EMPOWERING EDUCATION: TEACHERS' ROLE IN DIGITALIZING LEARNING - AN UMBRELLA REVIEW

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Abstract

As teachers are central to digitalizing education, we summarize 40 years of research on their role in that process within a systematic umbrella review that includes 23 systematic reviews with a total of 1062 primary studies focusing technology integration and aspects of digital literacy. Our fndings highlight the international acceptance of the TPACK framework as well as the need for a clear concept of digital literacy. It is unique that we identify and discuss parallels in developing teachers' digital literacy and integrating digital technologies in the teaching profession as well as barriers to those goals. We conclude by suggesting future directions for research and describing the implications for schools, teacher education, and institutions providing professional development to in-service teachers. Keywords TPACK · Digital literacy · Technology integration · Strategies

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I. Introduction

A variety of stakeholders must be mutually committed to creating digitally competent schools (Pettersson, 2018; Saileret al., 2021), and teachers are seen as crucial to this process of digitalization (Bridwell-Mitchell, 2015; Lockton &Fargason, 2019). Moreover, the role of teachers in digitalizing education must be recognized as a complex, holistic phenomenon (Ertmer&Ottenbreit-Leftwich, 2010). Teachers can be a driving force of digitalization, but the COVID-19 pandemic and associated distance teaching/learning have also made teachers prisoners of the rapid digitalization of society and of the associated expectations for education as they are forced to use digital technologies (Wohlfart et al., 2021). Before 2020, some institutions were still discussing data protection guidelines while others were already trying to "crack the code of education reform" (Tienken& Starr, 2020). By 2021, this situation had changed entirely, and distance learning and digitalization became inescapable, yet only 41% of teachers internationally reported havinglearned how to integrate digital technologies into teaching (Drosselet al., 2019; IEA, 2019). While policy and organizational infrastructure are pivotal in successfully promoting the digitalization of education, research has shown that teachers' digital literacy is more important in that process than rich access to digital technologies (Pettersson, 2018). Previous research on the role of teachers in this process has often focused either on their (perceived) digital literacy or on their willingness and ability to integrate technology (e.g., Granić&Marangunić, 2019; mcknight et al., 2016). Various models have been developed to examine the digital literacy of teachers and teacher educators, the most prominent being the Technological-Pedagogical-Content-Knowledge (TPACK) model (Koehler & Mishra, 2008; Mishra & Koehler, 2006), which acknowledges the complexity of teaching by diferentiating seven knowledge domains in the interplay of technological, pedagogical, and content knowledge. Since the model's frst publication in the mid-2000s, the international scientifc community has directed much attention and encouragement but also criticism toward it. To date, the original article by Mishra and Koehler (2006) has been cited over 10,000 times (Google Scholar). Due to global trends of digitalization, the literature on digitalization in education has fourished in recent decades, occasioning a number of literature reviews in this crowded feld. As the number of publications per year relentlessly increases, it has become difcult to stay abreast of current fndings, but literature reviews have the advantage of systematically structuring and summarizing the previous literature on a specifc topic (Mullins et al., 2014). Because teachers are central to implementing digitalization, this second-order review study aims to examine the (main) research focus of previous reviews related to teachers' perspectives on the digitalization of school education and to identify future directions for research on the role of teachers in this process. Due to varying theoretical approaches and research questions, timeframes and sample groups, previous reviews on teachers' role on the digital transformation often focus very specifc aspects of these. It is unique to this approach, that we are able to identify parallels and connections between overarching themes which have been examined independently in the past. With this holistic overview of research on the digitalization of education from a teachers' perspective, we aim to answer the following research questions:

II.Method

An abundance of research on teachers and the digitization of education has been conducted in the past decades. Systematic reviews and meta-analyses ofer context-specifc overviews and critical reviews of these studies and add to our knowledge base. Our goal is to refnethis knowledge base by combining these reviews "under one umbrella." Instead of repeating searches, assessing the study eligibility of included articles, etc., we provide a systematic overview and critical review of research on a complex topic, following the protocol recommended for umbrella reviews by the Joanna Briggs Institute (Aromataris et al., 2015). Furthermore, we analyze whether, and discuss how, independently derived conclusions and discussions of these reviews align.

III.Inclusion criteria

In our umbrella review, we refer to syntheses of research evidence, including systematic reviews and meta-analyses focusing on pre- and in-service teachers' digital literacy as well as their application of technology-based education in primary and secondary education. Due to the emerging nature of our research topic, we include all available review types and articles (Grant & Booth, 2009)

Search procedure

The search was conducted using the search engine ebscohost and included the databases Education Resource Complete, Academic Search Complete, and Education Resources Information Center. To ensure the quality of the syntheses, only articles and reviews published in peer-reviewed journals were included. For better reproducibility, we opted for articles in English language as the lingua franca in the global, scientifc community. The selected search terms were determined by means of an exploratory literature analysis of scientifc and educational policy documents as well as the authors' expertise. In a frst search attempt, we used various synonyms of the terms "digital literacy" and "digital competence" as well as "technology integration" and "educational technology," with the addition of "teachers" and various "review" methods. As this yielded over 20,000 results, we refned the search string to focus on teachers' digital literacy and integration of technology. This resulted in the following Boolean search phrase: ("digital literac*" OR "digital competenc*" OR "ICT skill*" OR "digital skill*" OR "computer skill*" OR "technological skill*" OR "e-literac*" OR "multi-modal skill*" OR ("technology" AND ("implementation" OR "integration" OR "application")) AND teacher* AND (review OR synthesis OR meta-analysis). A total of 9,080 results were identifed in the search (date of last search: May 6, 2021). To further reduce the number of articles to a manageable amount, we adapted our search string to consider only studies including "review," "synthesis," or "meta-analysis" in the title, which yielded a total of 683 results across the three databases. After duplicates were removed, 542 studies were submitted for further title and abstract screening. Figure 1 summarizes the search (identifcation) and eligibility steps (screening and checking).

Study selection

All the identifed articles were examined by two researchers through an initial screening of titles and abstracts based on the inclusion and exclusion criteria. This resulted in the exclusion of 498 publications. We excluded articles that did not conduct a systematic review or meta-study as well as those lacking an educational, digital, or teacher-centered

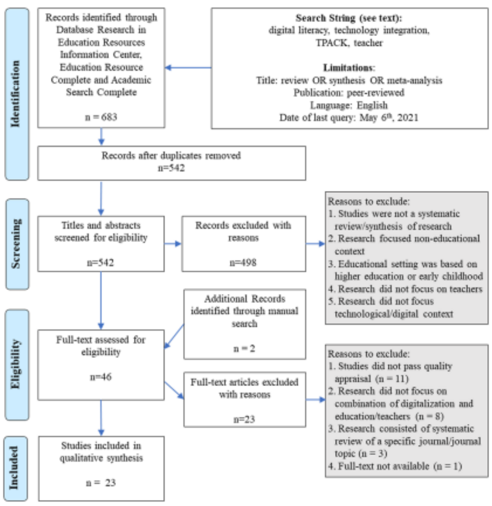

Fig. 1 Flow diagram of the literature search and selection of eligible reviews (adapted from the PRISMA Statement; Moher et al., 2009)

Focus. Articles focusing on studies of early childhood or higher education were also excluded from further analysis. Of the selected 44 articles, we were not able to access one paper and received no positive response after reaching out to the authors via email. Furthermore, we conducted hand searches of pertinent academic journals in the feld and of the reference lists of the identifed articles and extracted two additional papers: Rokenes and Krumsvik (2014) and Wang et al. (2018). In summary, 45 articles were read in full text and assessed for eligibility based on the a priori inclusion and exclusion criteria: (1) Context the study examined digitization in the context of teaching and learning. (2) Teacher sample the study targeted pre- or in-service teachers in primary or secondary education. (3) Methodological quality the study was a systematic review or meta-study. The decision to exclude full-text articles was made by the frst author in discussion with the second author. Upon reading the full texts, 11 articles were excluded due to the context or sample of the study.

Next, the methodological quality of the remaining 34 articles was assessed with an appraisal checklist based on the JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses (Aromataris et al., 2015; Moher et al., 2009) as well as Gessler and Siemer (2020). Only articles that at least partially met all the appraisal criteria were included in the subsequent qualitative synthesis of our umbrella review. Eleven articles did not meet the minimum requirements and were excluded from further analysis. In total, we included 23 articles in our qualitative synthesis based on extensive screening and assessment of the identifed records (Fig. 1). Except for two meta-analyses, the conducted studies are categorized as systematic reviews with narrative overviews of the state of research on the given topic.

Data analysis

To answer the research questions, we conducted a quantitative and qualitative content analysis of the 23 systematic reviews. For the quantitative analysis, a protocol was developed for categorizing the general characteristics (publication site, research design, included studies, research objective(s)/questions). This was followed by a content-based thematic analysis of the 23 articles to identify latent patterns, themes, and subthemes through an iterative reading and coding process (Braun & Clarke, 2006) supported by MAXQDA software. The identifed themes were discussed by the team of authors and then recoded by the frst author. Finally, 16 categories (with varying numbers of subcategories) were identifed from 1780 coded posts.

IV.Quantitative results

The umbrella review included 23 research articles from 18 scientifc journals, published between 2006 and 2020. Without regard to possible duplicates, we found 1321 studies within the reviews.1 We identifed the overlapping studies among the reviews and determined that this umbrella review includes 1062 studies. The reviews included studies published between 1980 and 2020 (Fig. 2). We found that several authors were mentioned and included repeatedly: Chai, Koh, Koehler, Mishra, Polly, and Tondeur. We also found overlap for several publications; e.g., the study by Niess (2005) was included in seven of the reviews, six studies were included in fve reviews, and a further 14 studies appeared in four reviews. Notwithstanding, 84% of the studies (890) were included in only one review.

Qualitative fndings

The qualitative analysis was guided by the formulated research questions. In "Research focus of previous reviews" section, we provide an overview of the main research foci of the included reviews (RQ 1). Next, we describe the current state of research on teachers' digital literacy ("Digital literacy" section RQ 2) and their (supposed) role in the integration of technology ("Technology integration"section RQ 3). Finally, in "Future research

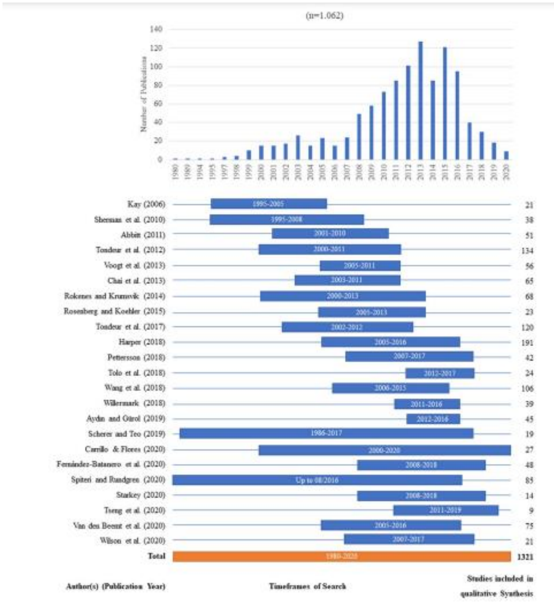

Fig. 2 Publication development of articles included in the selected reviews (n = 23)

V.Research focus of previous reviews

In regard to RQ 1, we identifed six themes as main research foci of previous reviews on the digitalization of school education from the perspective of teachers: (1) Digital Literacy, (2) Teacher Preparation (Programs),
(3) Role of Teachers, (4) Institutional Environment, (5) Technology Integration, and. (6) Technology as Tools.

The most prominent theme, which was included in over half of the reviews, concerned teachers' digital literacy (n=14). Within these reviews, methods and instruments which assessed and discussed digital literacy of teachers were analyzed (e.g. Rosenberg and Koehler (2015) critically refect how context is considered in TPACK research). The role and responsibilities of teacher preparation (programs) was addressed in eleven of the reviews, often in combination with a demand for a better preparation concerning digital literacy (e.g. Rokenes&Krumsvik, 2014). Several reviews also focused the critical role of teachers (n=11) and/or the institutional environment (n=9) in the process of digital transformation within the education system, highlighting the need for a holistic analysis on digitalization of school education and reliance on further stakeholders (e.g. Pettersson, 2018). Critical factors and requirements for successful technology integration were included and discussed in seven of the reviews. Finally, we identifed a sixth theme which examined (specifc) technologies as tools which infuence and support student learning as well as interaction between teachers and students (Harper, 2018). Table 1 ofers an overview of the main research focus of all 23 reviews as well as the identifed themes included within these.

Digital literacy

To answer RQ2, we analyzed how teachers' digital literacy was approached in the reviews and considered their main fndings. This topic was a thematic focus of 14 of the 23 systematic reviews, including 10 reviews that applied the TPACK framework. We present the fndings of our qualitative analysis related to the individual and the assumed concept of digital literacy (4.2.1), TPACK (4.2.2), approaches to developing teachers' digital literacy (4.2.3), and prevalent requirements (4.2.4).

Concept of digital literacy

The reviews ofer a variety of defnitions of digital literacy from policy papers and scientifc studies alike. Rokenes and Krumsvik (2014, p. 252) follow a defnition of digital literacy from Scandinavian studies on ICT in education and include "skills, knowledge, creativity and attitudes" in respect to digital media. Spiteri and Chang Rundgren (2020) include areas of digital literacy as proposed by the European Commission's framework for developing and understanding digital competence in Europe (Ferrari, 2013; Starkey, 2020)

Table 1 (continued)

Author(s) and year of publication	Number of studies included	Study designs included	Sample	Main research focus	Themes included						Theoretical framework		
					Digital literacy	Teacher preparation (Programs)	Role of teachers	Institutional environment	Technology integration	Technology as tools	TPACK	Other[a]	None
Sherman et al. (2010)	24	n.a.	Middle school education/ teaching	Identifies and describes teaching methods and content that characterize middle school technology education teaching practice			x	x					x
Spiteri and Chang Rundgren (2020)	27	Quantitative (n = 11), qualitative (n = 10), mixed methods (n = 6)	Primary education	Synthesizes previous research on the use of digital technology to illustrate factors affecting technology integration.	x		x		x	x			x
Starkey (2020)	48	Qualitative (n = 24), quantitative (n = 7), mixed methods (n = 11)	Preservice teachers	Synthesizes previous studies examining the preparation of teachers for the digital age and identifies future research.	x	x		x			x[b]		

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Table 1 Overview and research focus of selected reviews on teachers' role in the digitalization of education (n=25)

Author(s) and year of publication	Number of studies included	Study designs included	Sample	Main research focus	Themes included						Theoretical framework		
					Digital literacy	Teacher preparation (Programs)	Role of teachers	Institutional environment	Technology integration	Technology as tools	TPACK	Other[a]	None
Abbit (2011)	20	n.a.	Preservice teachers	Examines the emerging methods and instruments designed to assess the TPACK of preservice teachers.	x	x					x		
Aydin and Gürol (2019)	65	Quantitative (n= 45), qualitative (n= 9), mixed methods (n= 11)	Teachers, students, administrators, and schools	Summarizes critical factors pertinent to ICT use in education and discusses directions for future ICT research.	x				x				x
Carrillo and Flores (2020)	134	Qualitative (n= 53), quantitative (n= 30), mixed methods (n=51)	Preservice and in-service teachers, teacher educators, and other academic staff	Analyzes how and why online teaching and learning occurs in teacher education and explores its implications.			x			x		x	

Table 1 (continued)

Author(s) and year of publication	Number of studies included	Study designs included	Sample	Main research focus	Themes included						Theoretical framework		
					Digital literacy	Teacher preparation (Programs)	Role of teachers	Institutional environment	Technology integration	Technology as tools	TPACK	Other[a]	None
Chai et al. (2013)	74	Qualitative (n= 31), quantitative (n= 13), mixed methods (n=11), non-data-driven (n=19)	TPACK research	Consolidates research concerning emerging trends, findings, and issues generated in TPACK studies and identifies future research needs.	x		x				x		
Fernández-Batanero et al. (2020)	21	Qualitative (n= 8), quantitative (n=6), mixed methods (n=7)	Primary, high school, and university teachers	Identifies research trends and directions for future research on digital competencies and teacher professional development.	x	x		x					x
Harper (2018)	25	Qualitative (n= 16), quantitative (n=4), mixed methods (n=3), theoretical (n= 2)	K-12 educational settings	Synthesizes previous research on how technology influences interactions between teachers and students.			x			x			x

Table 1 (continued)

Author(s) and year of publication	Number of studies included	Study design included	Sample	Main research focus	Themes included						Theoretical framework		
					Digital literacy	Teacher preparation (Programs)	Role of teachers	Institutional environment	Technology integration	Technology as tools	TPACK	Other[a]	None
Røkenes and Krumsvik (2014)	42	Qualitative (n = 24), quantitative (n = 7), mixed methods (n = 11)	Preservice teachers (secondary education)	Reviews knowledge about empirical research on ICT training in teacher education and discusses implications for teacher education institutions.	x	x							x
Rosenberg and Koehler (2015)	70	n.a.	TPACK research	Synthesizes whether and how context is considered in current TPACK research.	x			x			x		
Scherer and Teo (2019)	46	Quantitative (k = 51 correlation matrices)	In-service and preservice teachers	Synthesizes and discusses quantitative research evidence on the structural relations among core variables of the TAM for teachers.					x			x	

TPACK

Eight reviews specifcally focus on the TPACK framework and examine various aspects of previous research, including publication development, the distinction between TPACK knowledge domains, the measurement of TPACK, the interplay between context and TPACK, and model development and TPACK development (Table 2). The reviews report (in broad agreement) on the emergence and publication development of the TPACK model based on the original contribution of Shulman (1986) and the contributions of Mishra and Koehler (Koehler & Mishra, 2008; Mishra & Koehler, 2006). In addition, the studies of Pierson (2001) and Niess (2005) play a special role. These emerged shortly before and concurrently with the TPACK model, respectively, and refer to TPCK as "technology-enhanced" PCK. Concerning the distinction of knowledge domains, four reviews specifcally acknowledge that a clear defnition and delineation of individual knowledge domains is rare and nearly impossible. They also concur that clear defnitions and operationalization of knowledge domains would be helpful in (further) developing both the theoretical model and individual survey instruments. The reviews often report TPACK as an overarching knowledge domain. Nevertheless, individual reviews refer to specifc knowledge domains, with technical knowledge (TK) taking a special role, as it strongly correlates with the development of TPACK (Wang et al., 2018). TK was defned in various ways and aligned with specifc technologies (both analog and digital) or types of knowledge (Voogt et al., 2013), which points to challenges in distinguishing domain-specifc from domainunspecifc technologies (Chai et al., 2013) as well as their dynamic and changeable nature over time (Abbitt, 2011; Voogt et al., 2013; Wang et al., 2018). The most prominent topic discussed in the TPACK reviews is how to measure teachers' TPACK. Five of the reviews present approaches and instruments for identifying and measuring TPACK, distinguishing between self-assessment and performance assessment, the former being applied in the large majority of studies. The survey instrument developed and validated by Schmidt et al. (2009) to measure self-perceived TPACK is explicitly highlighted in fve of the eight reviews. In addition to quantifed surveys, these studies also mention interviews, open-ended questions (mostly in the context of student teaching), interventions (with pre/post survey designs), refective questionnaires, and document analyses as possible data collection methods. In addition to self-assessment, the reviews acknowledge that performance assessment by experts or peers plays an important role in measuring TPACK; such assessment applies either quantitative or qualitative content analysis (or both) to evaluate observations, refection sheets, interviews, and classroom materials. Overall, although they agree on the importance of context in connection with TPACK, the reviews treat this topic rather marginally as a limitation or area for further research and thus refer predominantly to school types, subject areas, pedagogical approaches, and the characteristics and beliefs of teachers. An exception is Rosenberg and Koehler' (2015) context-specifc review, which discusses the meaning and presence of context in TPACK research based on Porras-Hernández and Salinas-Amescua's (2013) conceptual

Table 2 Thematic overview of research on TPACK (n = 8)

Authors (Year of publication)	Publication development	Distinction of knowledge domains	Measuring TPACK	TPACK and context	Model development	Developing TPACK
Abbitt (2011)	x		x	x		
Chai et al. (2013)	x	x	x	x	x	x
Rosenberg and Koehler (2015)	x			x		
Starkey (2020)		x		x		
Voogt et al. (2013)	x	x	x	x		x
Wang et al. (2018)	x	x	x	x		x
Willermark (2018)	x		x	x	x	
Wilson et al. (2020)		x	x	x		x

VI. Discussion

In synthesizing the 23 selected reviews, we found an abundance of evidence highlighting the importance of research on teachers' role in the process of digitalization. Our goal was to refne this knowledge base by combining these reviews "under one umbrella." Instead of repeating searches, assessing the study eligibility of included articles, etc., we have distilled the fndings of at least 1062 studies over the past 40 years that examine specifc aspects of teachers and their role in the digitalization of education, ofering an exclusive overview of past research on a meta-level, enabling a critical discussion thereof and proposing steps to pursue in upcoming years. The holistic approach of our umbrella review examining digitalization of education from a teachers' perspective ofers the unique opportunity to discuss parallels and links between diverse theoretical approaches. As a result of this inclusive approach, we found that the requirements and strategies proposed for developing digital literacy and the integration of digital technologies into teaching appear to be strikingly similar (see Chaps. 4.2.3, 4.2.4, & 4.3.1). Although previous research has shown that digital literacy correlates positively with the integration of technology in teaching (mcknight et al., 2016; Starkey, 2020), we highlight that research so far put a sole focus on one of the two. Examining and better understanding the connection and dependences between these two areas could help clear up ambiguities. We further found that the reviews highlight the necessity of discussing and refecting on (existing) approaches and requirements for developing digital literacy as well as integrating technology into classes. The reviews identify and present an abundance of strategies for "developing" digital literacy and "supporting" technology integration (see Chaps. 4.2.3 & 4.3.1) but provide no evidence of the actual impact of these strategies. Based on the fndings of our umbrella review, we recommend a critical discussion, application, and evaluation of these strategies in practice as a holistic approach involving the scientifc community, schools, and policy representatives. In this sense, several reviews often lacked a clear theoretical background which could support their respective research focus. This appears to be the case for the successful integration of technology in teaching. While an abundance of moderator variables for technology acceptance are mentioned in the reviews (Chap. 4.3.2), the reviews lack a discussion of the results and associated implications. In addition, as the fndings show that multiple concepts are used to defne digital literacy and that the TPACK model lacks clear defnitions of the individual knowledge domains (Chaps. 4.2.1 & 4.2.2), we believe it is essential to more clearly defne the concepts applied in the analysis of digitalization in education. The (further) development of the TPACK framework as proposed by Willermark (2018) represents a 360 O. Wohlfart, I. Wagner 1 3 frst step in this direction. In particular, a shift from TPACK as knowledge to TPACK as competence may ofer the potential to better understand the appropriate applications in practical teaching. Because education relies on a large, complex network of involved stakeholders (e.g., teachers, students, leadership, parents, policy makers), future research should consider multiple perspectives. For example, Tondeuret al. (2012) suggest the collaborative development of a technology plan for teacher education programs. Standardized selfevaluation tools, such as SELFIE,2 enable looking from multiple perspectives at schools' status quo in examining the profciency of students, teachers, and leadership in applying digital tools (European Commission, 2020).

VII. Conclusion

Teachers are central to the process of digitalizing education, so this umbrella review summarizes 40 years of research on their role in that process. The 1062 studies included in the 23 examined reviews make possible a sweeping overview of previous research as 362 O. Wohlfart, I. Wagner 1 3 well as an outlook for future studies. We found broad variation in the conceptualization of digital literacy and described various approaches to successfully developing digital literacy and integrating digital technologies as well as parallels between these two distinct research areas. Finally, we examined and synthesized the calls for future research in fve areas: understanding context, (critically) refecting on processes and outcomes, variety in methodological approaches, diversity of perspectives, and clarifying concepts.

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