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Review Article

Teacher Collaboration Through Digital Tools in the 21st Century—Issues and Challenges: A Comprehensive Literature Review

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ABSTRACT

Teacher collaboration is important for teacher professionalism, student learning and school progress. Understanding the tools, issues, and challenges inherent in teacher collaboration via technology becomes increasingly imperative in addressing the complexities of 21st-century education. However, scarce attention has been paid to using digital tools in teacher collaboration. Therefore, this paper aims to comprehensively review the digital tools employed by teachers to enhance collaboration and the issues and challenges confronted when digital tools were integrated into teacher collaboration. Eleven journal articles from the Web of Science, ERIC and Science Direct in the past five years were comprehensively reviewed. Findings indicate that various digital tools have revolutionized how teachers interact, communicate, and collaborate. However, issues and challenges hinder the smoothness and effectiveness of teacher collaboration via technology. Educational authorities are highly urged to implement various policies to develop digital infrastructure, promote teachers' digital competence and identify approaches to foster effective, sustained and high-level teacher collaboration through technology. Limitations and recommendations for future research are also discussed.

Keywords: Challenges, digital tools, issues, teacher collaboration

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INTRODUCTION

The educational landscape is changing, with a growing emphasis on fostering collaborative practices among teachers (Methlagl, 2022). Teacher collaboration entails collective interactions within a group in activities with the common goal of accomplishing a shared task. It involves

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working and reflecting jointly for job-related purposes (Vangrieken et al., 2015). Teachers need to be adept collaborators to carry out their duties effectively. Ongoing and professional collaboration among teachers ensures the quality of education and enhances successful school development (García-Martínez et al., 2021). Both teachers and students experience positive outcomes through high-quality collaboration.

Many studies have constantly emphasized the importance and benefits of teacher collaboration. Teacher collaboration benefits students, teachers, and even schools (Vangrieken et al., 2015). Collaboration among teachers helps address the diverse needs of students and establish a shared responsibility to enhance students' learning, ultimately boosting overall student accomplishments (Jones-Goods, 2018). Collaboration implies a positive influence on the confidence, job satisfaction, and sense of belonging of teachers (Reeves et al., 2017). Participating in collaborative groups enables teachers to unite, work as teams, and foster group thinking, enhancing teachers' self-efficacy (Choi & Kang, 2019). Schools that value professional collaborations and where teachers are actively involved in collaborative activities prove more successful than those that do not (Özbilen & Çekiç, 2022). Such activities add to the school's problem-solving abilities, enhancing the culture of collaboration (Yilmaz, 2022). Researchers must consistently strive to adapt to the dynamic demands of collaborative initiatives in the educational field in the 21st century (Şahin, 2023). Thus, this paper would further lead to exploration into teacher collaboration understanding.

By acknowledging the increasingly important role of teacher collaboration in educational sectors, great attention has been paid to exploring various aspects of teacher collaboration in different studies. Five systematic literature reviews have been identified in the five years to provide insights on enhancing teacher collaboration for instructional improvement, students' academic achievement and school progress (García-Martínez et al., 2021, 2022; Kolleck, 2019; Şahin, 2023; Weddle, 2022). The synthesis of these literature reviews, as shown in Table 1, aims to specify the research gaps identified in this paper:

The recent reviews mainly focused on factors or ways to encourage teacher collaboration and the impacts of teacher collaboration on teacher professional development and student learning (Table 1). In the current discourse on collaboration within educational settings, the predominant focus appears to be on the general improvements that students, teachers, and schools can achieve. However, critical examination reveals a noticeable gap in exploring technological dimensions within teacher collaboration and the formidable challenges in leveraging technology for collaborative purposes.

Based on the review, the research by Kolleck (2019) and Weddle (2022) underscored a conspicuous absence of engagement with the technological facets of teacher collaboration. While contributing

Table 1
Synthesis of the recent literature review

Author & Year	Database & Timeframe	Research Focus	Main Findings
Kolleck (2019)	Eric, PubPsych, Sciencedirect, Primo and Web of Knowledge: 25 articles published after 1990 were selected.	The relationship between motivation and collaboration	Intrinsic motivation, collegial support and a shared vision will impact collaboration effectiveness. Teacher collaboration is regarded as a threat to teacher autonomy.
García-Martínez et al. (2021)	WOS and Scopus: 18 articles between 2009 and 2019 were selected	The impact of teacher collaboration on school improvement	The most collaborative methods focused on teaching techniques and enhancing students' academic performance.
García-Martínez et al. (2022)	WOS and Scopus16: articles between 2009 and 2019 were selected	The ways to promote teacher collaboration by establishing professional networks	Technology helps foster productive relationships among teachers by establishing a collaborative networking culture.
Weddle (2022)	Eric and Google Scholar: 43 peer-reviewed sources from 2006 to 2018 were selected.	The methods used to study collaboration for instructional improvement	Utilizing interdisciplinary and critical theories could broaden our understanding of collaboration aiming at transformation.
Şahin (2023)	WOS, Eric and Scopus: 40 articles between 2018 and 2022 were selected	Studies on teacher collaboration in terms of English language teaching	Collaboration greatly affects the nature and scope of English Language Teaching.

to the broader discourse, their studies fail to delve into the intricate web of challenges faced by educators seeking to enhance collaboration through the utilization of technologies. On the other hand, García-Martínez et al. (2021) marginally touched upon the role of technology in teacher collaboration by advocating for future research to dissect the impact of educational technology and teacher training on psychosocial factors. The study suggests identifying strategies that facilitate teacher collaboration, albeit within a limited technological scope. However, the omission of a detailed exploration into the challenges teachers face in incorporating technology hampers the comprehensiveness of their contribution.

Furthermore, García-Martínez et al. (2022) delved into establishing networks to enhance online collaboration. Yet, their investigation is confined to cultivating a collaborative networking culture and the methodologies for its establishment. The critical examination of the technological intricacies in creating effective online collaboration is noticeably absent from their exploration. In addition, this study reviewed

articles dated 2011 to 2018. It has been more than five years since then.

Besides, Şahin (2023) confirmed the positive impacts of collaborating with other teachers through technological tools and platforms for language learning and teaching. Yet the study did not systematically summarize the technological tools commonly used in teacher collaboration, nor did it elaborate on the challenges or barriers in using technology for collaboration. Hence, a comprehensive literature review on teacher collaboration in the 21st century addressing technology integration in collaborative efforts remains comparatively scarce.

With the advancement of technology, changes in all aspects of fields are undeniable (Nugrohowati et al., 2020; Singh et al., 2021). In the realm of education, the methods for both teaching and learning have been shaped by the introduction of technological platforms, digital tools, and other social media resources (Annamalai, 2021; Shah et al., 2022). The research fields have demonstrated a growing interest in the relationship between collaboration and technology (Lee et al., 2021). Technology can expand teachers' networks and offer more channels for them to interact and share knowledge (Shah et al., 2022). The negative influence of technology is also indicated at the same time, leading to mistrust, virtual bullying and an overburden of information (Jin et al., 2023). Challenges and obstacles exist between teachers and social media use in collaboration and teaching, such as privacy management, teaching effectiveness and technical integration of different tools (Manca & Ranieri, 2016). It is beneficial and necessary to comprehensively investigate the application of technologies in teacher collaboration to leverage its advantages fully (García-Martínez et al., 2022; Şahin, 2023).

The primary challenges affecting collaborative actions in teaching were identified as problems related to digital tools (Hajar & Manan, 2022). A digital tool is straightforwardly characterized as software, social media, learning platforms, websites, or digital resources that teachers use to foster collaboration for professional development and student progress (Hrastinski, 2021). Digital tools have been widely applied in the field of teacher collaboration. Video-conferencing software enabled teachers from different schools or universities to interact and collaborate, contributing to teachers' mutual growth and advancement regardless of distance constraints (Koutsouris et al., 2017). Teachers use social media like Twitter and Facebook to enhance professional development collaboration and support students' learning progress (Chugh & Ruhi, 2018; Liljekvist et al., 2021). E-learning platforms enhance online collaboration among teachers, which greatly benefits school improvement (García-Martínez et al., 2022). E-mail and other web-based communication tools were adopted for pre-service teachers to collaborate online with overseas partners. It provides pre-service teachers with authentic collaboration chances and boosts their confidence (Hur et al., 2020). English teachers also adopted digital tools and platforms to enhance language learning and teaching (Şahin, 2023). Those studies have evidenced

how teachers leverage digital tools to build collective expertise pertinent to their daily teaching practices to support their professional growth and students' learning.

Digital tools provide opportunities that facilitate the sharing of materials and enhance interactions between trainers and teachers, as well as among teachers (Şahin, 2023). The nature of digital tools employed to support collaborative activities is crucial in understanding and studying teacher collaboration (Borko & Potari, 2024). Few studies have attempted to synthesize what and how digital tools are used in teacher collaboration. Identifying further technological tools to improve current collaboration methods is an area that remains inadequately explored (Maican et al., 2019), and more efforts need to be made (García-Martínez et al., 2021). Teachers sometimes are reluctant to compromise on technology-related issues. Integrating new technology into collaboration could complicate matters further, making collaborative teaching quite intricate (Nistor, 2016). Even though the school has equipped itself with the latest instructional software or hardware, many teachers fail to utilize the newly acquired technologies (Cooper & Bray, 2011). A lack of preparedness for technological knowledge and practice impedes teachers from adapting to changes in teaching and collaborating (Hardiah, 2020). As we tackle the complexities of the 21st century, understanding the tools, issues, and challenges inherent in teacher collaboration becomes increasingly imperative. Further exploration in this area could lead to significant advancements in promoting effective teamwork in educational settings in the new era.

Therefore, this paper seeks to review the digital tools employed by teachers to enhance collaboration in the last five years and the issues and challenges encountered when the digital tools were integrated into teacher collaboration. Correspondingly, the research questions are:

a. What digital tools have been employed by teachers to enhance collaboration over the last five years?

b. What issues and challenges were encountered when the digital tools were integrated into teacher collaboration?

METHODOLOGY

According to Onwuegbuzie (2016), the comprehensive literature review is a methodology that can be conducted either as a standalone process or to inform primary research at various stages. The main goal is to review issues related to a specific topic, and multiple resources are often advocated. By utilizing diverse sources, the reviewer can extract greater insights from the data, potentially leading to a more holistic understanding of a particular phenomenon and, consequently, elevating the quality of the syntheses (Onwuegbuzie et al., 2012). This review aims to provide a comprehensive understanding of the application of digital tools to enhance teacher collaboration and the challenges accompanied during the process. Seven steps are involved in conducting a comprehensive literature review: exploring topics, initiating a literature search, sorting and organizing

the data, selecting the data, expanding the search, data analysis and synthesis, and results presentation (Onwuegbuzie, 2016).

Literature Search

The literature was searched and collected from December 2023 to January 2024. A wide-ranging search across various databases identified possible journal papers that describe digital tools integrated into teacher collaboration. Databases, including Web of Science, Science Direct, and ERIC, were chosen based on their impact and reputation. Those databases usually encompass a broad range of peer-reviewed articles from high-ranking journals, typically of high quality and with enough data to support this review analysis. Besides, ERIC provides the biggest and most comprehensive collection of education journals. Therefore, the quality and comprehensiveness of the literature selected for this review are highly justified.

The rapid development of technology prompts this research to focus on selecting the latest literature published between 2019 and 2023. The main goal is not to offer a historical overview but to explore the up-to-date applications of digital tools in teacher collaboration to gain practical implications. Besides, the paper reviewed by García-Martínez et al. (2022), which focused on networks for online collaboration, included articles up to 2018. This is another reason the articles selected for the current review start from 2019. A comprehensive literature review allows for a review of studies employing various methodologies, encompassing quantitative and qualitative approaches. It synthesizes necessary information from qualitative and quantitative studies (Onwuegbuzie, 2016). The following key terms aided with Boolean operators were applied in the literature searching stage: "teacher collaboration" OR "collaborative teaching" OR "teamwork" OR "professional collaboration" OR "collective teaching" AND "technologies/ technology" OR "digital tools."

Inclusion and Exclusion Criteria

Effective inclusion and exclusion criteria play a crucial role in avoiding selection being either too broad or too limited in scope (Toronto & Remington, 2020). It is a guideline for sorting and organizing information suitable for this review analysis. Based on the previous analysis, the inclusion and exclusion criteria for this review are listed below:

a. The articles were confined to only the English language.

b. Peer-reviewed articles were included. Conference papers, books, and unpublished papers (Master's theses, doctoral dissertations) were excluded.

c. Full-text articles that could be downloaded for free were included. Those that were chargeable or had no full text available were excluded.

d. Only articles in which digital tools were applied to support teacher collaboration were included. Those articles that merely mentioned or did not centralize around this topic were excluded.

e. Only collaboration among teachers was included. The teacher-student

collaboration, school or university-enterprise collaboration and school-school collaboration were excluded.

Data Selection and Expansion

Following the selection procedures adopted by Vangrieken et al. (2015), the studies were first chosen according to the titles, resulting in 1081 articles from three databases. Then, abstracts and keywords were examined to exclude articles unrelated to the core research topics of this review. The articles identified were reduced to 54 thereafter. Subsequently, further reading was conducted, focusing on the introductory and concluding sections of articles to eliminate those that did not meet the specified exclusion criteria. Ten articles were selected for further analysis. Finally, a snowballing technique was employed to identify more relevant articles. The same steps, inclusion and exclusion criteria, were applied to articles found through snowballing. After eliminating duplicates, 11 articles were eligible for analysis. Tables 2 and 3 provide an overview of the studies selected for further analysis in terms of methods used and context, respectively.

Data Analysis and Synthesis

Tables 2 and 3 show that the selected articles employ diverse methodologies and encompass a broad spectrum of contexts, providing a comprehensive and global perspective for this literature review. A thorough evaluation of the articles centered on digital tools integrated into teacher collaboration was presented. Key information from each selected study was extracted. Data encompassing the following aspects were categorized: (1) author/s and year of publication; (2) digital tools used; (3) focus; (4) key findings (Table 4).

Table 2
Studies selected in terms of methods used

Methods Used	Number of Articles	Specific Articles
Quantitative	3	Maican et al. (2019), Delgado et al. (2021), Richter et al. (2022)
Qualitative	7	Hilli (2020), Acar & Peker (2021), E.R. Tazhibayeva & Dolidze (2021), Guo et al. (2022), Nguyen et al. (2023), Nicholas et al. (2023), Hoeh et al. (2023)
Mixed method	1	Carpenter et al. (2022)
Total	11	

Table 3
Studies selected in terms of context

Context	Number of Articles	Specific Articles
Romania	1	Maican et al. (2019)
United States	1	Hoeh et al. (2023)
China	1	Guo et al. (2022)
German	1	Richter et al. (2022)
Turkey	1	Acar & Peker (2021)
Australia	2	Nguyen et al. (2023), Nicholas et al. (2023)
Finland	1	Hilli (2020)
Russia	1	Delgado et al. (2021)
International context	2	Tazhibayeva & Dolidze (2021), Carpenter et al. (2022)
Total	11	

Table 4
Summary of the studies selected for analysis

Author/s & Year	Digital tools used	Focus	Key Findings
Maican et al. (2019)	Email, websites, E-learning platforms, video	Teachers' attitude and views on communication and collaboration applications	E-mail is the primary communication and collaboration application. Technology anxiety and self-efficacy affect the acceptance and use of online applications. Work engagement mediates the relationship between personality traits and online application use.
Hilli (2020)	Video conferencing system (Blackboard Collaborate), Google Hangout, FaceTime	Teacher collaboration in a virtual learning environment	Collaboration between school leaders can enable long-term teacher collaboration. The digital competence of teachers and the digital infrastructure will affect the effectiveness of teacher collaboration. VLEs can inspire new teaching practices and professional development.
Acar & Peker (2021)	eTwinning platform	Teachers' purposes and effects of using the eTwinning platform	The eTwinning platform was used for project building, online courses, professional development, and collaboration. The platform significantly improves teachers' professionalism and collaboration. The teachers' perceptions of their profession are positively shaped.
Tazhibayeva & Dolidze (2021)	Websites, Zoom Desktop video-conferencing software	E-collaboration in teacher professional engagement initiatives	E-collaboration is time and cost-effective for teacher development. Most teachers are motivated and committed to collaborative activity. collaboration between language teachers is essential for students' improvement.
Delgado et al. (2021)	Zoom, LMS	The use of better tools and methods to teach science classes on different campuses within a university	Diversity and dominion were gained with time and experience and transmitted to similar areas through collaboration. A strong link is identified between students' recommendations and their final grades. Students react positively towards teachers' collective efforts during the learning process.

Table 4 *(Continue)*

Author/s & Year	Digital tools used	Focus	Key Findings
Carpenter et al. (2022)	Facebook, Twitter, Padlet, Zoom, Flipgrid	Teachers' collaboration in a Global Read Aloud project	Technology expands the opportunities for teacher collaboration. Teachers benefit a lot from collaborating with other teachers in the project. Teachers share a positive view on collaborating with others in GPA, yet time and other challenges will sometimes hinder collaboration efforts.
Guo et al. (2022)	Online class software, WeChat, pre-recorded videos	Co-teaching program between local and remote teachers	Co-teaching has a positive impact on teachers and students in rural areas. Ineffective instruction, communication, and insufficient reward hinder collaboration in co-teaching.
Richter et al. (2022)	Instagram	Teacher collaboration on Instagram and its connection to teachers' self-efficacy, enthusiasm for teaching, and perceptions of digital social support	Three collaborative activities on Instagram: information seeking, information sharing, and co-creating. Enthusiastic teachers are more likely to seek information on Instagram. Teachers with higher self-efficacy are more likely to share content. Seeking, sharing, and co-creating are positively associated with perceived digital social support.
Nguyen et al. (2023)	Google Drive, Google Docs, and E-mail	Factors that enhance or hinder teachers' collaboration in an online platform	Limited time and feedback, as well as difficulty in observing, hinder online collaboration. Sharing objectives, positive attitudes, and active sharing and interaction contribute to online collaboration. The roasted lesson planning process proves to be beneficial for online collaborative activities.
Nicholas et al. (2023)	Facebook	Teacher-driven online collaboration and professional learning via Facebook	Teachers mainly use Facebook groups to provide peer support. School teachers rarely posted on Facebook groups and even discontinued posting support a year later. Further research is needed to explore the effective use of social media for cross-sector collaboration.
Hoeh et al. (2023)	Video	Interdisciplinary collaboration among teachers in a faculty learning community	The faculty learning community will help us understand pre-service teachers' needs. Interdisciplinary collaboration contributes to teachers' professionalism.

RESULTS

A total of 11 studies were analyzed in the present comprehensive literature review, encompassing multiple methodologies and various contexts worldwide. The findings were presented and categorized within the framework of the guiding research questions and aims outlined earlier. Qualitative data analysis techniques were optimal for analyzing the information extracted from selected studies. Theme analysis, one of the qualitative data analysis techniques, was applied here, and different themes were exacted to inform a paragraph or even a session (Onwuegbuzie et al., 2012). Hence, this part is organized according to two sub-themes: (1) digital tools employed in teacher collaboration and (2) issues and challenges encountered while integrating digital tools in teacher collaboration.

Digital Tools

With the evolution of technology integration into collaboration, teachers are no longer confined to traditional digital tools like telephone or radio. Many digital tools have come into place and contribute to enhancing teacher collaboration (Tazhibayeva & Dolidze, 2021). Upon synthesizing the selected studies, the identified digital tools can be divided into four categories based on the types: social media, online learning platforms, video and video-related software, e-mail, and websites.

Social Media

Various social networking media, including Instagram (Richter et al., 2022), Facebook (Carpenter et al., 2022; Nicholas et al., 2023), Twitter (Carpenter et al., 2022), and WeChat (Guo et al., 2022), are employed by teachers during the process. Three kinds of collaborative activities, including information seeking, sharing, and co-creating, are identified on Instagram. Teachers are more inclined to perform low-level collaborative activities, like seeking and sharing information, than high-cost co-creating on this platform (Richter et al., 2022). In the study by Nicholas et al. (2023), teachers are less likely to post information on Facebook and tend to seek support from their peer colleagues through the platform. In another case in the study by (Carpenter et al., 2022), teachers mutually post materials, ideas and curriculum on Facebook and Twitter, except for seeking partners. However, they are still less inclined to co-create materials or curricula with each other, which is in line with the findings of Richter et al. (2022). WeChat is employed to enhance communication and collaboration between remote and local teachers in rural areas of China in the process of live-streaming or pre-recorded course delivery to help teachers solve problems (Guo et al., 2022). All the above-mentioned platforms contribute to the interaction and sharing among teachers to some extent.

Online Learning Platform

Teachers have utilized such online learning platforms as the eTwinning platform (Acar & Peker, 2021), Padlet (Carpenter et al., 2022), online class software (Guo et al., 2022), and LMS (Learning Management

System; Delgado et al., 2021; Hilli, 2020) to facilitate collaboration. The eTwinning platform is widely employed by teachers in European schools to collaborate and conduct projects, hold seminars, and attend online courses. Teachers usually find partners to build projects and exchange ideas on this platform (Acar & Peker, 2021). Padlet, an online virtual 'bulletin board,' was also identified in the study of Carpenter et al. (2022), which aimed to help teachers connect and share resources. Some coordinate lessons and divide responsibilities through this platform. Remote teachers deliver classes through online class software to guide local teachers in teaching and enhance students' learning (Guo et al., 2022). Like Guo et al. (2022), Hilli (2020) also explored collaboration between local and rural teachers via LMS. Such LMS is adopted to enhance collaboration between teachers on different university campuses. It offers teachers supporting resources to prepare materials suitable for online classes (Delgado et al., 2021).

Video and Video-related Software

Video, Zoom, Flipgrid and other video-conferencing software are widely used by teachers to collaborate (Carpenter et al., 2022; Delgado et al., 2021; Guo et al., 2022; Hilli, 2020; Hoeh et al., 2023; Tazhibayeva & Dolidze, 2021). Pre-recorded videos from urban classrooms are transmitted directly to rural classrooms for students to watch. The rural teacher will stop the video in case of any questions. It is a different type of co-teaching to enhance teachers' professionalism and students' achievements (Guo et al., 2022). Training videos are collaboratively developed so teachers in an online learning community can imitate and learn professional skills. Group analysis, discussion and reflection are followed to improve teachers' expertise and instructional skills (Hoeh et al., 2023). A video conferencing system named Blackboard Collaborate provides a virtual environment for teachers to discuss concerns and address problems collaboratively. It is also noted that Google Hangout and FaceTime were previously used by teachers for virtual teaching (Hilli, 2020). Zoom and other video conferencing software are applied in a series of E-collaborative activities, encompassing group discussions, sharing all kinds of resources, online workshops and real-time chatting. It enables instant communication and collaboration among teachers (Delgado et al., 2021; Tazhibayeva & Dolidze, 2021).

E-mail and Websites

Maican et al. (2019) and Nguyen et al. (2023) identify e-mail and websites such as Google Drive and Google Docs for teachers to collaboratively share resources and learn from each other. E-mail has proven to be the most frequently used collaboration application among teachers and is considered a classical form of collaboration. It is a tool for teachers to communicate, share documents and maintain productive relationships (Maican et al., 2019). Lesson plans and other ideas to enhance course collaboration are shared among English language teachers through

e-mail, Google Drive and Google Docs (Nguyen et al., 2023).

Issues and Challenges

Multiple digital tools play a significant role in fostering collaborative efforts among teachers. Teachers can get emotional, social, and instrumental support through digital collaboration (Richter et al., 2022). These digital tools offer a virtual collaborative space for teachers to reflect on their teaching, reduce professional loneliness, and increase chances for professional development (Guo et al., 2022; Hilli, 2020; Hoeh et al., 2023). They provide multiple resources and fellow professionals to enhance both teaching and learning (Carpenter et al., 2022; Delgado et al., 2021; Tazhibayeva & Dolidze, 2021) and positively shape teachers' perceptions of professionalism (Acar & Peker, 2021). They reduce workload, save time, enhance class-delivery efficiency, boost teachers' self-confidence and foster harmonious collegial relationships to make teachers feel connected (Acar & Peker, 2021; Nguyen et al., 2023). Yet, to some teachers, the tools are reserved for resolving urgent difficulties that need a timely and quick response (Nicholas et al., 2023). Despite the advantages, teachers face a series of issues and challenges in employing digital tools to enhance collaboration with each other.

Hard to Maintain Long-term Collaboration

Different teacher schedules and time differences make collaboration challenging and sometimes even tedious (Hoeh et al., 2023). It is difficult for teachers to conduct efficient observation and obtain sufficient feedback in collaboration through digital tools (Nguyen et al., 2023). Lacking a reliable mechanism to assess the resource's quality results in misunderstood or missing information, leading to mistrust and frustration among teachers (Richter et al., 2022; Tazhibayeva & Dolidze, 2021). Some fail to adhere to their commitments due to overwhelming connections and demanding sharing needs (Carpenter et al., 2022). Some discontinue posting information and support on social media because they do not receive enough comments or acknowledgments. It is hard to maintain ongoing and active interaction in a virtual environment (Guo et al., 2022; Nicholas et al., 2023). The frequent turnover of teachers, with individuals leaving and joining, poses a significant obstacle to maintaining continuous and sustainable collaborative efforts (Hilli, 2020). The elevated costs associated with interaction likewise diminish teachers' incentive for sustained collaboration through technology (Guo et al., 2022).

Unwillingness and Inadequate Competence to Participate

Teachers are reluctant to participate in collaborative programs, afraid of unforeseen consequences it may bring, losing teaching autonomy (Hilli, 2020), and lowering social and academic positions, for instance (Guo et al., 2022). Some teachers are not competent enough and have a hard time learning to interact with others using digital tools.

This limitation poses a challenge, as they encounter difficulties utilizing the newly introduced multifunctional technologies to ensure immediate communication and collaboration (Hilli, 2020). Lacking the necessary digital skills, experience, and confidence restricts their engagement in the collaboration process (Carpenter et al., 2022), decreasing their self-efficacy in co-teaching and weakening their control of classes (Guo et al., 2022).

Insufficient Digital Infrastructure

Technology scarcity and poor linkage sometimes cause troubles in teacher collaboration, impeding the timely fulfillment of collaborative tasks (Tazhibayeva & Dolidze, 2021). Teachers must reconsider their teaching routines and evaluate the compatibility of the software with planned lessons to make sure all teachers can observe and engage as wireless networks proved inadequate in supporting audiovisual transmission. Technology-related issues even hinder the establishment of teacher relationships due to non-timely communication and collaboration (Hilli, 2020). The technology platforms supported by one school may be prohibited by another, complicating teachers' efforts to perform collaborative activities (Carpenter et al., 2022). Insufficient support and technological training from educational institutions make teachers feel isolated in managing diverse teaching tasks, leading to difficulty in collaboration (Delgado et al., 2021).

DISCUSSION

This comprehensive literature review aimed to explore contemporary applications of digital tools in fostering teacher collaboration. The study delves into the issues and challenges teachers encounter as they collaborate through digital tools, emphasizing the practical implications derived from these insights. A thorough examination of articles spanning the last five years from three prominent databases was undertaken to accomplish this.

Teachers and teacher educators in different contexts worldwide have tried various ways to explore multiple digital tools to support their collaborative activities and enhance their professional practices. The landscape of digital tools in teacher collaboration is diverse, encompassing social media, online learning platforms, video conferencing, e-mail and websites. These digital tools can be employed by teachers in different educational activities and foster the adoption of novel pedagogical strategies and creative teaching techniques. This technological transformation has revolutionized teachers' interactions, communication, and collaboration, aligning with the virtual collaboration trend identified by Şahin (2023) and García-Martínez et al. (2022). Virtual collaboration, distinguished by its flexibility and adaptability, offers a unique platform for teachers to contribute more evenly (Singh et al., 2021). This trend facilitates the exchange and adaptation of resources via feedback and joint elaboration, thereby acting as a foundation for nurturing communities of practice among educators

(Borko & Potari, 2024). However, the feasibility and extent to which these digital tools can support collaborative activities among participants in a virtual environment are still in question. It is crucial to recognize the inability of digital tools to entirely replace face-to-face interactions (Tazhibayeva & Dolidze, 2021), prompting the need for a balanced approach that integrates traditional and technology-supported collaboration. This presents an intriguing avenue for future research to explore effective strategies for seamlessly combining online and offline teacher collaboration to optimize professional development and student progress.

The selection of digital tools applied in collaboration is subject to different contexts. Teachers commonly use tools such as Facebook and e-mail in Western countries for daily communication, whereas, in China, WeChat is the preferred choice. The efficiency of digital tools tends to depend on the nature of different tasks. Social media tools are more effective for collaborative tasks requiring real-time responses and frequent interactions. However, video conferencing software is usually the better option for more complex work that demands in-depth discussions. This is consistent with the findings presented by Borko and Potari (2024), who claimed that different tools allow teachers to engage in collaborative activities in different contexts.

Building upon Little's (1990) categorization of collaboration levels, our review reveals a prevalence of low-level collaboration among teachers using digital tools, predominantly focused on resource sharing and support seeking. This contrasts with Hargreaves and O'Connor's (2017) emphasis on weak collegiality and dialogue-centric collaborations. The gender difference Bush and Grotjohann (2020) identified in high-level collaborative activities is absent in our study. Nevertheless, collaboration closely tied to teaching practice and unified by common goals proves impactful in shaping beliefs and improving outcomes (Carpenter et al., 2022), urging further exploration of strategies to promote high-level collaborative activities rich in collegiality.

Self-efficacy and technological competence emerge as critical factors influencing virtual collaboration among teachers. High self-efficacy and better technology knowledge correlate with increased interaction, while the lack of technological competence hinders collaborative efforts. Productive relationships among teachers can be fostered through technology (García-Martínez et al., 2022). The positive interaction between teachers' self-efficacy, digital competence, and collegial collaboration underscores the need for policies and training programs to enhance teachers' technological capabilities (Basilotta-Gómez-Pablos et al., 2022). Besides, those digital tools are more frequently used and have proven to be more successful in schools with rich resources and better technological facilities, as teachers are provided with more opportunities for digital training and are more easily accessible to the internet. This is certified

by Manca and Ranieri (2016), who stated that the difficulty in privacy management and technical integration of different tools have brought obstacles to collaboration through technology. Recognizing the interconnectedness of digital infrastructure and tools emphasizes the pivotal role of investments in school infrastructure in facilitating effective technology integration and teacher adaptation.

The intricacies of virtual collaboration reveal that trust, often established through in-person interaction ('touch'), is a crucial factor in team performance (De Jong et al., 2016). The challenge lies in the virtual environment's initial low trust, which gradually grows through effective communication over time (Baturay & Toker, 2019). Trustful relationships and closeness between teachers impact teachers' motivation to collaborate. Intrinsic motivation, collegial support and a shared vision contribute to collaboration effectiveness (Kolleck, 2019). However, though teachers are eager to engage in deeper collaborative relationships with colleagues, they simply do not have time due to a shift of focus on administrative expectations and duties. The expectations for collaboration outside of meetings were often unclear, and many teams encountered structural barriers to working together (Lockton, 2019). This highlights an urgent need for administrative actions to better support collaborative efforts. Besides, the tension between teachers' autonomy and collaboration in the digital realm necessitates careful consideration, prompting future research to explore strategies that promote trust for sustained, effective, and high-level teacher collaboration through technology.

CONCLUSION

This comprehensive review is critical as it addresses the growing necessity of understanding digital tools in teacher collaboration, directly contributing to educational effectiveness in the digital age. It fills existing research gaps, offers practical implications in collaborative practices among teachers, and provides insights into enhancing collaborative efforts in educational environments.

The results from this review demonstrated that integrating technologies opens new avenues for teachers to collaborate. Promoting teacher collaboration via technology breaks through constraints in time and space, allowing teachers to communicate and collaborate with peers worldwide.

Implications for Practice

Findings indicate that research and practice on technology-supported teacher collaboration remain in their early stages. There remains a significant gap between current practices and the potential benefits that technology can offer to enhance collaboration among educators. Therefore, continued interest and continuous efforts should be directed toward collaborating via technology to bridge this gap. Educational stakeholders, including teachers, school administrators, and policymakers, need to work together and make substantial advancements to overcome the barriers hindering teacher collaboration

and maximize the transformative potential of technology in facilitating teacher collaboration.

Teachers are central to enhancing collaborative activities through digital tools in their daily practice. It is of great significance for them to develop a positive attitude towards collaboration and actively participate in diverse training programs designed to enhance their teaching skills and digital competence, ultimately leading to increased efficiency and confidence in collaboration via technology. The establishment of mentorship programs and provision of resources by schools are also advocated through which the technologically competent and experienced teachers can guide newcomers in leveraging collaborative tools. Additionally, policymakers are recommended to cover digital competence in training programs for pre-service and in-service teachers and prioritize funding for upgrading technological infrastructure in schools, especially rural areas, to ensure teachers have equal and reliable access to a wide range of digital tools. Through the joint efforts of relevant stakeholders, educational institutions can fully leverage the advantages of digital tools to foster a collaborative and innovative teaching and learning environment in the 21st century.

Limitations and Suggestions

This paper specifically selected research articles that were downloaded from three databases. This could result in omitting other possible digital tools applied to teacher collaboration. Hence, the scope of our findings is constrained by only reviewing specific dimensions from restricted databases within the field. However, the constraints outlined here pave the way for future research endeavors. Therefore, subsequent researchers may expand their scope by incorporating multiple articles from additional databases and extending the timeframe to gain a more comprehensive perspective. Longitudinal studies are also encouraged to understand the long-term effects of teacher collaboration on teacher professional development and students' learning outcomes. This paper also paves the way for establishing global learning communities that foster cultural understanding and teacher professional development, eventually contributing to global educational enhancement.

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