the full text was required. Finally, 16 articles were selected, seven SCOPUS (43,75%), six PsyINFO (37,5%), and one each in ERIC, JsTOR, and WoS (6,25%), see Figure two. Systematic reading of the articles was carried out to obtain information related to the research questions, see Table 3.

Table 3
Research articles included in the SLR

N°	Author	Country	Type of study	Sample	Instruments	Educational level	Working área
1	Anderson et al. (2017)	United States	Training	14 early childhood education students	Focus group discussions, focus groups, interviews, lesson plans, field notes and observations.	University	Special education
2	Barbieri et al. (2021)	Italy, Greece y Portugal	Mixed, experimental	432 students	Interviews	Secondary and bachelor	Mathematics
3	Ciampa (2017)	United States	Case study	3 Teachers	Field notes, reflections and students' work	Elementary	Educational technology
4	Courey et al. (2015)	United States	Mixed	Teachers special education	Test Learning Mathematics for Teaching (LMT), rubric, survey and observations	University	Mathematics
5	Hill (2020)	United States	Mixed	60 Teachers	TPACK questionnaire (Zelkowski et al., 2013)	Elementary and secondary	Mathematics
6	Huang et al. (2020)	Taiwán y China	Quantitative	415 special education and 134 Teachers	TPACK questionnaire (Chai et al., 2011)	Special education	No data
7	Kao y Mzimela (2019)	South Africa	Qualitative	80 students	Interviews, observations and document analysis	Elementary	Language (braille)
8	Kaplon-Schilis y Lyublinskaya (2019)	United States	Quantitative	116 students	TPACK questionnaire validation	University	Science and mathematics
9	Karaaslan et al. (2023)	Turkey	Quantitative	446 students	Teaching Self-Efficacy Belief Questionnaire (TSBS) and Technological Pedagogical Content	University	Special education

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					Knowledge Scale (TPCKS) questionnaire.		
10	Kotzebue et al. (2021)	Germany	Quantitative	118 students	Questionnarie TPACK-PRE (competency area presentation) y TPACK - ISE (Information search and evaluation)	University	Sciense
11	Kuo (2015)	United States	Mixed	32 students	Discussion papers and comments.	University	Fundamentals of Literacy and Characteristics of Special education.
12	Kwok et al. (2021)	Ireland, Latvia, Lithuania, Portugal y United Kingdom.	Consensual declaration process	125 Teachers	Bibliographic sources, questionnaire (TPACK-21) and self-efficacy scale for students with disabilities in physical education (SE-PETE-D).	Secondary	Physical education
13	Lee et al. (2014)	Malaysia	Research based research	77 Teachers university	Questionnaire TPACK	University	Braille
14	Lyublinskaya y Tournaki (2014).	United States	Research based research	100 students postgraduate	TPACK rubric Lyublinskaya and Tournaki (2011)	University	Science and mathematics
15	Lyublinskaya y Kaplon-Schilis (2022).	United States	Research based research	175 planificaciones de clases.	TPACK rubric Lyublinskaya and Tournaki (2011)	University	Mathematics
16	Van Leendert et al. (2022)	Netherlands	Mixed	5 Teachers y students	Interviews, questionnaire and logbook	Secondary	Mathematics and braille

Source: Own elaboration.

3. RESULTS

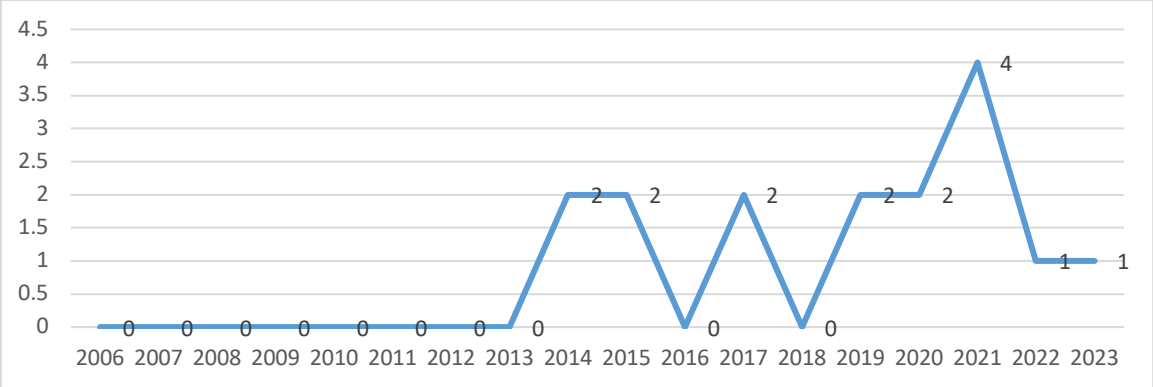
The first part of the analysis of the documents included, years of publication, geographical distribution, type of research, instruments used, and theme addressed to answer the first question.

3.1. Quantitative data indices of the TPACK model in special education

Publications are distributed between the period 2013 and 2023, with 2021 being the year of highest production, accounting for 25% of the total, see Figure 3.

Figure 3

TPACK articles by publication year



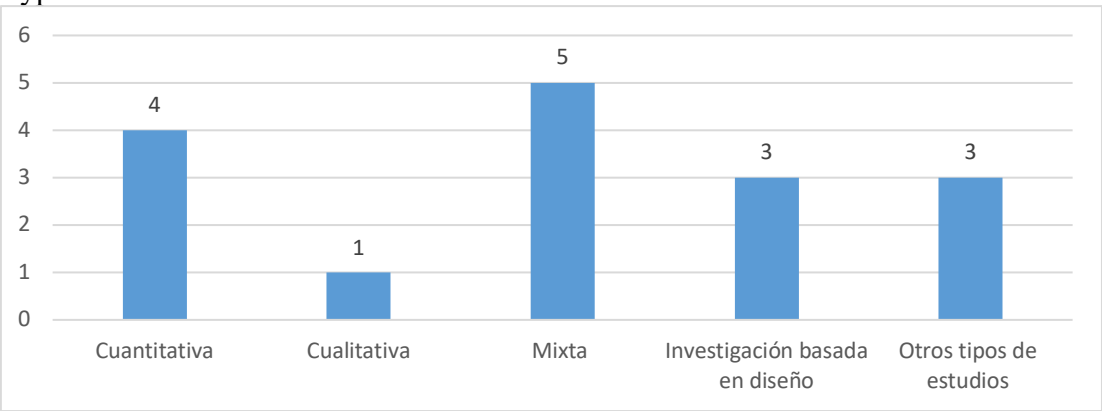
Source: Own elaboration.

In terms of geographical distribution, the United States is the country with the highest scientific production, with 50% of the articles reviewed. It should be noted that the European context presents a participation of 11 different countries.

Regarding the type of research, 37,5% are mixed, followed by 25% quantitative and 18,75% design-based research and other types of studies, see Figure 4.

Figure 4

Types of research found in this SLR



Source: Own elaboration.

The research is carried out mostly in university education with 56,25%, followed by primary and secondary education with 12,5% respectively. The most representative samples correspond to Karaaslan et al. (2023) and Barbieri et al. (2021) with 446 and 432

students from Turkey, Italy, Greece and Portugal, respectively. On the other hand, the smallest sample of only three teachers (Ciampa, 2017). Regarding the instruments, there is a predilection for the use of questionnaires that represent 43,75% of the total, followed by field notes with 18,75%. Finally, among the research topics or themes, mathematics stands out with 37,5% of the total, followed by the Braille language and science.

3.2. The TPACK model in special education by level of education

The second part of the analysis considers some of the approaches made by Paidicán and Arredondo (2022a) to provide answers to questions two, three, and four.

Table 4
TPACK research in special education by level of education

TPACK perspective	Authors	Quantity/ percentage
Primary	Ciampa (2017), Kao y Mzimela (2019)	2 (12,5%)
Secundary	Kwok et al. (2021), Van Leendert et al. (2022)	2 (12,5%)
University	Anderson et al. (2017), Courey et al. (2015), Kaplon-Schilis y Lyublinskaya (2019), Karaaslan et al. (2023), Kotzebue et al. (2021), Kuo (2015), Lee et al. (2014), Lyublinskaya y Tournaki (2014), Lyublinskaya y Kaplon-Schilis (2022).	9 (56,25%)
Primary and secundary	Hill (2020)	1 (6,25%)
Secundary and bachelor	Barbieri et al. (2021)	1 (6,25%)
Special school	Huang et al. (2020)	1 (6,25%)

Source: Own elaboration.

Table 4 shows that more than half of the studies of the TPACK model in special education are carried out at the university level, followed by primary and secondary with 12,5% respectively. In the primary studies, they present qualitative methodologies and case studies, with samples ranging from three to 80 cases, including students and teachers. Both studies consider three or more instruments including field notes, reflections, interviews, document analysis, observations, and student work. The subjects of educational technology and language through Braille were considered. Finally, the studies were carried out in the United States and South Africa. Referring to the findings, teachers require strong PK, TK, and CK knowledge, which needs to be continuously addressed in professional development processes. In addition, teachers require adequate time to explore and critically evaluate digital resources to strengthen personalization, taking into account the particularities of learners, for example in instances of visual impairment and the use of Braille

About the recommendations, there is a need to opt for participatory action research approach models (McTaggart, 1991) and active learning techniques (Desimone, 2009; Jaipal-Jamani & Figg, 2015), to ensure collaboration and social participation (Ciampa, 2017). To secondary school studies, there are mixed research and consensus statement processes, with samples ranging from five to 125 teachers. The instruments used were the TPACK-21 questionnaire, self-efficacy scale (SE-PETE-D), interviews and logbook. The areas included in the research were physical education and mathematics using Braille.

The studies were conducted in Europe, with the research by Kwok et al. (2021) including up to five countries.

The results indicate that teachers require greater TK and CK, both for special education and in mathematics and physical education, favoring the development of classes with appropriate adaptation according to the characteristics and context of the students. Finally, teachers need to be more aware of the importance of student support, such as, for example, the use of Braille. About the recommendations, more space for reflection among teachers is required, including more representative samples, to deepen the aspects related to the European Standards in Adapted Physical Activity (EUSAPA). Also, aspects related to the use and selection of assistive devices for students with SEN should be deepened.

Regarding the studies focused on the university setting, they mostly present design-based, qualitative, and mixed methodologies, which show an average of 129 cases, with the study by Karaaslan et al. (2023) presenting the most significant sample with 446 students, more than 60% of the studies were developed in the United States, including undergraduate and graduate students. The most commonly used instruments were the TPACK questionnaire and rubrics. The study by Anderson et al. (2017) presented the largest variety of instruments including: focus group discussion, focus group, interviews, lesson plans, field notes, and observations.

The results indicate that teacher training in areas related to TPACK facilitates the incorporation of IPAD and DYNABOOK, improving learning experiences and the systematic integration of ICT, including important areas such as logical-mathematical reasoning (Anderson et al., 2017; Courey et al., 2015; Kuo, 2015). Furthermore, the levels of self-efficacy measured utilizing the TPACK questionnaire indicate that women perform better than men and that the use of this type of instrument is valid for postgraduate students (Kaplon-Schilis and Lyublinskaya, 2019; Karaaslan et al., 2023). Also, it was observed that the use of the TPACK model allowed for specific didactic insights in areas related to E-learning, Braille, artificial intelligence, augmented reality, and 3D printing (Kotzebue et al., 2021; Lee et al., 2014). Finally, the use of new tools such as the rubric allows for a broader view of the TPACK model, including both theoretical and practical aspects, as exemplified by the analysis of lesson plans (Lyublinskaya and Tournaki, 2014; Lyublinskaya and Kaplon-Schilis, 2022).

In relation to the recommendations, the consolidation of new instruments related to TPACK is required, in different contexts and with larger samples (Courey et al., 2015; Lyublinskaya and Kaplon-Schilis, 2022). There is also a need to deepen lines of research related to classroom design, classroom culture and organisation, and the use of ICT and their ways of thinking and acting at the time of implementation (Anderson et al., 2017; Kotzebue et al., 2021; Lee et al., 2014). Finally, it requires the development of training processes in special education settings, including teacher and students, as well as the use of feedback as a mechanism for teachers' professional reflection (Kuo 2015; Lyublinskaya and Tournaki, 2014).

Studies that include more than one educational level, are characterized by their mixed methodology, with samples ranging from 60 to 432 individuals, the research by Barbieri et al. (2021), which includes the participation of students from Greece, Italy, and Portugal, stands out. The preferred instruments are the TPACK Questionnaire (Zelkowski et al., 2013) and interviews. The results indicate that high teacher confidence positively affects ICT integration, even though time and resources are the main obstacles (Hill,

2020). Moreover, the incorporation of Serius Game promotes significant changes, especially in mathematics, and, in addition, activates mental resources (Barbieri et al., 2021). It is recommended that future research should delve deeper into classroom observations, as they allow for a more objective view of ICT integration through TPACK. Finally, the study developed in special schools sought to compare the realities of Chinese and Taiwanese teachers with a sample of 415 schools, the instrument used was the TPACK questionnaire (Chai et al., 2011). The results indicate that Chinese teachers perform better than their Taiwanese peers, the likely explanation being that China has educational policies related to special education. It is recommended that a wider variety of instruments be applied during data collection.

4.DISCUSIONES

Research on the TPACK model, in a context that includes special education, is mainly developed in North America, with the United States being the country with the largest production, according to Lee et al. (2002), Paidicán and Arredondo (2023a) and Sakaria et al. (2023). It is worth noting that only the Huang et al. (2020) study was carried out in a special school, contrary to what might be thought before the present SLR.

There is an increase in TPACK and special education research as of 2021, which is in line with the need arising from the COVID-19 health emergency, which required teachers to acquire new knowledge, skills and abilities that are specific to the demands of using new technologies, similar to what happened with the TPACK model in rural contexts, whose main obstacle was related to the lack of resources and inputs, both technological and human (Paidicán and Arredondo, 2024).

Furthermore, there is agreement on the need to maintain a balance in the development of teachers' PK, TK, and CK knowledge, ensuring the success of the studies, although this is not always comparable and is conditioned by various contextual factors (Paidicán and Arredondo, 2022a; Paidicán et al., 2024; Setiawan et al., 2019; Voogt et al., 2013).

In relation to the use of instruments, there is a diversification of these, ranging from the TPACK questionnaire and its various versions to classroom observation, the latter being the most valued by researchers, as it allows them to obtain a more objective view of the classroom reality, for Schmid et al. (2024) this type of practice allows different conceptualizations of TPACK to be obtained through empirical findings.

Finally, research shows that the lack of resources and inputs affects the development of experiences, weakening the organizational elements and their implementation (Sampaio, 2016; Da Silva et al., 2021).

5.CONCLUSIONES

Concerning the results obtained, it is concluded:

The development of the scientific production of the TPACK model and special education is scarce, obtaining only 16 out of a total of 286 documents, representing 5,59%. The publications are concentrated between 2014 and 2023, although the original TPACK model emerged in 2006.

More than 30 SRs related to the TPACK model are obtained, with the year 2023 standing out as the most productive. However, there are no literature reviews about special education, so this SR represents a real contribution to developing the TPACK model.

Most of the studies are carried out at the university level, with the United States accounting for half of the research reviewed. Furthermore, the studies use the questionnaire as the most common instrument, with the emergence of new instruments such as TPCKS, TPACK-PRE, TPACK-ISE, and TPACK-21 standing out. In the curricular areas, mathematics and the use of Braille show a more significant development, although at a very preliminary stage.

The research mainly recommends expanding the samples in quantity and context, including a greater diversity of research instruments, with classroom observation representing the most objective view when analyzing using the TPACK model. In addition, the instances of professional training through the TPACK model require the participation of teachers and students, being relevant to the development of spaces for reflection, including the various TK, PK, and CK knowledge.

To conclude, the present SLR in its genesis represents a complement in the development of the TPACK model, although it is necessary to carry out analyses that prioritize methodological aspects of the research and, in addition, address areas of emerging technologies such as artificial intelligence, virtual reality, and augmented reality.

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APPENDIX

Table 5

Summary SLR, bibliometrics and scientometrics of the TPACK model last five years (2019-2023)

Author	Period of years	Article numbers	Databases consulted	Research focus
Albeta et al. (2023)	2006 a 2021	44 publications	Harzing's Publish and Perish a través de SCOPUS, Google Books y Google Scholar.	Analyse blended learning based on TPACK from the perspective of the philosophy of progressivism.
Assis y Vieira-Santos (2021)	2012-2018	24 artícles	CIET: EnPET	TPACK competences in the knowledge construction of the virtual teacher.
Bahtiar et al. (2023)	2012 to 2022	640 publications	Google Scholar	Identify and analyse TPACK research trends in 21st century science learning in the form of TPACK papers.
Brianza et al. (2022)	Rosenberg y Koehler (2015) between 2005-2013 y 2014-2020	58 artícles	Web of Science (WoS), SCOPUS, Education Resources Information Center (ERIC), PsycInfo y Google Scholar	To provide an overview of the existing literature on TPACK and contextual knowledge.
Coronado & Velásquez (2023)	2017 to 2022	65 artícles	Google Scholar, Semantic Scholar, REDIB, Dialnet, Scielo, ScienceDi-rect), Redalyc y Science and Education	Describe trends on TPACK for the implementation of digital educational resources.
Dewi et al. (2021)	2010-2020	184 artícles	SCOPUS	To investigate research trends related to the TPACK topic, which is particularly useful for developing online teacher learning skills.
Feng y Mustapha, (2023)	2012 to 2022	841 studies	CNKI y CiteSpace	To analyse the bibliometric characteristics of papers published from 2012 to 2022 on TPACK study in China.
Handayani et al. (2023)	2018 to 2022	305 artícles	WoS	To clarify which elements are relevant to TPACK, it is important to map the database associated with TPACK.
Irwanto (2021)	January 2010 to june 2021	106 publications	Springer	To provide a comprehensive overview of previous literature and some possible

				directions for researchers and educators for future TPACK studies.
Jiménez et al. (2023)	From the 2015-2021	16 studies	SCOPUS, WoS, Spinger Link, Proquest Central, Science Direct, REDALYC y DIALNET	To explore the trends associated with the development of technological pedagogical knowledge (TPACK) based on the study of lessons.
Jinyao & Bhattacharyya (2022)	2018 to 2022	4.589 artícles	SCOPUS	Review English Foreign Language articles related to TPACK.
Joshi, S. (2023).	2006-2021	75 artícles	ERIC, Education Source, Child Development and Adolescent Studies, Psyc INFO y Academic Search Ultimate	To analyse TPACK teachers' self-efficacy, self-efficacy beliefs, computer self-efficacy and technological support in relation to professional development.
Karampelas (2023)	From the 2007	2.680 artícles	SCOPUS	Examine articles that combine the terms TPACK and STEM.
Kholid et al. (2023)	January 2018 to december 2022	25 artícles	ERIC y SCOPUS	Examine the development of Technological, Pedagogical and Content Knowledge (TPACK) in mathematics education and its impact on teaching
Konyalıhatipoğlu, y İskenderoğlu. (2022).	No data.	20 artícles and 8 dissertation	ERIC (EBSCO), ProQuest Dissertations and Theses Global, Emerald Insight, Sage Journal s, Science Direct, Scopus (A&I), Springer LINK, Taylor & Francis, Wiley Online Library Full Collection and Google Scholar, YOK National Dissertation Center y ULAKBIM National Database	To examine in the context of the target studies, method, sample, data collection tools, data analysis techniques, the distribution of topics in TPACK in primary education.
Lee et al. (2022)	2011-2020	700 artícles	SCOPUS	Exploration of the bibliometric characteristics of TPACK from 2011 to 2020.
Lemke et al. (2022)	Between 2010-2022	38 studies	Newspaper portal da CAPES e na Biblioteca Digital Brasileira de Teses e Dissertações (BDTD)	Demonstrate and characterise scientific productions on TPACK, basic education and teacher knowledge.

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Major & McDonald (2021)	Until 2021	13 artícles	Academic Search Elite, ERIC y Google Scholar	Interventions that help trainers develop TPACK.
Nasir et al. (2023)	2013 to 2022	528 publications	SCOPUS	Knowing the development of the publication of scientific articles on the TPACK Model.
Ning et al. (2022)	June 2006- july 2022	59 publications	WoS, Google Scholar, ProQuest y SCOPUS	Analysis of the effect of a teacher education intervention on TPACK and the differences under the influence of different variables.
Paidicán & Arredondo (2022a)	From the 2006 mayo 2019	19 artícles	ERIC, Google Scholar, SCOPUS, WoS,	To analyse the scientific literature related to TPACK in primary education.
Paidicán & Arredondo (2023a)	Start of the model (2006) to april2020	15 doctoral theses	TESEO, DIALNET, Doctoral Theses in Network (TDR) y Open Theses and Theses and Dissertations (OATD)	To examine recent doctoral work related to the TPACK model with a focus on primary education.
Paidicán & Arredondo (2023b)	Start of the model (2006) to november 2022.	22 artícles	ERIC, Dialnet y Redalyc, SciELO, Scopus, WoS,	To examine the scientific production related to the TPACK model in the Ibero-American context.
Putri et al. (2022)	2012-2021	910 artícles	SCOPUS	Present a summary of science education research within the TPACK framework.
Rahman et al. (2023)	From the 2018 a 2023	10 artícles	Google Scholar, MPDI, ScienceDirect, Wiley y ERIC.	Analyse design thinking integrated with technological pedagogical content knowledge (TPACK) in education.
Rukmana (2023)	2006 to 2022	9 artícles	Google Scholar	To analyse in depth various articles related to the development of the TPACK tool that has been carried out, especially in the field of science learning.
Sakaria et al. (2023)	January 2018 to january 2022	31 artícles	WoS	To investigate the aspects that influence the PCK of primary and secondary mathematics teachers..
Smit et al. (2023)	January 2021	43 artícles	ERIC y Google Scholar	To obtain an overview of research related to geography teachers and PCK.
Sofwan et al. (2023)	2010 to 2022	28 artícles s	Science Direct	Examine in depth studies on TPACK and technology integration for trainee teachers.

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Su (2023)	2007 to 2022	112 artícles	SCOPUS	To analyse global trends in research on the development of technological pedagogical content knowledge (TPACK) in in-service teachers..
Suprapto et al. (2021)	2015-2019	2.075 publications	SCOPUS	To analyse the scientific trend of research on Technological Pedagogical Content Knowledge (TPACK) and explore how the contribution of Indonesian researchers has evolved..
Vásconez & Inga (2021).	2016-2020	60 artícles	SCOPUS, WoS	Contextualisation of TPACK, systematic review and analysis of national and international literature.
Yeh et al. (2021)	Until 13 to February 2020	11 artícles	SCOPUS y WoS	Learning by design
Yuliyanto et al. (2023)	2013 to 2023	123 artícles	SCOPUS	Provide an overview of the Technology, Pedagogical and Content Knowledge (TPACK) model of digital learning..
Zhang & Tang (2021)	April 2008 to december 2019	169 artícles	China Journal Full Text Database of *China National Knowledge Infrastructure* (CNKI)	To provide an overview of current teachers of TPACK in China
Zeng et al (2022)	2007 to 2022	28 publications	CNKI, WoS, SpringerLink, Google Scholar y ProQuest	To explore the relationship between teachers' self-efficacy and TPACK in the context of educational information technology integration and focus on the moderating variables affecting the relationship.

Source: Own elaboration.

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