ISELT 80
Interdisciplinary Studies in English Language Teaching

Pages 80 to 99

Enhancing Writing Skills in L2 Learners through Technology-Mediated Written Corrective Feedback: A Scoping Review of Articles Published between 2015 and 2025

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10.22080/iselt.2025.29098.1097

Received
April 25, 2025
Accepted
July 17, 2025
Available online
July 17, 2025

Keywords:
EFL learners, Scoping review, Technology-Mediated Written Corrective Feedback, Writing skill

Abstract

This scoping review aimed to investigate the impact of Technology-Mediated Written Corrective Feedback (TMWCF) on improving second language writing skills by analyzing 36 studies published between 2015 and 2025. To this end, a total of 36 articles indexed in large databases, such as ERIC, Google Scholar, ProQuest, ScienceDirect, and Scopus, were analyzed using NVivo 14. After the content coding of the studies, the results revealed that grammatical accuracy was more significantly improved by technology compared to other aspects of writing, such as fluency. The mixed-methods design was the most common research design, and undergraduate EFL students mostly agreed to participate in these studies. Results also revealed that feedback delivered through written means, such as written comments in Microsoft Word, was the most common type of feedback given to EFL learners. Additionally, technological tools like Grammarly were the most commonly employed technology for assessing writing. Besides, the most common limitations of these studies were their small sample sizes and the generalizability of their results. The present study also provides several implications for EFL teachers and learners regarding the effectiveness of TMWCF in improving the writing quality and accuracy of EFL learners.

1. INTRODUCTION

While conventional feedback methods offered certain benefits, they presented several drawbacks. For example, learners received feedback after a delay, which could reduce its effectiveness. Furthermore, time constraints and the necessity to provide consistent feedback to all students often resulted in less valuable feedback. Later, Technology-Mediated Written Corrective Feedback (TMWCF) was proposed as a credible alternative to deliver timely, organized, and adaptable support to improve EFL writing (Shi & Aryadoust, 2024). TMWCF can be provided as teacher-mediated feedback or artificial feedback, both offering unique perspectives during EFL writing

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instruction. Teacher-mediated feedback addresses students in a personalized manner through annotations on written texts, voices, or videos, thus allowing for a detailed and contextualized understanding of the EFL writing assessment. On the other hand, artificial feedback is generated using technological tools, such as Grammarly. AI-based feedback could help improve EFL learners' grammatical and spelling errors, although it is recognized primarily for providing feedback in real-time (Ranalli & Yamashita, 2022).

The extensive use of digital platforms to enhance education has caused a shift from traditional classrooms to technology-rich environments (Sherafati et al., 2020). The educational landscape has undergone a permanent transformation, as evidence suggests that learning can become more interactive, accessible, and personalized. This is exemplified by the growth of AI-based feedback platforms that enrich TMWCF. Lightweight programs, such as Grammarly, Microsoft Word, and Google Docs, offer instant suggestions for grammar and style. Professional platforms, such as Writing Pal and Criterion, use natural language processing and machine learning algorithms to deliver more detailed writing feedback (Lachner et al., 2017). These feedback tools, including generative AI systems such as ChatGPT and Microsoft Copilot, provide adaptive feedback tailored to each learner, further supporting engagement and the development of writing skills.

In recent years, a significant amount of research has focused on written corrective feedback as a traditional form of feedback provided to learners (Crosthwaite et al., 2022; Kim & Emeliyanova, 2019; Lee & Yoon, 2020; Zhang & Cheng, 2021). The research on the effectiveness of corrective feedback became more profound and extensive with the assistance of technology to improve learners' writing (Lachner et al., 2017). Additionally, the development of online tools like Edmodo was beneficial for correcting learners' errors (Wıhastyanang et al., 2020). Using technology to solicit feedback could be a solution for reducing teachers' workload and the heavy burden of correcting learners' errors (Han & Sari, 2024). In this regard, AI-based feedback introduced another dimension to research in this area (Cheng, 2017; Cunningham, 2019; Han & Sari, 2024). Therefore, more research is needed to guide teachers and learners in applying technology to enhance EFL learners' writing (Al-Olimat & AbuSeileek, 2015). Also, previous studies have examined how various types of technology can influence various aspects of L2 writing (Cheng, 2017; Noordin & Khojasteh, 2021). Several studies also explored micro and macro elements of writing (e.g., Lachner et al., 2017; Strobl et al., 2019). However, very few, if any, have conducted a scoping review of these micro and macro elements. To address this gap, this study examined how EFL learners can utilize the TMWCF approach for their L2 writing development in EFL contexts. By analyzing trends and challenges in TMWCF from 2015 to 2025, this research aimed to deepen understanding of how digital platforms influence L2 writing development, ultimately guiding future innovations in language education and teaching methods.

2. LITERATURE REVIEW

Written Corrective Feedback

Written corrective feedback is among the types of feedback teachers provide to help improve students' language production. It involves giving feedback on students' written drafts (Dewi et al., 2023). Unlike oral corrective feedback, which requires a quick response as students make errors, written corrective feedback is delivered to learners after they complete their writing tasks (Shintani, 2016). In recent years, much research has highlighted the effects of written corrective feedback on EFL learners' writing drafts (Ahern-Dodson & Reisinger, 2017; Hoang, 2022; Lee &

Yoon, 2020). Written feedback can be divided into two categories: written corrective feedback and technology-generated feedback (Dewi et al., 2023).

Previous research emphasized the significance of written corrective feedback. For example, Dewi et al. (2023) conducted a systematic review to analyze the extent to which written corrections support the development of Asian Indonesian EFL writing. Ultimately, they concluded that feedback could serve as a remedial solution to address EFL learners' weaknesses in their writing, thereby improving their skills. Additionally, technological advancements have created various sources for correcting learner errors (Kataoka et al., 2023). For instance, Althoubiti (2021) compared teachers' and students' perceptions toward feedback provided by technology and the traditional modes of feedback. The results of this comparison showed that teachers favored technology more than students did, although students preferred traditional feedback methods. Therefore, more research is needed to ensure the overall effectiveness of TMWCF on learners' language proficiency (Lachner et al., 2017; Papin & Michaud, 2024).

Technology-Mediated Written Corrective Feedback

The expansion of technology resulted in the integration of technology into EFL classes (Wıhastyanang et al., 2020). TMWCF is highly fruitful for EFL teachers because it reduces their workload and supports language learning via instant feedback (Hojeij & Ayber, 2022; Kataoka et al., 2023). Moreover, it is fascinating and enjoyable for language learners (Han & Sari, 2024). Recently, various applications (e.g., Google Docs, Writing Pal, Grammarly, Wikis, Forums, Blogs, and Microsoft Word) have been developed for areas such as natural language processing, allowing learners to receive automatic written feedback (Papin & Michaud, 2024; Shi & Aryadoust, 2024; Shintani, 2016).

In addition to the previously mentioned technological tools, AI tools can also be used to inform learners of their errors (Shi & Aryadoust, 2024). TMWCF can aid students in revising and improving their texts (Alias et al., 2024; Han & Sari, 2024; Lachner et al., 2017). Previous research showed that TMWCF can influence learners' proficiency. For example, Yamashita (2021) examined the effectiveness of corrective feedback in enhancing students' grammatical accuracy in a writing composition course. Results showed a significant link between writing accuracy, content development, and the type of feedback provided to students. Additionally, students who revised their writing more frequently achieved higher scores on the post-test. Likewise, Ranalli and Yamashita (2022) explored automatic corrective feedback tools, such as Grammarly. It was demonstrated that Grammarly was effective in correcting common L2 errors ten times more than Microsoft Word.

Besides, Valero Haro et al. (2024) assessed whether directed and undirected online peer feedback could enhance students' writing skills. Using a pre-test and post-test design, they found that all students' argumentative essay writing improved after the instruction. Similarly, Alias et al. (2024) investigated the effectiveness of automatic written feedback platforms on learners' writing performance. Results showed that automatic written feedback tools could boost students' writing performance. In a similar vein, Banihashem et al. (2024) compared the quality of feedback generated by ChatGPT and peer feedback. They discovered that ChatGPT and peer feedback provide distinct feedback. ChatGPT tends to be more descriptive, while peer assessment includes diagnostic information as well. Their results showed no significant relationship between the essay quality and the feedback strategy used.

Overall, reviewing the literature on TMWCF reveals that it is still in its infancy (Alias et al., 2024; Jiang & Yu, 2022; Papin & Michaud, 2024; Shi & Aryadoust, 2024). Given that technology is advancing rapidly, this motivates researchers to implement different forms of

providing feedback through technology to assess its effectiveness in language learning classes. Furthermore, few studies have recognized the importance of AI-based feedback as one type of technology (Shi & Aryadoust, 2024). Besides that, systematic reviews, such as those by Alias et al. (2024), have explored the effects of TMWC. However, technological progress is significant, yet previous research has not examined the latest technological advancements (Sherafati & Mahmoudi Largani, 2023). To date, no scoping review has systematically examined trends and patterns in this emerging field, where only a limited number of studies have been published, leaving the overall direction of findings unclear (Pillay, 2022). Therefore, this study aims to provide a comprehensive overview of articles published from 2015 to 2025, thereby enhancing the identification of technological trends and patterns. Since few studies could be found prior to that time that exactly fit the primary purpose of this research, we have decided to consider articles written after 2015. Thus, the present article attempted to examine the impact of technological feedback on the writing development of Iranian EFL learners through a scoping review methodology. To this end, the following research questions were developed:

Research Questions

1. Which aspects of L2 writing are most improved through TMWCF?
2. What research designs and participants are most widely used in the existing research on TMWCF for L2 writing development?
3. What are the key types, features, and modes of TMWCF used in L2 writing instruction?
4. What are the main limitations identified in the existing research on TMWCF for L2 writing development?

3. METHODOLOGY

Research Design

This scoping review used an exploratory sequential mixed methods design (Ary et al., 2019). This design was adopted to map accessible articles about TMWCF and examine how it enhances writing skills. This research design is suitable for the current scoping review, as it provides a well-rounded overview of the existing research based on available articles. Accordingly, based on Lachner et al. (2017), the researchers identified 36 articles (published between 2015 and 2025) to recognize themes, gaps, and trends in the related research.

A scoping review provides a comprehensive overview of the existing research landscape, enabling the identification of what has been studied, how it has been explored, and the scope and limitations of the current evidence (Khalil et al., 2025). Through a scoping review, researchers can examine methods and design while considering contextual factors related to any research area. Utilizing these benefits, the present scoping review provides significant insights into TMWCF research, focusing on the trends and results of the recent articles in this field, thereby advancing the literature on language education. Additionally, it contributes to a deeper understanding of this evolving research area (Yamashita, 2021). It enables learners to take greater ownership of their learning and pinpoint areas where their writing skills need improvement (Hojeij & Ayber, 2022).

Data Sources

The data sources for this scoping review were gathered from a wide range of academic databases, articles, and journals to expand the scope and depth of the research literature. Relevant sources include peer-reviewed articles, the internet, and other relevant and valid sources in this area include: EBSCOhost, Scopus, ProQuest, JSTOR, Google Scholar, ERIC (Electronic Registration

Information Center), IEEE (Institute of Electrical and Electronics Engineers), Science Direct, and Springer Link articles (Chong & Reinders, 2022; Palioura & Sapounidis, 2024).

First, to gather valuable information for this article, Google Scholar was not the only source the researchers relied on. Instead, other databases were explored to discover high-quality articles. They used relevant keywords and phrases such as "computer feedback," "computer-generated feedback," "computer-assisted feedback," "technology-mediated feedback," "AI-generated feedback," "mobile-mediated feedback," and "mobile-generated feedback." Second, once all relevant articles were identified, the first researcher reviewed them to remove duplicates. This process ensured a comprehensive search for relevant articles (Chong & Reinders, 2022). The literature selected for this review was published within the last 10 years (i.e., 2015–2025) to ensure it reflects recent advancements and emerging trends in the area of TMWCF, meanwhile that the selected sources were suitable for recent advancements and progressing trends in the area of TMWCF, such as ChatGPT (Banihashem et al., 2024) and specifically ChatGPT 4 (Pack et al., 2025), to support EFL learners' writing skills.

Inclusion and Exclusion Criteria

The search method for articles in this review followed a systematic approach (Banihashem et al., 2024), which involved the following steps. First, a list of relevant keywords and phrases was compiled. Keywords were developed for the areas of writing skills, EFL learners, and TMWCF, which were used to establish the inclusion and exclusion criteria to guide the quality assessment of the selected studies. These keywords directed the search for studies that met the inclusion criteria in the databases (He et al., 2024). Articles were included based on the following criteria:

I. Inclusion criteria
    1. Being primary research
    2. Using technology to generate feedback
    3. Including both face-to-face and online teaching
    4. Including both synchronous and asynchronous feedback
    5. Including teachers' feedback via technological tools
    6. Including feedback generated by technological applications, such as AI tools
    7. Including peer-feedback given through technological tools
    8. Including the effects of feedback on learners' skills
    9. Assessing writing as well as different components of this skill, such as accuracy and fluency
    10. Including peer-reviewed (respectable peer-reviewed publications, or high-quality theses)
    11. Including articles between 2015–2025
    12. Including articles that were written in English

II. Exclusion criteria
    1. Being secondary research
    2. Assessing the impact of online teaching on learners' skills, such as reading, writing, speaking, and listening
    3. Including the psychological aspects of learning, such as motivation and perception
    4. Excluding which aspects of writing improved
    5. Excluding articles before 2015
    6. Including articles written in non-English languages
    7. Assessing other skills

8. Excluding articles that compare different methods of feedback
9. Excluding Duplicate studies

Following the relevant procedure, 100 articles related to writing skills were initially identified and evaluated. Of these, 70 articles were chosen based on their relevance to feedback and technology. Forty articles were further filtered using criteria focused on the integration of technological feedback and the development of writing through technology. Finally, to ensure academic quality and reliability, 36 articles published in Q1 and Q2 journals (respected peer-reviewed publications or high-quality theses) were maintained for in-depth analysis. It was decided not to include older articles because researchers aimed to focus on the effects of recent technological applications.

There are 3 vital steps for the filtering process to prioritize studies:

1. Directly approaching TMWCF in writing,
2. Illustrating an appropriate design (i.e., assessing the impact of feedback on EFL learners' writing aspects)
3. Being published in high-impact, roughly peer-reviewed journals.

More than 100 articles have been published in the last decade, appearing as journal articles and broadcast explanations, which are accessible in various databases, such as ProQuest (Macaro, 2019). The inclusion criteria have confirmed the relevance of the articles selected for review. The results of the search for relevant articles were strengthened by using Boolean operators (AND, OR) to access more research articles. Filters were also applied to limit articles to those searched for during the specified time frame and to exclude articles from non-peer-reviewed journals (Dewi et al., 2023).

Data Collection

The first step in data collection was data gathering, which involved browsing through and examining the titles and abstracts of articles saved from the databases to determine initial relevance based on the inclusion and exclusion criteria. Once the significance of the titles and abstracts was confirmed, the full texts of these articles were downloaded, allowing the researchers to proceed to the next stage, where they determined the inclusion or exclusion criteria (Jiang & Yu, 2022). For each article included in the research, the researchers recorded key information, including but not limited to author(s), publication year, journal, study design, methodology, and important findings related to TMWCF and writing skills development. Organizing and documenting this information was essential for integrating the literature.

Finally, the collected data was explained by unifying the necessary information and linking the findings to the research questions, providing an overview of the current state of the research and highlighting significant contributions while identifying opportunities for future research. (Wıhastyanang et al., 2020). A summary of the steps for collecting the essential articles for the present study is shown in Figure 1 (see below).

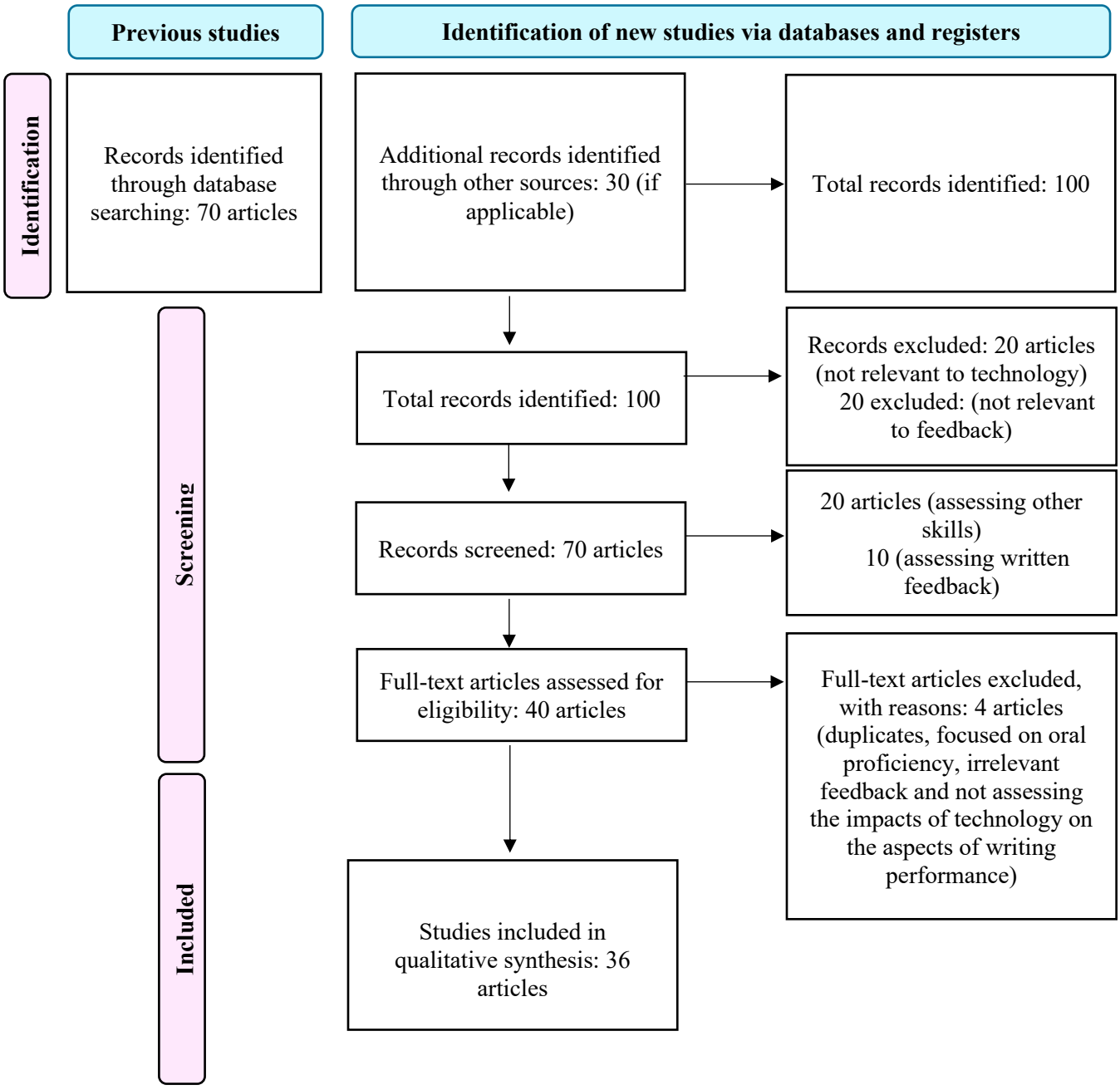

Figure 1: Representation of the Prisma Flowchart, Adopted from Page et al. (2021)

Data Analysis

Analyzing the collected data involved multiple complicated steps to ensure clarity and depth in the investigation. The current research article employed an inductive content analysis approach for analyzing qualitative data. The grounded theory approach was employed for analyzing and coding the data, following (Corbin & Strauss, 2015). To this end, their framework for analyzing qualitative data was utilized in this study. First, Table 1 (see: Supplementary Information Files) was developed and included as supplementary material on a website. The link to access the data is provided at the end of the article, under the supplementary information section. Next, while

analyzing the data, the principal codes (initial coding) were derived from a review of existing literature. Additionally, the articles were read in an iterative process, extracting relevant information associated with each label extracted through open coding, which was interactively based on the articles. To enhance comprehensiveness, each code was summarized and categorized (axial coding); as a result, categories emerged that reflected significant trends and patterns, as well as revealing information regarding the effectiveness and popularity of the methods and types of technology used in these articles. Finally, the most appropriate categories were selected, while merging or removing others (selective coding). To ensure the reliability (inter-rater) and credibility of the findings, the (first two) researchers independently analyzed and coded the data, then reviewed and commented on each other's codes and categories to reach an optimal compromise on the findings. The findings were uploaded to a Telegram group, which was created specifically for this investigation. Researchers attempted to follow the procedures reported in scoping reviews (e.g.,Chong & Reinders, 2022; Reinders et al., 2025; Weisleder et al., 2024) to increase confidence in the results.

Additionally, the positionality of the researchers needed to be disclosed to enhance the research's transparency. In the present inquiry, the first author was responsible for developing and conceptualizing the research topic, as well as the research questions. He was responsible for writing the introduction section, collecting and analyzing data, and drafting the conclusion. Furthermore, he assisted the second author with reporting and writing the methodology section. The second author agreed to write the literature review and discussion. Besides, she completed the methodology section of this scoping review. She helped the first author in analyzing the data and reviewing and editing the manuscript. Additionally, a professor of applied linguistics (the third author) guided other researchers in reviewing and editing, as well as collecting the required data. Ultimately, the Prisma chart in Figure 1 (see above) was included to ensure the objectivity and validity of the results.

4. RESULTS

Research Question One

The most improved aspects of writing

Research question one addressed the most improved aspects of writing in L2 learners. Table 1, provided in Supplementary Information Files, summarizes the previous studies covered in this paper, spanning from 2015 to 2025. According to this table, the most improved aspects of writing included: grammatical accuracy (Articles: 1, 3, 4, 5, 7, 8, 9, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 27, 28, 30, 31, 33, and 35), vocabulary (Articles: 1, 2, 3, 5, 6, 8, 10, 16, 20, 21, 22, and 24), organization, coherence, and structure (Articles: 1, 2, 3, 5, 9, 10, 12, 16, 22, 30, and 34), content and content development (Articles: 2, 5, 9, 12, 22, 30, and 34), punctuation and mechanics (Articles: 1, 3, 5, 6, 20, and 21), spelling (Articles: 1, 3, 6, and 21), lexical sophistication, collocation errors (Articles: 7, 25, and 27), and fluency (Article: 16). The frequencies and percentages of the impacts of technological feedback on different micro and macro aspects of writing are shown in Figure 2.

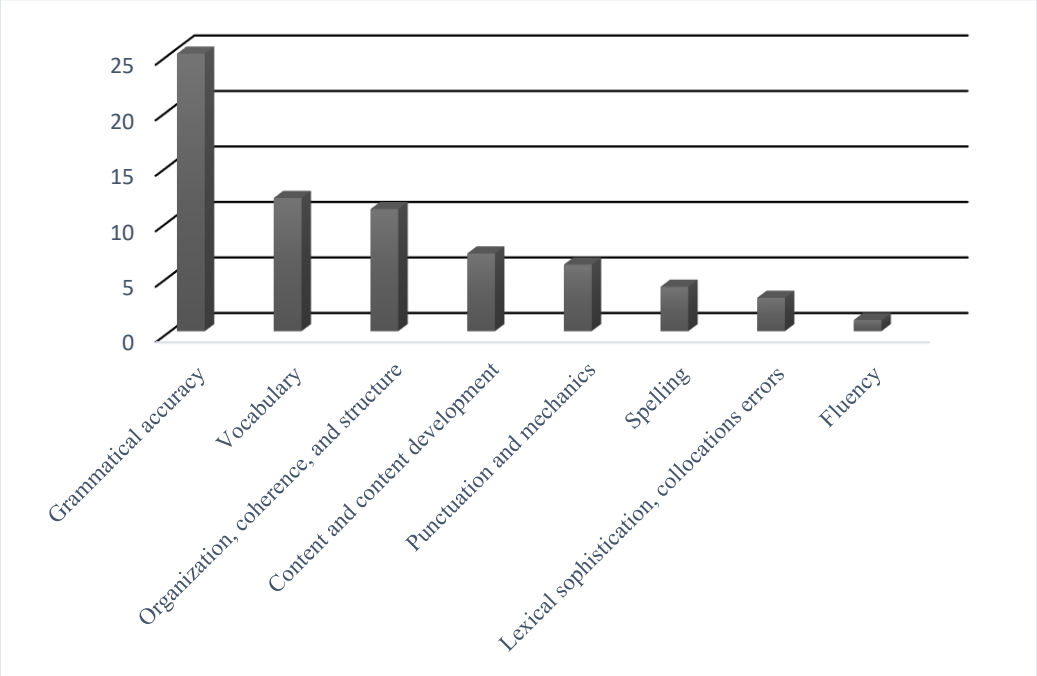

Figure 2: Representation of the Most Frequently Improved Aspects of Writing

Additionally, the following pie chart (see Figure 3) illustrates the frequency and percentage of each of these aspects.

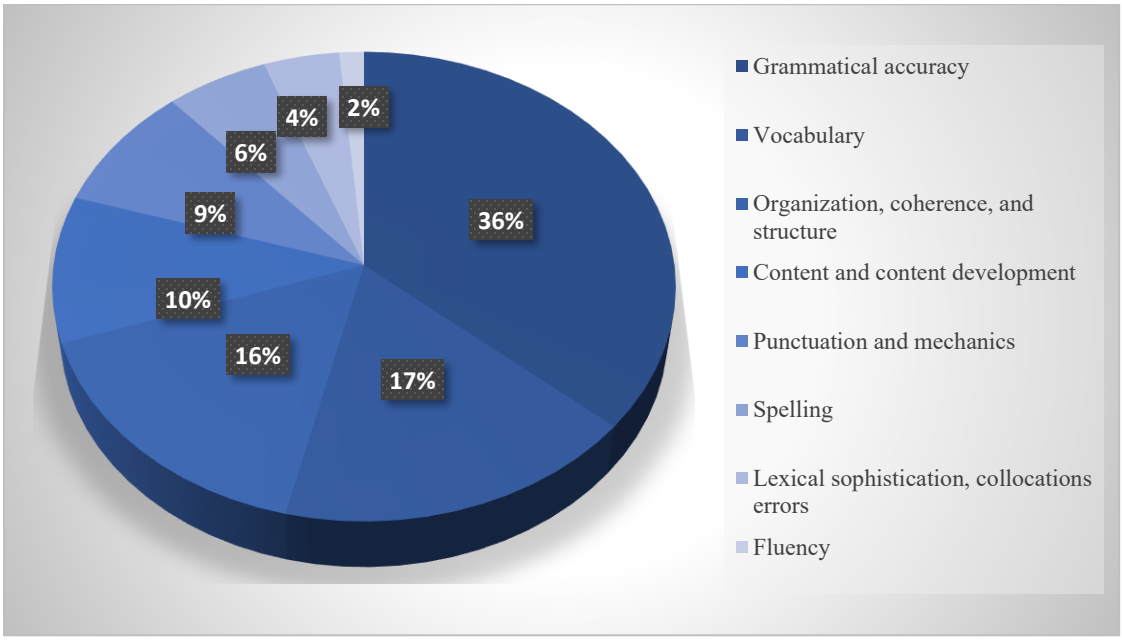

Figure 3: Aspects of Writing That Were Most Improved

Research Question Two

Common Research Designs and Participant Profiles in TMWCF Studies

- **Research Designs**

Research question two probed the methodological features of TMWCF articles, including research samples and design. According to the data in Supplementary Information Files, which summarizes studies conducted between 2015 and 2025, the most common research designs were mixed methods (Articles: 2, 4, 8, 10, 13, 14, 15, 17, 18, 24, 26, 27, 29, 30, and 35), quantitative (Experimental/Quasi) (Articles: 3, 5, 6, 7, 12, 16, 21, 22, 23, 25, 28, 32, 34, and 36), and qualitative (Articles: 1, 11, 19, 30, 31, 33, and 35). Figure 4 illustrates the percentage of each design.

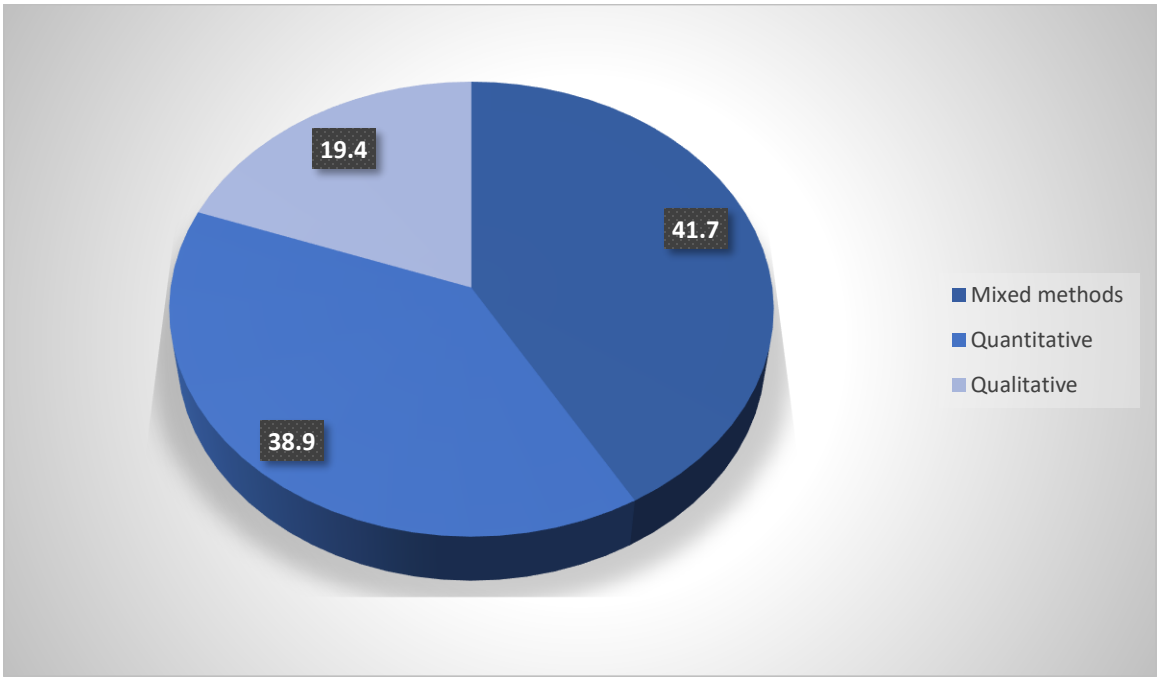

Figure 4: The Percentage of Study Designs

Research Participants

The tabulated descriptions in Supplementary Information Files also revealed that most participants were undergraduate university students (Articles: 1, 6, 10, 11, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 25, 26, 28, 29, 30, 31, 32, 34, 35, and 36), EFL learners (Articles: 1, 5, 13, 14, 15, 16, 17, 18, 20, 21, 26, 27, 28, 29, 30, and 34), ESL learners (Articles: 8, 19, 27, 35, and 36), teachers (Articles: 4, 24, and 33), ELL students (Articles: 2, 23, and 35), students of educational psychology/language (Articles: 20 and 34), middle/high school students (Articles: 33 and 36), first-year students (Articles: 25 and 30), graduate students (Article 6), and in one study, participant details were not explicitly mentioned (Article: 12). Table 2 illustrates the frequency and percentage of the participants.

Table 2: Frequency of Participant Groups across 36 Reviewed Studies

Participants Group	Frequency	Percentage
University/Undergraduate Students	24	66.7
EFL Learners	14	44.4
ESL Learners	5	13.9
Teachers	3	8.3
ELL Students	3	8.3
Educational Psychology/Language Students	2	5.6
Middle/High School Students	2	5.6
Freshmen/First-Year Students	2	5.6
Graduate Students	1	2.8
Not Specified	1	2.8

Research Question Three

Key Types, Features, and Modes of TMWCF Used in EFL Learners' Writing Instruction

- **Key Types and Features**

Research question three examined the technological characteristics of the applications used to improve participants' writing, as well as the types and modes of feedback provided by these applications. The analysis of studies from 2015 to 2025 revealed that a range of technologies played an important role in enhancing the writing skills of EFL learners. These technologies offered several features that significantly improved both the writing process and the feedback received. For example, word processing tools like Google Docs and Microsoft Word include notable features such as real-time collaboration, comment insertion, and track changes, enabling students to receive ongoing and constructive feedback. Google Docs, in particular, facilitates peer collaboration, while Microsoft Word helps identify both local and global errors, such as spelling, grammar, and organizational issues, thereby improving the writing process (Articles: 1, 9, 32, 22, and 34). Additionally, Learning Management Systems (LMSs) like Blackboard and Moodle centralize the entire learning experience, offering features such as assignment management, quizzes, and feedback sharing. These platforms can integrate oral feedback and written feedback smoothly, creating a well-rounded feedback environment (Articles: 32, 22, 33, and 20).

Alongside these, screen-capture software like Screencast-O-Matic and video conferencing tools such as Zoom provide multimodal feedback through visual and auditory means, offering a personalized touch that is essential in remote learning settings. These technologies are perfect for real-time interactions and can deliver either synchronous or asynchronous feedback, depending on the needs of the EFL learners (Articles: 24, 35, 19, and 29). Furthermore, automated feedback systems, such as Grammarly, Pigai, and Criterion, offer AI-driven, immediate feedback on grammar, syntax, punctuation, and writing structure. These systems feature diagnostic feedback that highlights areas for improvement, generating suggestions and corrections that help EFL learners refine their work (Articles: 13, 17, 21, and 36). Google Drive and Writeabout.com further enhance collaborative learning by enabling peer review and comment-based feedback, creating a shared space where EFL learners can engage in mutual feedback exchanges (Articles: 34 and 25). Together, these technologies provide a range of advanced feedback options, real-time

collaboration features, and automated corrections, collectively enhancing EFL learners' writing skills across various aspects of the writing process (Articles: 9, 19, 20, 32, and 36).

Modes

As outlined in Supplementary Information Files, the analysis of studies from 2015 to 2025 revealed that the modes of feedback used were written feedback (Articles: 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, and 36), oral feedback (Articles: 1, 2, 15, 19, 22, 24, 25, 29, 30, 34, and 35), video feedback (Articles: 2, 4, 8, 15, 16, 18, 28, 30, and 34), and audio feedback (Articles: 2, 15, 18, 19, and 29). Figure 5 illustrates the percentage of these modes.

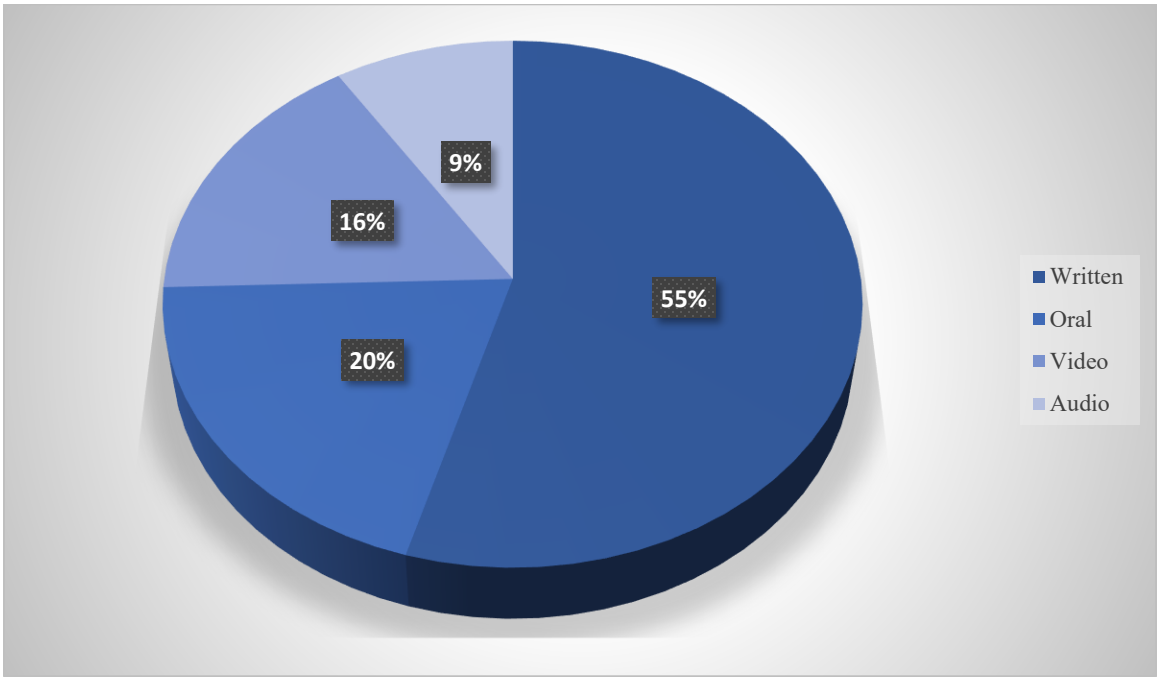

Figure 5: The Percentage of Modes of Feedback

Research Question Four

Limitations

Research question four analyzed the limitations of TMWCF research. After reviewing the studies published between 2015 and 2015, it was revealed that the majority of the limitations involved small sample sizes (Articles: 2, 5, 7, 11, 12, 14, 15, 17, 18, 20, 24, 27, 28, 29, 31, 32, 33, and 34), generalizability of studies' results (Articles: 1, 5, 7, 14, 15, 18, 20, 21, 24, 28, 31, 35, and 36), utilization of Apps like Edmo and ChatGPT 4 and technological issues (Articles: 3, 7, 8, 9, 23, and 34), employment of homogeneous participants (Articles: 5, 6, 12, 13, 15, 28, and 29), challenges in data collection and the need for additional techniques (Articles: 10, 12, and 27), paying attention to a single aspect of writing (Articles: 5, 17, 26, 29, 30, and 36), bias from teachers or instructors (Articles: 21, 24, 29, and 36), design of studies (Articles: 12, 13, 15, and 26), and the absence of comparisons with other types of feedback (Articles: 17, 19, 24, and 35). Some studies did not

consider the students' variables (Articles: 9 and 35), lack of enough time for administration (Articles: 4, 12, 18, 32, and 34), faced issues with control and experimental groups (Articles: 25 and 26), and difficulty in interpretation of feedback (Articles: 6, 19, 34, and 36), lack of standardized criteria (Article: 22), absence of objective measures (Article: 22), and uncertainty regarding the enhancement of learners' revision skills as a result of using Automated Writing Evaluation (AWE) (Article: 22).

5. DISCUSSION

The first research question explored the aspects of writing that were enhanced by technological tools. It was discovered that grammatical accuracy, vocabulary, organization, coherence, and structure were primarily enhanced through feedback from these tools. In contrast, spelling, lexical sophistication, collocation errors, and fluency were the areas that benefited the least from technology as a source of feedback. This finding aligns with previous research (e.g.,Abdu & Abdullah, 2022; Al-Olimat & AbuSeileek, 2015; Atar Sharghi et al., 2022; Banihashem et al., 2024; Cunningham, 2019; Han & Sari, 2024; Imsa-ard & Barrot, 2024; Shen et al., 2023; Zhu et al., 2020), acknowledging the effects of technological tools in improving students' grammatical knowledge. In other words, these tools help learners become aware of their structural inaccuracies. Hence, learners acquire accurate language structures, such as knowing when to use the plural 's'.

Although most research emphasizes the importance of these tools in developing learners' grammatical knowledge, some studies state that language fluency, vocabulary, and spelling (e.g.,Gao & Ma, 2020; Imsa-ard & Barrot, 2024; Papin & Michaud, 2024) were mainly improved when utilizing technological tools for correcting writing errors. Hence, this finding contradicts earlier research (Ahern-Dodson & Reisinger, 2017; Chacón-Beltrán & Echitchi, 2022; Hojeij & Ayber, 2022; Imsa-ard & Barrot, 2024). This is because learners acquire grammar more quickly through features offered by applications like Microsoft Word (Ranalli & Yamashita, 2022). However, with the expansion of technology, various technological applications such as AI tools and Grammarly can enhance macro-level aspects of writing (Banihashem et al., 2024; Tambunan et al., 2022). Thus, technological tools will play a principal role in the process of learning a language and reduce the burden on the shoulders of both language learners and teachers.

The second research question examined the methodological characteristics of articles published in the field of TMWCF. It was revealed that most researchers selected a mixed-methods design for conducting TMWCF research (e.g., Ahern-Dodson & Reisinger, 2017; Cunningham, 2019; Gao & Ma, 2020; Hojeij & Ayber, 2022; Yamashita, 2021). Additionally, quantitative research was employed in some studies (e.g., Al-Olimat & AbuSeileek, 2015; Atar Sharghi et al., 2022; Guo et al., 2024). This can be justified because, in experimental research, a treatment is used to evaluate the effectiveness of a method or tool (Ary et al., 2019), such as technological tools like ChatGPT. Furthermore, the qualitative research design was employed in a limited number of studies (e.g., Abdu & Abdullah, 2022; Delante, 2017; Koltovskaia, 2020; Shintani & Aubrey, 2016). This result agrees with the common practice in applied linguistics, which favors mixed-methods studies. Hence, researchers could benefit from the strengths of both quantitative and qualitative methods (Sherafati et al., 2020). Accordingly, this could increase the reliability and validity of mixed methods research.

However, this finding conflicts with some previous research that used a qualitative design for their investigation (Abdu & Abdullah, 2022; Kjærgaard, 2018). The limited use of qualitative methods for TMWCF may be related to concerns about the generalizability of their results (Abdu & Abdullah, 2022), their limited samples, which can affect the results, and the lack of objectivity due to the self-report nature of their data employed for conducting research via this method

(Kjærgaard, 2018). TMWCF research, as a new method, necessitates quantitative research because the high generalizability associated with this approach can help establish its validity.

Furthermore, undergraduate learners and high school EFL learners have been reported as participants in most previous studies on TMWCF (Han & Sari, 2024; Kim, 2018; Link et al., 2020; Pham, 2022; Sherafati & Mahmoudi Largani, 2023; Valero Haro et al., 2024). This can be explained by the claim that teachers pursue criteria for choosing participants (Jiang & Yu, 2022). Thus, to recruit the most qualified samples, they decided among those they knew were suitable for their research. Another reason for choosing undergraduate learners and high school EFL learners to participate in the previously mentioned research could be convenience and availability, which allowed researchers to conduct their research with ease. Moreover, EFL learners have participated in most of the TMWCF research. Several studies reported EFL learners as their sample (e.g., Sherafati & Mahmoudi Largani, 2023; Wıhastyanang et al., 2020). This finding can be justified since many students were learning English as their foreign language. Consequently, many studies have focused on TMWCF. However, among the previous studies on TMWCF, one article reported graduate students as participants, which contrasts with other studies that used different groups (e.g., Banihashem et al., 2024). This might have resulted from limitations imposed on researchers, which forced them to select participants from a single institution and course.

The third research question inquired about the technological tools employed in technology feedback research and explained their features. It was revealed that Google Docs and Microsoft Word were the most popular applications for providing feedback to learners. These applications supported features such as real-time connection, comment insertion, and tracking changes. These results could be supported by the previous research, which confirmed the asynchronous nature of these applications (Cunningham, 2019; Shintani, 2016). Although Google Docs can be regarded as a synchronous tool (Shintani, 2016), other tools have also emerged—such as Screencast-O-Matic, video conferencing platforms like Zoom, as well as writing tools like Grammarly, Pigai, and Criterion—that offer various features including real-time communication, personalized feedback, immediate corrections, and the ability to enhance learners' writing quality and accuracy. Therefore, the synchronous characteristics of these applications may contribute positively to the development of EFL learners' writing skills (Shintani, 2016).

In a similar vein, the results showed that the majority of feedback provided by technology was written. This finding is supported by most of the studies conducted in these areas (e.g., Papin & Michaud, 2024; Shen et al., 2023; Sherafati & Mahmoudi Largani, 2023). For instance, Al-Olimat and AbuSeileek (2015) utilized Microsoft Word to deliver written feedback to students. However, these results are different from some articles that employed oral and video channels for offering their feedback (e.g., Ahern-Dodson & Reisinger, 2017; Althoubiti, 2021; Cunningham, 2019; Hojeij & Ayber, 2022; Shintani & Aubrey, 2016). In fact, technological development has made it possible to deliver oral and video feedback through various platforms. As a result, students have multiple options for receiving feedback from teachers through various modes, which can facilitate the efficient digestion of feedback while increasing their L2 proficiency more rapidly.

Finally, the fourth research question investigated the limitations of TMWCF research. The authors conducting TMWCF research primarily acknowledged sample size, generalizability, technological issues, and the utilization of Apps like Edmo and ChatGPT 4. This result conformed to the bulk of previous studies (see Table 1 in Supplementary Information Files), as most researchers struggled with time and financial limitations imposed on them. They were obliged to undertake the research even though they knew that these limitations could affect the results. Thus, it was recommended that future researchers replicate these studies with larger participant groups and severe controlled conditions to examine whether they could achieve the results reported in the previous literature.

This result contradicts some previous studies (e.g., Koltovskaia, 2020; Papin & Michaud, 2024; Peungcharoenkun & Waluyo, 2024; Wıhastyanang et al., 2020), which presented issues with the design and interpretation of the findings as significant challenges that researchers might encounter during their studies. This could have resulted from initial differences among participants, reducing the reliability and validity of the findings. Besides, a lack of standardized criteria and objective measures was reported by Link et al. (2020) as a limitation. Furthermore, it has been noted that the effectiveness of using AWE in improving learners' revision skills remains unclear (Link et al., 2020). These limitations, primarily related to the specific nature of the study, were reported because they presented major obstacles during its execution. In fact, these limitations can exist in other studies conducted in this area. Consequently, it can be concluded that more limitations could be attributed to these research studies, other than what was mentioned as limitations of these studies. In fact, nearly all of the significant limitations are openly acknowledged by their own researchers themselves, which explains the inconsistencies among them.

Consequently, technological feedback can be used as a supportive tool in language classes and even outside the class by EFL learners. Through technology-enhanced feedback, EFL learners can increase their language skills and become independent language learners. Applications like Grammarly, which provide written feedback on students' mistakes, offer a variety of features such as instant comments on errors and constructive feedback on learners' writing. Overall, studies on feedback via technology have made significant contributions to second language acquisition research, enhancing the effectiveness of language classes despite limitations such as sample size.

6. CONCLUSION

This scoping review provides fresh insight into previous studies published between 2015 and 2025 on TMWCF and writing skills. The study provided an overview of key features, including the most improved aspects of writing, types, and modes of feedback, popular technological tools, research designs, and participant characteristics. It is significant because it has important implications for EFL learners and teachers, syllabus and material designers, and policymakers. First, for EFL learners, it promotes their writing development by exposing them to various types of TMWCF, including automated corrective feedback, peer feedback, and teacher-led digital feedback. This helps them develop grammar and coherence, becoming better writers and gaining more interactive and engaging experiences. Second, for language teachers, the study provides a research-based foundation for designing effective instructional strategies that incorporate technology to optimize feedback delivery.

Additionally, syllabus and material designers could benefit from incorporating technological tools while producing materials and textbooks for their writing courses (Sherafati & Mahmoudi Largani, 2023). These applications can be integrated into English writing classes, helping students address fundamental issues such as spelling and punctuation (Koltovskaia, 2020). Thus, this study contributed to a large body of knowledge concerning English language skills and TMWCF. TMWCF could be conducive to any language course since it proffers timely, personalized, and informative feedback (Hojeij & Ayber, 2022). Accordingly, both teachers and language learners could benefit from these technology-related features. Finally, policymakers could improve technological facilities and requirements for using technology in language classes. A course on implementing technology for enhancing learners' skills could be planned for prospective teachers to increase their technological awareness on this issue. Additionally, some experts could be employed to resolve technical issues that arise when students use technology in their language classes.

However, this study had some limitations. First, it employed a few articles as its primary source for analysis. In fact, the 36 articles gathered for this study could be replaced by a corpus comprising many studies. Another limitation pertains to the subjectivity inherent in data analysis in any qualitative research, which could lead to biased results. Additionally, the absence of a meta-analysis in this scoping review may affect its generalizability. Furthermore, the study has a limited and narrow focus on written corrective feedback. Besides, due to resource constraints, the researchers could not able to assess all aspects of technological feedback. Recognizing these limitations might encourage other researchers to include a much broader scope of publications. Moreover, they could adopt other research methods, such as meta-analysis, to explore the effectiveness of various types of TMWCF, including AI. Moreover, they could explore other skills, such as speaking, to assess how technology can improve these skills.

Furthermore, an examination of the effectiveness of technologies like AI on oral proficiency in different contexts, such as the Iranian EFL setting with TEFL students as participants, is justified. They could implement a longitudinal design to assess better the effectiveness of TMWCF on learners' writing development. Moreover, they could assess EFL learners' and teachers' perceptions of the effectiveness of technological feedback tools in general, as well as of any specific program created for this purpose. Lastly, future research could explore how technology-assisted feedback could be utilized for assessing language learners' writing and to what extent teachers could rely on these applications to evaluate learners' proficiency.

Funding:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest:

The authors declare that they have no conflict of interest.

Supplementary Information: Table 1

The online version includes supplementary material available at: Supplementary Information Files.

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