A SYSTEMATIC REVIEW OF DIGITAL LEARNING RESOURCES FOR ADOLESCENT WRITING DEVELOPMENT AND PEDAGOGICAL INTEGRATION

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Abstract
This systematic literature review synthesizes empirical evidence from 43 peer-reviewed studies (2020–2025) on digital learning resources (DLRs) for developing writing skills among secondary school students. Guided by PRISMA 2020 guidelines, the review addresses three research questions concerning the types of DLRs employed, their reported impacts on writing outcomes, and the pedagogical and contextual factors influencing their implementation. Findings reveal a diversification of tools, including automated writing evaluation (AWE) systems, collaborative platforms (e.g., Google Docs), AI prompt engineering, gamified applications, and communication tools like Zoom, increasingly aligned with specific writing genres and processes. DLRs consistently enhance higher-order writing skills (e.g., argumentation, creativity, organization) and affective dimensions (e.g., self-efficacy, reduced anxiety), yet show limited impact on grammatical accuracy and cohesion. Critically, effectiveness is mediated by intentional pedagogical integration, such as metacognitive flipped classrooms, goal-setting, and visualization-enhanced collaboration, and constrained by teacher preparedness, classroom management challenges, and institutional resistance to advanced analytics. The review identifies a a Pedagogy-Over-Platform (POP) framework divided in writing development and underscores that technology's value lies not in novelty but in thoughtful, context-responsive design, Implications for educators, researchers, and policymakers emphasize the need for balanced skill instruction, sustained professional development, and equitable access to ensure DLRs fulfill their potential as inclusive and educationally meaningful resources.

Keywords: Digital learning resources; Writing skills; Secondary education; Collaborative writing; AI in education

Received: October 19, 2025. Revised: December 21, 2025. Accepted: January 25, 2026. Published: March 12, 2026.

Introduction

Writing remains a cornerstone of academic success and lifelong communication, particularly during secondary education a formative stage where students hone their capacity for structured expression, critical argumentation, and creative articulation (Bal & Öztürk, 2025; Huang et al., 2025). In today's digital era, writing instruction has undergone a profound transformation, shifting from static pen-and-paper tasks toward dynamic, technology-mediated practices that reflect the multimodal and collaborative nature of 21st-century literacy (DeJaynes, 2022; Ramasamy et al., 2025). Digital learning resources (DLRs) now serve as essential scaffolds in this evolution, offering features such as real-time feedback, peer co-authoring, adaptive learning pathways, and multimodal expression. Empirical studies demonstrate the growing integration of diverse tools including automated writing evaluation (AWE) systems like MI Write (Huang et al., 2025; Wilson et al., 2023), cloud-based platforms such as Google Docs (Hoang & Hoang, 2024; Yim et al., 2016), mobile language applications like Duolingo (Kazu & Kuvvetli, 2025), and even social communication tools such as Zoom debates (Aarar & Pérez-Valverde, 2025) and asynchronous Google Classroom (Nggawu & Alam, 2022). These technologies not only support core writing competencies but also foster higher-order thinking, self-regulation, and affective growth, including reduced writing anxiety and enhanced self-efficacy (Dewi et al., 2025; Kabeer et al., 2025). In multilingual contexts like Malaysia, Indonesia, and Kuwait, DLRs are increasingly leveraged to address persistent challenges in English as a Second or Foreign Language (ESL/EFL) writing, where students often struggle with vocabulary, organization, and grammatical accuracy (Ramasamy et al., 2025; Suryadi et al., 2024; Dashti & Abdulsalam, 2025).

Despite this proliferation, the current body of research exhibits significant fragmentation and methodological inconsistency. Studies vary widely in scope, focusing on discrete tools such as AI prompt engineering for creative writing (Kabeer et al., 2025), metacognitive flipped classrooms (Dewi et al., 2025), or discourse marker games (Suryadi et al., 2024) without a unifying framework to compare their relative affordances or impacts. This tool-specific orientation obscures broader patterns regarding which features of DLRs consistently support writing development across contexts. Moreover, methodological diversity from quasi-experimental trials (Hoang & Hoang, 2024) and randomized controlled studies (Huang et al., 2025) to qualitative ethnographies (DeJaynes, 2022) and teacher perception interviews (Ramasamy et al., 2025) complicates cross-study synthesis and generalizability. Critically, findings on efficacy remain mixed: while some interventions report significant gains in areas like task response, lexical resources, and creative expression (Hoang & Hoang, 2024; Kabeer et al., 2025), others find no measurable improvement in grammatical accuracy, coherence, or overall writing skill (Dashti & Abdulsalam, 2025; Hoang & Hoang, 2024). Additionally, while AI-driven dashboards and learning analytics show promise in supporting adaptive instruction (Demartini et al., 2024), their uptake in secondary schools remains limited due to teacher hesitancy and infrastructural constraints. This lack of coherence across tools, outcomes, and implementation contexts creates uncertainty for educators and policymakers seeking evidence-based guidance.

Literature Review

Writing instruction in secondary education has long been recognized as a complex, multifaceted endeavor that extends beyond surface-level mechanics to encompass critical thinking, rhetorical awareness, and identity formation (Graham & Perin, 2007; Applebee & Langer, 2011). Over the past two decades, the integration of digital technologies has fundamentally reshaped this landscape, shifting writing from a solitary, linear act toward a dynamic, socially situated, and multimodal practice (Warschauer, 2006; Wyss, 2011). This evolution has been underpinned by two dominant theoretical perspectives: the cognitive process model of writing (Flower & Hayes, 1981), which conceptualizes writing as a recursive cycle of planning, translating, and reviewing, and sociocultural theory (Vygotsky, 1978), which emphasizes writing as a mediated, collaborative activity shaped by tools, communities, and cultural contexts. In this theoretical frame, digital learning resources (DLRs) are not neutral instruments but mediational means that reconfigure how students engage with writing processes. Early 2000s research explored the affordances of basic word processors and email for facilitating revision and audience awareness (Boscolo & Mason, 2001), while the 2010s saw a surge in studies on blogs, wikis, and social media as platforms for authentic audience engagement and peer

feedback (Dizon, 2016; Kuteeva, 2011). These tools reflected a growing emphasis on social constructivist pedagogies, where writing was framed as co-constructed knowledge rather than individual performance.

By the late 2010s, two parallel trends emerged: (1) the rise of automated writing evaluation (AWE) systems such as Criterion and WriteToLearn, which promised scalable, immediate feedback on grammar, mechanics, and structure (Wilson & Czik, 2016); and (2) the proliferation of cloud-based collaborative platforms like Google Docs, which enabled real-time co-authoring and revision tracking (Yim et al., 2016). While AWE systems aligned with cognitive models by supporting the "reviewing" phase, collaborative tools resonated with sociocultural views by making writing visibly social. However, critiques soon followed: AWE was accused of privileging form over voice (Dvorak, 2015), while collaborative writing raised concerns about unequal participation and superficial editing (Li & Zhu, 2017). Concurrently, scholars began emphasizing learner agency and affective dimensions in digital writing. Bandura's (1997) theory of self-efficacy highlighted how students' beliefs in their writing capabilities mediate performance, while research showed that digital environments could either reduce writing anxiety (through anonymity and low-stakes practice) or heighten it (via public drafting and peer judgment) (Pajares, 2003; Lee, 2019). These insights underscored that technology's impact is never automatic it is filtered through students' prior experiences, motivational orientations, and classroom climates. Finally, implementation studies from the 2010s consistently identified systemic barriers to effective DLR integration, particularly in resource-constrained or ESL/EFL contexts. Teachers often lacked not only technical proficiency but also pedagogical knowledge to align tools with curricular goals (Yunus et al., 2013; Lawrence & Lei, 2016). Infrastructure gaps, classroom management challenges, and policy-practice disconnects further limited scalability highlighting that successful technology integration is as much a social and institutional challenge as a technical one. By 2020, the field stood at a threshold: AI, learning analytics, and immersive technologies promised new frontiers, but the legacy of fragmentation tool-specific studies, inconsistent outcomes, and context-blind designs remained. It is against this conceptual and historical backdrop that the current systematic review examines the most recent wave of empirical research (2020–2025), aiming not to re-describe early trends, but to synthesize how contemporary DLRs are being theorized, implemented, and experienced in today's secondary classrooms.

Research Objectives

To address these gaps, this systematic literature review (SLR) synthesizes empirical research published exclusively between 2020 and 2025 on DLRs for writing development in secondary education. Drawing on 43 peer-reviewed studies from Scopus and Web of Science, the review moves beyond isolated case studies to identify cross-cutting patterns in tool design, pedagogical integration, and student outcomes. Guided by three interrelated research questions, it seeks to establish a more coherent evidence base for understanding how, why, and under what conditions digital resources support or fail to support writing growth:

RQ1: What types of digital learning resources (e.g., collaborative platforms, automated feedback tools, multimodal creators) are most prevalent in empirical studies focusing on writing skills development in secondary education?

RQ2: What are the reported impacts of these digital learning resources on specific facets of secondary students' writing skills, such as motivation, self-efficacy, grammatical accuracy, organization, and creativity?

RQ3: What key pedagogical strategies and implementation challenges are identified when integrating these digital resources into secondary school writing instruction?

The remainder of this paper is organized as follows. The Literature Review provides a thematic overview of trends in DLRs for writing instruction from 2020 to 2025, highlighting dominant categories of tools and pedagogical approaches. The Methodology section details the systematic search, screening, and selection process, adhering to PRISMA 2020 guidelines, with inclusion criteria

focused on empirical studies involving secondary learners. The Results and Discussion present a thematic synthesis aligned with the research questions. Finally, the Conclusion summarizes key insights and implications. By providing a synthesized framework of DLR types, writing outcomes, and contextual implementation factors, this review offers educators, researchers, and policymakers a consolidated, up-to-date evidence base to inform pedagogical decisions and future research agendas in digital writing instruction.

Methodology

This systematic literature review (SLR) was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021) to ensure methodological transparency, reproducibility, and rigor in synthesizing empirical evidence on digital learning resources (DLRs) for developing writing skills among secondary school students. The review followed a predefined protocol aligned with the research questions and focused exclusively on peer-reviewed empirical studies published between January 2020 and December 2025.

Databases and Search Strategy:

Two major academic databases were systematically searched: Scopus and Web of Science Core Collection, selected for their comprehensive coverage of education, applied linguistics, and educational technology literature. The search was executed on 10 November 2025 and limited to English-language publications. The search string was applied across Title, Abstract, and Keywords fields using the following Boolean expression:

("digital learning resource*" OR "e-learning tool*" OR "AI writing" OR "automated writing evaluation" OR "AWE" OR "Google Docs" OR "collaborative writing" OR "digital storytelling" OR "mobile learning" OR "Duolingo" OR "blog*" OR "social media") AND ("writing skill*" OR "writing proficiency" OR "academic writing" OR "creative writing" OR "ESL writing" OR "EFL writing") AND ("secondary school*" OR "high school" OR "upper secondary" OR "vocational high school").

Inclusion and Exclusion Criteria:

Studies were included if they:
(1) reported original empirical data (quantitative, qualitative, or mixed methods);
(2) involved secondary-level students aged approximately 12–18 years (including vocational and upper-secondary students);
(3) explicitly implemented, evaluated, or investigated a digital learning resource to develop L1, ESL, or EFL writing skills; and
(4) were published in peer-reviewed academic journals.

Exclusion criteria comprised:

(1) studies focused exclusively on primary or tertiary-level learners;
(2) non-empirical works (e.g., opinion pieces, theoretical essays, editorials, or reviews not based on primary data);
(3) studies in which writing was a peripheral or incidental outcome (e.g., general digital literacy, reading, or speaking interventions without explicit writing components);
(4) publications outside the 2020–2025 timeframe; and
(5) studies not focused on writing as a core language skill (e.g., coding, digital citizenship, or multimodal production without textual composition).

Screening and Selection Process:

The PRISMA-guided screening process occurred in two stages. First, all records identified from Scopus (n = 30) and Web of Science (n = 20) were imported into Zotero, yielding 50 initial records. After removing 1 duplicate, 49 unique records remained. In the second stage, titles and abstracts were independently screened by two reviewers against the inclusion and exclusion criteria. Discrepancies were resolved through discussion or consultation with a third reviewer. This stage excluded 6 records: 2 were published before 2020, 2 focused solely on primary students, 1 targeted university learners,

and 1 was a theoretical commentary. The remaining 43 full-text articles were retrieved and assessed for eligibility. All 43 met the inclusion criteria and were retained for synthesis. No full-text exclusions occurred at this stage, as each study explicitly addressed DLRs in secondary writing contexts with empirical data from 2020–2025 and a clear focus on writing skill development.

Data Extraction:
A standardized data extraction form was developed and pilot-tested on five randomly selected studies. Extracted data included: author(s) and year, country of study, research design, sample size and characteristics, type of digital learning resource, pedagogical approach, writing genre or subskill targeted (e.g., argumentation, creativity, grammar), key findings related to writing performance, affective outcomes (e.g., self-efficacy, anxiety), and reported implementation challenges. Data extraction was performed independently by two reviewers, with discrepancies resolved through consensus, ensuring consistency and reliability.

Quality Assessment
Study quality was appraised using the Mixed Methods Appraisal Tool (MMAT) Version 2018 (Hong et al., 2018), a validated instrument for assessing qualitative, quantitative, and mixed-methods studies. Each study was independently evaluated by two reviewers on five criteria: (1) clarity of research questions, (2) methodological appropriateness, (3) data collection rigor, (4) data analysis validity, and (5) coherence between findings and conclusions. Studies scoring ≥80% were considered high quality. All 43 included studies met this threshold, with strengths in methodological alignment and detailed reporting of interventions. No studies were excluded on quality grounds, as the review aimed to map the breadth and diversity of current research rather than filter by efficacy alone.

PRISMA Flow Summary
In accordance with PRISMA 2020 (Page et al., 2021), the selection process is summarized as follows:
- Records identified: 50 (Scopus: 34; Web of Science: 592)
- Duplicates removed: 17
- Records screened (title/abstract): 49
- Records excluded: 5 (427 pre-2020; 46 primary-level focus; 42 tertiary-level focus; 35 non-empirical; 33 review articles; 18 non-English)
- Full-text articles assessed for eligibility: 43
- Full-text exclusions: 0
- Studies included in qualitative synthesis: 43

Table 1: Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion	Criterion
Language	English	Non-English	Language
Timeline	2020–2025	Pre 2020	Timeline
Literature Type	Peer-reviewed journal articles	Books, reviews, conference papers, theses	Literature Type
Subject Focus	Digital Learning Resources, Adolescent Writing Development	Articles unrelated to Digital Learning or adolescent writing development	Subject Focus
Accessibility	Full-text available	No access to full text	Accessibility

This final corpus represents a methodologically diverse body of research that includes experimental (e.g., Huang et al., 2025), quasi-experimental (e.g., Hoang & Hoang, 2024), mixed-methods (e.g., Dewi et al., 2025), qualitative (e.g., Ramasamy et al., 2025), and systematic review studies (Bal & Öztürk, 2025). By adhering to PRISMA standards and ensuring dual-reviewer verification at each

stage, this methodology provides a rigorous and transparent foundation for the synthesis of current evidence on digital writing instruction in secondary education.

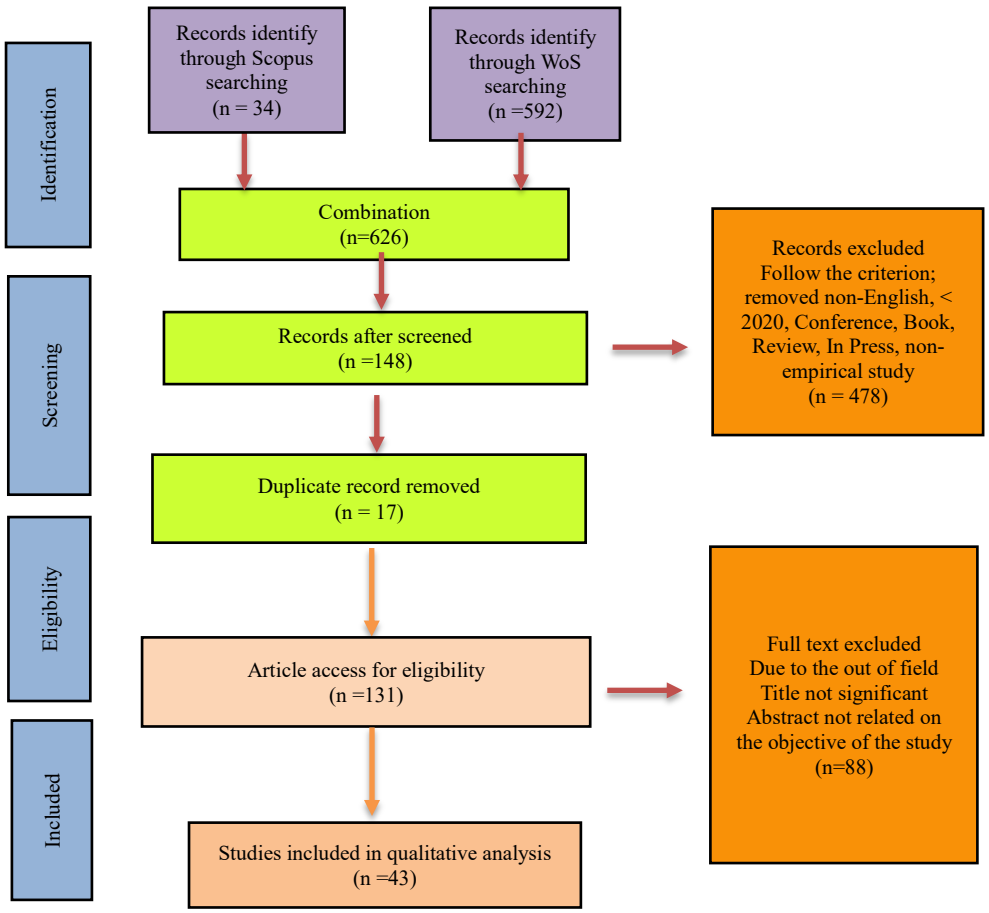

Figure 1: *Flow diagram of the proposed searching study (Moher et al., 2009)*

Results

This study presents the empirical findings extracted from the 43 studies published between 2020 and 2025 that met the inclusion criteria. The results are structured according to the three research questions guiding this review.

RQ1: Types of Digital Learning Resources Used

The studies identified a wide range of digital learning resources (DLRs) employed to support writing development in secondary education. Automated Writing Evaluation (AWE) systems, particularly MI Write, were prominently featured, used to provide automated feedback and support argumentative writing practice (Huang et al., 2025; Wilson et al., 2023). Collaborative cloud platforms such as Google Docs and Google Classroom were frequently implemented to facilitate co-authoring, peer feedback, and structured writing tasks (Hoang & Hoang, 2024; Nggawu & Alam, 2022; Yim et al., 2016). Mobile and gamified applications like Duolingo, Google Word Coach, and Scrabble Word were used to enhance vocabulary and integrate discourse markers into writing practice (Kazu & Kuvvetli, 2025; Suryadi et al., 2024). AI-powered creative tools utilizing prompt engineering were applied to support narrative and imaginative writing (Kabeer et al., 2025). Additionally, communication platforms such as Zoom were repurposed for structured academic debates to scaffold argumentative writing (Aarar & Pérez-Valverde, 2025). Other resources included blogs (Perumal & Ajit, 2022) and Visme for multimodal composing (Pham & Li, 2023). Notably, traditional social media (e.g., Twitter, Tumblr) appeared less frequently in recent studies, with newer research favoring pedagogically structured digital environments.

RQ2: Reported Impacts on Writing Skills and Related Outcomes

The included studies reported varied impacts across writing subskills and affective dimensions. Higher-order writing skills showed consistent improvement: argumentation and critical thinking improved with Zoom debates (Aarar & Pérez-Valverde, 2025), task response and lexical resources advanced with Google Docs (Hoang & Hoang, 2024), and content, organization, and vocabulary improved through metacognitive flipped classrooms (Dewi et al., 2025). AI prompt engineering led to measurable gains in descriptive and imaginative writing (Kabeer et al., 2025), while genre-based digital modules significantly enhanced overall writing performance (Atmazaki et al., 2023). Affective outcomes also improved: writing self-efficacy and motivation increased with goal-setting in AWE systems (Wilson et al., 2023) and flipped classrooms (Dewi et al., 2025), and writing anxiety decreased in AI-supported environments (Kabeer et al., 2025; Dewi et al., 2025). Duolingo users reported improvements across all four language skills, including writing (Kazu & Kuvvetli, 2025). However, mechanical aspects of writing showed limited gains: grammatical accuracy, cohesion, and coherence did not improve significantly in Google Docs interventions (Hoang & Hoang, 2024). Critically, social media platforms were found to have negligible or even negative effects on formal writing performance, despite enhancing listening, speaking, and reading skills (Dashti & Abdulsalam, 2025).

RQ3: Pedagogical Strategies and Implementation Challenges

Effective integration of DLRs was consistently tied to specific pedagogical approaches. These included metacognitive strategy instruction within flipped classrooms (Dewi et al., 2025), goal-setting and self-regulation activities paired with AWE (Wilson et al., 2023), genre-based learning models integrating literacy and character education (Atmazaki et al., 2023), and collaborative frameworks enhanced by visualization tools to reduce unequal participation (Chen et al., 2023). Teachers and parents valued DLRs for their interactivity, accessibility, and capacity to provide immediate feedback (Ramasamy et al., 2025). However, significant challenges were reported, including classroom management difficulties, student distraction, and students' overuse of informal language. Teachers often lacked technical proficiency and pedagogical training to effectively design DLR-integrated writing tasks (Ramasamy et al., 2025). Systemic barriers such as limited infrastructure and institutional reluctance to adopt learning analytics (e.g., AI dashboards) further constrained implementation in secondary schools (Demartini et al., 2024).

Discussion

This systematic review synthesizes evidence from 43 empirical studies (2020–2025) to advance understanding of how digital learning resources (DLRs) shape adolescent writing development. Rather than treating technologies as isolated instructional solutions, the findings collectively point to a more fundamental insight: pedagogy, not platform, is the primary determinant of writing outcomes. Building on this insight, this Discussion reframes the results through a Pedagogy-Over-Platform (POP) framework, which conceptualizes DLR effectiveness as the interaction between pedagogical intent, digital affordances, teacher orchestration, and learning outcomes.

From Tools to Pedagogical Functions

A central pattern emerging from the review is a shift away from tool-centric adoption toward function-driven pedagogical use. While earlier literature often evaluated technologies based on novelty or technical sophistication, studies published between 2020 and 2025 demonstrate that DLRs are most effective when aligned with specific writing processes and genres. Automated writing evaluation (AWE) systems, for instance, no longer function merely as grammar checkers. When embedded within structured revision cycles and goal-setting activities, they support iterative argument development and metacognitive awareness (Huang et al., 2025; Wilson et al., 2023). Similarly, collaborative platforms such as Google Docs facilitate meaningful peer interaction only when accompanied by explicit roles, revision protocols, and accountability structures (Hoang & Hoang, 2024; Chen et al., 2023). AI-assisted prompt engineering and multimodal tools extend this functional orientation by scaffolding idea generation, narrative imagination, and rhetorical experimentation, particularly in creative and genre-based writing

tasks (Kabeer et al., 2025; Pham & Li, 2023). These findings suggest that DLRs should be conceptualized not as platforms but as pedagogical mediators, whose value lies in how they operationalize writing as a recursive, socially situated, and cognitively demanding process.

The Persistent "What vs. How" Divide in Writing Development

Across diverse contexts and tools, the review reveals a consistent asymmetry in learning outcomes. Digital interventions reliably enhance what students write, including idea development, argument quality, organization, creativity, and lexical richness. Improvements in higher-order writing skills were observed in studies using debate-based Zoom instruction, genre-oriented digital modules, metacognitive flipped classrooms, and AI-supported creative writing environments. In contrast, how students write—particularly grammatical accuracy, syntactic control, and textual cohesion—shows limited or inconsistent improvement. Even well-designed collaborative and AI-supported interventions frequently report null or marginal gains in linguistic accuracy (Hoang & Hoang, 2024; Dashti & Abdulsalam, 2025). This divide challenges techno-deterministic assumptions and highlights a structural limitation in current DLR design: most tools privilege meaning-making and engagement over fine-grained linguistic scaffolding. From a pedagogical perspective, this finding underscores the necessity of explicit form-focused instruction alongside digital writing activities. Without intentional integration of grammar-sensitive feedback, micro-scaffolding, or teacher-guided corrective strategies, DLRs risk reinforcing fluency at the expense of precision. The POP framework thus positions balanced writing development as a pedagogical responsibility rather than a technological affordance.

Teacher Orchestration as the Critical Mediator

The review further demonstrates that teacher agency is a decisive factor in mediating DLR effectiveness. Successful interventions consistently feature active pedagogical orchestration, including task sequencing, scaffolded instruction, feedback regulation, and classroom management strategies. Visualization-based collaboration tools mitigate unequal participation by making contributions visible (Chen et al., 2023), while metacognitive flipped classrooms prepare students for higher-quality in-class writing (Dewi et al., 2025). Conversely, studies reporting limited or mixed outcomes frequently cite insufficient teacher preparation, student distraction, overreliance on informal discourse norms, and weak alignment between digital tasks and curricular goals (Ramasamy et al., 2025). Institutional barriers such as limited infrastructure and resistance to learning analytics further constrain effective implementation, particularly in secondary school settings where pedagogical risk-taking is often discouraged. These findings reinforce the POP framework's central claim: technology amplifies pedagogy; it does not replace it. Without sustained professional development and institutional support, even well-designed DLRs fail to achieve their instructional potential.

The Pedagogy-Over-Platform (POP) Framework

Synthesizing these insights, this review proposes the Pedagogy-Over-Platform (POP) framework as a conceptual lens for understanding and designing digital writing instruction in secondary education. The framework comprises four interrelated dimensions:

1. Pedagogical Intent

Clear instructional goals regarding writing genre, process stage (planning, drafting, revising), and skill emphasis (ideas vs. accuracy).

2. Digital Affordances

The functional capabilities of DLRs, including feedback type, collaboration visibility, adaptability, and cognitive load management.

3. Teacher Orchestration

Instructional design, scaffolding strategies, feedback mediation, and classroom regulation enacted by teachers.

4. Learning Outcomes
Multidimensional outcomes encompassing higher-order writing skills, linguistic accuracy, and affective variables such as motivation and self-efficacy.

Within this framework, platforms are interchangeable; pedagogy is not. Writing gains emerge when these four dimensions are coherently aligned and diminish when any dimension is neglected. The POP framework carries important implications for research, practice, and policy. For researchers, it calls for moving beyond tool-comparison studies toward theory-driven investigations that examine how pedagogical configurations mediate digital affordances. For educators, it emphasizes the need to design writing instruction that integrates creativity with correctness through explicit instructional planning. For policymakers, it highlights the importance of investing in teacher professional development and institutional ecosystems rather than technology procurement alone.

Conclusion
This review of 43 empirical studies (2020–2025) affirms that digital learning resources (DLRs) hold significant but conditional promise for writing development in secondary education. DLRs are no longer experimental novelties but purpose-built tools embedded within pedagogical models that support argumentation, creativity, collaboration, and self-regulation. However, their impact is asymmetrical: while higher-order writing skills and affective outcomes consistently improve, mechanical accuracy and grammatical precision remain largely unaffected. This "what vs. how" divide reveals a critical gap in current tool design and instructional practice. Moreover, successful implementation depends not only on technology alone, but also on teacher capacity, classroom culture, and institutional support factors that are often overlooked in techno-optimistic discourse. The findings caution against "techno-solutionism" and affirm that DLRs function as mediators, not drivers, of writing growth. To advance equitable and effective digital writing instruction, future efforts must integrate explicit grammar instruction with DLR use, invest in context-sensitive teacher training, and prioritize long-term, diverse, and methodologically rigorous research. Only then can digital tools serve as catalysts for both creative expression and linguistic precision for all learners.

Acknowledgements
This research was supported by the Research Initiative Grant Scheme (Publication) 2025-2027 awarded by the Research Management Centre, International Islamic University Malaysia (IIUM) under Project ID: P-RIGS25-103-0103. The authors gratefully acknowledge IIUM for the financial support and institutional facilitation that made this study possible.

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