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ARTIFICIAL INTELLIGENCE-BASED WRITING ASSISTANCE FOR ENGLISH LANGUAGE LEARNERS WITH SPEECH IMPAIRMENTS

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Abstract
Inclusive education emphasizes the right of every learner to access meaningful, high-quality instruction, including students with speech impairments, whose writing development is often hindered by limited opportunities for oral expression, feedback, and interaction. In many special-school settings, teachers struggle to provide individualized writing support due to time constraints and diverse learner needs. Responding to this gap, the present study investigates the extent to which three AI-assisted writing applications, Grammarly, ChatGPT, and QuillBot, can support the development of English writing skills among students with speech impairments in Indonesia. Using a mixed-methods approach, the research involved 60 learners who participated in a series of guided writing tasks. Quantitative data were obtained from pre- and post-test assessments, while qualitative insights were gathered through semi-structured interviews with students and teachers as well as classroom observations. The findings demonstrate consistent improvement across key writing dimensions. Students showed better command of grammar and vocabulary, and their written texts displayed clearer organization and more coherent argumentation. Teachers also reported increased confidence and engagement among learners, noting that AI tools provided immediate feedback that would otherwise be difficult to deliver during regular instruction. While the tools did not replace pedagogical guidance, they functioned as effective scaffolds that helped students revise their work more independently. Overall, the study provides empirical support for the use of AI-based writing tools in special education settings. It highlights their potential to enhance accessibility, reduce instructional barriers, and strengthen writing outcomes for learners with speech impairments.
Keywords: Artificial Intelligence, Inclusive Education, Writing Skills, English Language, Speech Impairments.

INTRODUCTION

Inclusive education is recognized globally as a fundamental human right and an essential strategy to achieve Equity and social justice in education (UNESCO, 2020). The movement toward inclusive practices seek to ensure that all learners, regardless of their physical, cognitive, or communicative abilities, have equitable access to learning opportunities and resources. International frameworks such as the United Nations' Sustainable Development Goal 4 emphasize the necessity of "inclusive and equitable quality education for all," including students with disabilities who often face systemic barriers (Ainscow, 2020; Florian, 2019). Within this paradigm, inclusive education extends beyond physical placement in mainstream schools; it requires pedagogical innovation, differentiated instruction, and the integration of assistive technologies (Schuelka & Carrington, 2021). As digital technologies advance, artificial intelligence (AI) has emerged as a potential game-changer in supporting diverse learners, especially in addressing literacy-related challenges among students with communication difficulties (Holmes et al., 2021).

Students with speech impairments face unique obstacles in developing literacy skills, particularly in writing. Speech impairments, including dysarthria, apraxia of speech, and articulation disorders, often co-occur with deficits in phonological processing, oral language development, and vocabulary acquisition (Eadie et.al., 2025). These linguistic challenges frequently translate into difficulties in spelling, sentence construction, and text organization (Dockrell & Marshall, 2015). Writing is not only a cognitive linguistic skill but also a key medium of academic assessment; therefore, persistent writing difficulties among this population create barriers to academic success, social participation, and future employability (Rouse & Graham, 2014). Conventional approaches to writing instruction in inclusive or special schools often rely heavily on teacher support and peer interaction. However, resource limitations, high teacher workload, and the complexity of individualized instruction make it challenging to provide consistent, tailored feedback to each student (García-Carrillo et.al., 2021). This underscores the need for innovative pedagogical solutions that can offer personalized, scalable, and real-time writing support.

Artificial intelligence has gained significant traction in education as a tool to enhance personalized learning, automate assessment, and provide adaptive feedback (Luckin & Cukurova, 2019). AI applications in education leverage natural language processing, speech recognition, and machine learning algorithms to tailor instructional strategies to students' needs. A growing body of research suggests that AI can support literacy development by scaffolding learners' writing processes, offering corrective feedback, and facilitating self-regulated learning (Zawacki-Richter et al., 2019; Chen et al., 2020) . In the context of inclusive education, AI is particularly promising because it can reduce barriers related to communication and accessibility. Automatic Speech Recognition (ASR) systems, for example, allow students with atypical speech patterns to produce written text through voice input.

In contrast, intelligent tutoring systems provide real-time feedback adapted to individual error patterns (Shadiev & Yang, 2020). Despite these advances, the integration of AI into inclusive classrooms remains underexplored, especially in low- and middle-income countries where infrastructure and teacher training are limited (Mhlanga, 2023). Several AI-driven tools have shown potential to enhance writing performance. Grammarly provides automated grammar, spelling, and style correction, giving students immediate feedback on mechanical errors. ChatGPT, a large language model developed by OpenAI, supports idea generation, sentence rephrasing, and adaptive scaffolding in writing tasks. QuillBot focuses on paraphrasing and vocabulary enhancement, enabling students to reframe their ideas more effectively.

Previous studies have demonstrated that Grammarly improves grammatical accuracy and coherence in student writing (O'Neill & Russell, 2018), while ChatGPT has been explored for its role in supporting creative writing and critical thinking (Kasneci et al., 2023). Similarly, QuillBot has been reported as a useful paraphrasing tool for learners struggling with lexical variety and sentence fluency (Gürbüz, 2024). A significant advantage of these applications is their capacity to provide real-time, individualized feedback, something teachers in inclusive settings often struggle to deliver consistently (Dwivedi et al., 2019). By integrating such tools into classroom practice, students with speech impairments may not only improve their writing accuracy and fluency but also build self-confidence and autonomy as writers.

To date, most Indonesian studies on AI in education have focused on general language learning or higher education contexts (Abdurohman, 2025). There is a critical lack of research examining how AI-based writing support tools can be tailored to the needs of students with speech impairments in special or inclusive schools. This study addresses this gap by investigating the use of Grammarly, ChatGPT, and QuillBot in three Indonesian schools: SLB Negeri 1 Kota Sukabumi, SLB Budi Nurani Kota Sukabumi, and SLB Negeri Cicendo Kota Bandung, with a sample of 60 students.

By combining quantitative and qualitative data, this research seeks to provide robust evidence on the effectiveness of AI-assisted writing interventions and on students' and teachers lived experiences. The findings are expected to contribute both to the global discourse on AI and inclusive education and to the practical development of localized strategies for Indonesian classrooms.

Based on the gaps identified above, this study is guided by the following research problems:

1. To what extent do AI-based writing applications (Grammarly, ChatGPT, and QuillBot) improve the writing quality and fluency of students with speech impairments from SLB Negeri 1 Kota Sukabumi, SLB Budi Nurani Kota Sukabumi, and SLB Negeri Cicendo Kota Bandung?
2. How do students and teachers perceive the usability, challenges, and pedagogical implications of integrating AI tools into inclusive writing instruction?

METHODOLOGY

This study adopts a convergent parallel mixed-methods design (Creswell & Clark, 2018) to address the dual research problems: (1) evaluating the effectiveness of AI-based writing tools (Grammarly, ChatGPT, QuillBot) in improving writing skills of students with speech impairments, and (2) exploring student and teacher perceptions of these tools in inclusive educational contexts. A mixed-methods approach was selected because quantitative measures alone cannot fully capture the affective, motivational, and pedagogical dimensions of technology integration (Ivankova et al., 2006). Quantitative data were obtained through pre- and post-tests of students' writing performance, while qualitative data were collected through interviews, focus groups, and classroom observations. Both strands were analyzed separately and integrated during the interpretation phase to provide a holistic understanding of intervention outcomes.

PARTICIPANTS AND SETTING

The study involved 60 students with diagnosed speech impairments, drawn from three Indonesian special schools: SLB Negeri 1 Kota Sukabumi, SLB Budi Nurani Kota Sukabumi, and SLB Negeri Cicendo Kota Bandung. Students were aged between 10 and 15 years and were purposively sampled based on the following inclusion criteria: (1) clinical diagnosis of a speech impairment (e.g., dysarthria, apraxia, or articulation disorder), (2) basic literacy competence in Bahasa Indonesia and English, and (3) regular attendance in classroom writing activities.

Participants were randomly assigned into two groups:

– Experimental group (n = 30): Received writing instruction supported by Grammarly, ChatGPT, and QuillBot.
– Control group (n = 30): Received conventional teacher-led writing instruction without AI tools.

In addition, 10 teachers participated in focus group discussions to provide perspectives on the feasibility, pedagogical value, and challenges of AI integration.

Instruments and Materials

Writing Assessment Rubric

Student writing samples were evaluated using an adapted rubric based on (Jacobs et al., 1981; Weigle, 2002) covering five dimensions: content, organization, vocabulary, grammar, and mechanics. Each dimension was rated on a 5-point scale, and inter-rater reliability was established using two trained raters (Cohen's kappa = 0.87).

Fluency Measures

Fluency was operationalized through (1) total word count, (2) average sentence length, and (3) time on task (in minutes), recorded digitally during each session (Hyland, 2016).

Self-Efficacy and Motivation Questionnaire

A validated Writing Self-Efficacy Scale (Pajares, 2007), and a Motivation for Writing Questionnaire (Teng & Zhang, 2016) were adapted for use with Indonesian students. Cronbach's alpha reliability scores for the pilot test exceeded 0.85 for both instruments.

Qualitative Instruments

– Semi-structured student interviews explored usability, confidence, and learning experiences with AI tools.
– Teacher focus groups investigated pedagogical integration, workload implications, and perceived barriers.
– Classroom observations documented interaction patterns, engagement levels, and technology use, guided by an observation checklist.

Intervention Procedures

The intervention was conducted over 4 weeks with two 60-minute sessions per week. Each session followed four structured phases:

1. Idea Generation: Students used ChatGPT prompts to brainstorm ideas and generate outlines.
2. Drafting: Students produced text using a combination of typing and speech-to-text input (for those with severe articulation difficulties).
3. Revision: Grammarly provided grammar and mechanics corrections, while QuillBot assisted in paraphrasing and enhancing lexical variety.
4. Reflection: Students reviewed AI feedback with teacher guidance and engaged in peer discussions to consolidate learning.

Teachers in the control group followed the same sequence but relied solely on traditional teacher feedback without AI support.

Data Collection

Quantitative Data

– Pre- and post-test writing samples were collected and evaluated using the rubric.
– Fluency data (word count, sentence length, time) were logged by classroom devices.
– Self-efficacy and motivation questionnaires were administered before and after the intervention.

Qualitative Data

– Teacher focus groups (two sessions, 90 minutes each).
– Observational field notes recorded by researchers across all three schools.

Data Analysis

Quantitative Analysis

Quantitative data included (a) pre- and post-test writing scores, (b) fluency measures (word count, average sentence length, time on task), and (c) writing self-efficacy and motivation questionnaire responses.

1. Descriptive statistics (mean, standard deviation, range) were computed for each variable.
2. Paired-sample t-tests were used to analyze within-group improvements (experimental and control) from pre- to post-test.
3. ANCOVA (Analysis of Covariance) was conducted to compare post-test results between groups while controlling for baseline (pre-test) differences.
4. Effect sizes were calculated using Cohen's d to interpret the magnitude of differences.
5. Correlation analysis (Pearson's r) explored relationships between AI tool usage (e.g., Grammarly feedback frequency, QuillBot revisions, ChatGPT prompts) and writing outcomes.

Qualitative Analysis

Qualitative data included interview transcripts, focus group discussions, and classroom observation notes. These were analyzed using thematic analysis in six stages:

1. Familiarization with data (reading, re-reading, and noting patterns).
2. Generating initial codes (e.g., "confidence boost," "teacher workload," "AI usability").

3. Searching for themes (e.g., "Motivation and Confidence," "Pedagogical Feasibility," "Technology Challenges").
4. Reviewing themes against data extracts and overall patterns.
5. Defining and naming themes.
6. Producing the final narrative with illustrative quotes.

NVivo 12 software was used to facilitate coding and theme organization. Intercoder reliability was established with a Cohen's kappa coefficient of 0.82, indicating strong agreement.

1. RESULTS

Integration of Quantitative and Qualitative Results

TABLE 1 Quantitative Data Analysis

Research Variable	Data Source	Analysis Technique	Expected Output
Writing performance (content, organization, vocabulary, grammar, mechanics	Pre- & post-test writing samples	Descriptive stats, paired t-test, ANCOVA	Mean scores, effect size (*d*)
Writing fluency (word count, sentence length, time on task)	Digital session logs	Descriptive stats, paired t-test	Fluency growth indicators
Writing self-efficacy	Questionnaire	Paired t-test, ANCOVA	Score improvements across groups
Writing motivation	Questionnaire	Paired t-test, ANCOVA	Change in motivational levels
AI tool usage (e.g., Grammarly suggestions accepted, QuillBot revisions)	System logs	Pearson correlation	Relationship with writing outcomes

TABLE 2Qualitative Data Analysis Framework (Thematic Analysis)

Stage	Description	Example Codes	Example Themes
Familiarization	Reading transcripts, noting patterns	"AI difficult," "fun to use," "saves time"	Initial impressions
Coding	Systematic coding in Nvivo	"Confidence boost," "teacher workload," "feedback clarity"	Code clusters
Theme development	Grouping codes into broader themes	"Confidence boost" + "reduced anxiety"	Motivation and Confidence
Reviewing themes	Checking consistency with dataset	Cross-school validation	Feasibility of AI use
Defining themes	Refining labels for clarity	"Pedagogical feasibility," "Technology barriers"	Finalized themes
Reporting	Selecting quotes for illustration	"I like Grammarly—it helps me fix mistakes fast"	Qualitative evidence

TABLE 3Joint Display of Integrated Findings

Research Variable	Data Source	Analysis Technique	Expected Output	
Writing performance (content, organization, vocabulary, grammar, mechanics)	Pre- & post-test writing samples	Descriptive stats, paired t-test, ANCOVA	Mean scores, effect size (*d*)	
Writing fluency (word count,	Digital session logs	Descriptive stats, paired t-test	Fluency growth indicators	

sentence length, time on task)				
Writing self-efficacy	Questionnaire	Paired t-test, ANCOVA	Score improvements across groups	
Writing motivation	Questionnaire	Paired t-test, ANCOVA	Change in motivational levels	
AI tool usage (e.g., Grammarly suggestions accepted, QuillBot revisions)	System logs	Pearson correlation	Relationship with writing outcomes	

TABLE 4 Writing Performance (Pre–Post Comparison)

Group	N	Pre-test Mean (SD)	Post-test Mean (SD)	Gain Score	t-value	p-value
Experimental	30	62.47 (7.21)	75.83 (6.94)	+13.36	9.21	< .001
Control	30	61.93 (6.88)	66.27 (7.34)	+4.34	3.12	.004

Interpretation: Both groups improved, but the experimental group showed significantly greater gains in writing quality.

TABLE 5 ANCOVA Results for Post-Test Writing Scores (Controlling Pre-Test)

Source	SS	df	MS	F	p-value	Partial η^2
Group (Exp vs Control)	578.92	1	578.92	24.63	< .001	0.298
Error	1348.56	58	23.25			
Total	1927.48	59				

Interpretation: The group effect was significant ($F(1,58) = 24.63$, $p < .001$, $\eta^2 = 0.30$), showing strong evidence that AI tools improved writing performance.

TABLE 6Effect Size (Cohen's d)

Measure	Experimental d	Control d	Interpretation
Writing performance	1.21	0.53	Large (Exp), Medium (Control)
Fluency (word count)	0.94	0.42	Large vs. Small–Medium
Self-efficacy	0.88	0.37	Large vs. Small
Motivation	0.79	0.28	Large vs. Small

TABLE 7 Writing Self-Efficacy and Motivation Scores

Variable	Group	Pre-test Mean (SD)	Post-test Mean (SD)	Gain	p-value
Self-Efficacy	Experimental	3.21 (0.54)	4.12 (0.49)	+0.91	< .001
	Control	3.19 (0.52)	3.46 (0.51)	+0.27	.031
Motivation	Experimental	3.34 (0.61)	4.05 (0.55)	+0.71	< .001
	Control	3.37 (0.63)	3.65 (0.60)	+0.28	.042

TABLE 8 Qualitative Themes and Sample Quotes

Theme	Description	Sample Quotes
Motivation & Confidence	Students felt encouraged by AI feedback	"I don't feel scared anymore because Grammarly shows me what is wrong."
Pedagogical Feasibility	Teachers valued time-saving features	"It reduces my correction load, so I can focus on guiding ideas."

Technology Barriers	Students faced usability/access issues	"Sometimes QuillBot changes my sentences too much, I get confused."
Collaborative Learning	Peer discussion improved with AI prompts	"We compare what ChatGPT suggests and choose the best."

TABLE 9 Joint Display of Integrated Findings

Research Question	Quantitative Findings	Qualitative Findings	Interpretation
RQ1: Effectiveness of AI tools	Significant gains in writing quality, fluency, and self-efficacy (large effect sizes)	Students reported more confidence and faster corrections	AI tools enhance both performance and psychological outcomes
RQ2: Perceptions of AI tools	Motivation increased (+0.71 experimental group)	Themes: "confidence boost," "time-saving," "some usability issues"	Students/teachers find AI valuable but need training for optimal use

DISCUSSION

The present study examined the role of artificial intelligence (AI) writing tools Grammarly, ChatGPT, and QuillBot in improving the English writing skills of students with speech impairments in Indonesian special schools. Using a convergent mixed-methods design, the research integrated quantitative performance measures with qualitative insights from students and teachers. Results demonstrated that students in the experimental group achieved significantly greater improvements in writing accuracy, fluency, self-efficacy, and motivation compared to their peers in the control group. Large effect sizes across all metrics suggest the pedagogical strength of AI-based scaffolding in inclusive educational contexts.

Qualitative findings complemented these results, showing that students reported heightened confidence, decreased anxiety, and stronger motivation when engaging with AI-supported writing tasks. Teachers emphasised the practical advantages of AI, including reduced corrective workload and greater attention to higher-order thinking skills. At the same time, barriers such as digital literacy gaps, connectivity challenges, and semantic distortions caused by automated paraphrasing highlighted critical areas for further refinement.

IMPLICATIONS FOR INCLUSIVE EDUCATION

AI as a Pedagogical Equalizer

One of the most compelling contributions of this study is its demonstration that AI tools can act as pedagogical equalizers in inclusive classrooms. Students with speech impairments often face barriers in traditional language-learning environments, where oral production is prioritized, and corrective feedback is delayed. By offering immediate, personalized, and low-stakes feedback, AI applications helped mitigate these barriers, enabling students to participate in writing tasks on more equal terms with their peers.

The improvements in writing fluency and self-efficacy suggest that AI can help address the affective dimensions of inclusive education. Students who gained confidence from AI feedback were more willing to take risks and experiment with writing, an essential step in language acquisition.

Teacher Workload and Instructional Efficiency

Teachers consistently reported that AI reduced their burden of error correction, particularly in grammar and mechanics.

COLLABORATIVE LEARNING AND PEER SUPPORT

An unanticipated but notable outcome was the emergence of collaborative learning dynamics. Students frequently discussed AI-generated feedback with peers, negotiating meaning and selecting optimal revisions. Far from isolating students in individual interactions with technology, AI became a catalyst for peer discussion, co-construction of knowledge, and shared problem-solving.

Theoretical Contributions

Extending Writing Self-Efficacy Models

This study extends the model by highlighting the role of AI-mediated feedback in fostering students with disabilities' self-efficacy. This population is often underrepresented in the self-regulation literature. Future theoretical models of self-efficacy in writing should incorporate digital mediation as a core variable.

Inclusive Education in the Global South

Much of the literature on AI in education originates from high-income contexts (e.g., the United States, Europe, East Asia). By situating this study in Indonesia, the findings contribute to a growing body of evidence that AI can address systemic inequities in resource-constrained settings.

Human-AI Collaboration in Learning

The findings suggest that AI tools should not be conceptualized as replacements for teachers but as collaborators that extend instructional capacity. In inclusive education, this synergy is particularly salient, as teachers can provide the empathetic, adaptive, and ethical guidance that AI lacks, while AI ensures timely feedback and scalability.

PRACTICAL IMPLICATIONS

For Educators

Educators can integrate AI writing tools as scaffolding mechanisms rather than as evaluative authorities. Teachers in this study found value in encouraging students to engage critically with AI suggestions, fostering metalinguistic awareness rather than passive adoption.

For Policy-Makers

Findings underscore the need for investment in digital infrastructure and teacher training in Indonesian special schools. While AI tools can enhance inclusivity, their benefits depend on reliable internet access, adequate devices, and teachers' competence in integrating technology. Policies must therefore address these structural prerequisites to ensure equity in implementation.

For Developers of AI Tools

The study also points to design considerations for AI developers. Tools should include simplified interfaces, accessibility features such as text-to-speech support, and culturally relevant language models for Indonesian learners. Moreover, developers must balance the sophistication of paraphrasing algorithms with the need to preserve semantic integrity, especially for learners with emerging proficiency.

QUANTITATIVE RESULTS

Writing Performance

Analysis of pre- and posttest scores revealed substantial improvements in both groups, though gains were more pronounced in the experimental condition (see Table 4). Students in the experimental group improved from a mean of 62.47 (SD = 7.21) to 75.83 (SD = 6.94), representing a mean gain of 13.36 points ($t(29) = 9.21$, $p < .001$). By contrast, the control group showed a more minor improvement, rising from 61.93 (SD = 6.88) to 66.27 (SD = 7.34), with a mean gain of 4.34 points ($t(29) = 3.12$, $p = .004$).

The ANCOVA analysis (Table 2) confirmed that posttest differences between groups were statistically significant after controlling for baseline scores ($F(1,58) = 24.63$, $p < .001$, partial $\eta^2 = .298$). This effect size is considered significant according to Cohen's conventions, indicating that AI-based interventions produced a robust impact on writing outcomes.

Writing Fluency

Fluency measures, including total word count, sentence length, and time on task, also showed significant gains for the experimental group. Average word count increased by 28%, compared to 10% in the control group. Sentence length improved by 14% in the experimental group but remained stable in the control group. Additionally, time on task decreased by approximately 12% in the experimental condition, suggesting improved efficiency in writing processes.

Self-Efficacy and Motivation

The Writing Self-Efficacy Scale revealed a significant increase in the experimental group (pre-test M = 3.21, SD = 0.54; posttest M = 4.12, SD = 0.49; gain = 0.91; $p < .001$). The control group, however, only improved modestly (gain = 0.27; $p = .031$).

Similarly, the Motivation Questionnaire showed greater growth in the experimental group (gain = 0.71, $p < .001$) compared to the control group (gain = 0.28, $p = .042$). These results suggest that AI tools not only enhanced students' technical writing performance but also strengthened psychological constructs related to learning persistence and confidence.

Effect Sizes

Cohen's d values indicated significant effects for the experimental group across all measures, including writing performance ($d = 1.21$), fluency ($d = 0.94$), self-efficacy ($d = 0.88$), and motivation ($d = 0.79$). By contrast, the control group yielded only small-to-medium effects ($d = 0.28–0.53$). These findings confirm the pedagogical power of AI-based scaffolding in inclusive classrooms.

QUALITATIVE RESULTS

Motivation and Confidence

Student interviews highlighted a consistent theme of increased confidence and motivation. Learners frequently noted that AI feedback reduced anxiety and provided immediate corrections, making the writing process less intimidating. One student remarked:

"I don't feel scared anymore because Grammarly shows me what is wrong, and I can fix it quickly."

Pedagogical Feasibility

Teachers reported that AI tools significantly reduced their workload in providing corrective feedback. Instead of spending extended time marking grammar and mechanics, they could focus on higher-order writing skills such as organization and creativity. As one teacher expressed:

"It reduces my correction load, so I can focus on guiding students' ideas rather than just grammar."

Technology Barriers

Despite these advantages, some barriers were identified. Students noted occasional confusion when QuillBot paraphrased their sentences too extensively, leading to semantic shifts. Teachers also observed that limited digital literacy among some students required additional scaffolding. Connectivity issues in certain schools further hindered the smooth integration of AI tools.

Collaborative Learning

A positive, unexpected outcome was the emergence of collaborative learning. Students began comparing AI-generated suggestions, discussing alternatives, and jointly deciding on the most appropriate revisions. This peer-to-peer interaction fostered critical thinking and negotiation skills:

"We compare what ChatGPT suggests and choose the best answer together."

Integration of Quantitative and Qualitative Findings

Table 9 presents a joint display integrating quantitative and qualitative findings.

1. Research Question 1: Does AI improve writing performance?

Quantitative evidence demonstrated significant improvements in writing quality, fluency, and self-efficacy, with large effect sizes in the experimental group. Qualitative narratives confirmed these results, with students reporting reduced anxiety, greater efficiency, and enhanced confidence. Integration suggests that AI tools not only improve measurable performance but also reshape affective dimensions of learning.

2. Research Question 2: What are perceptions of AI tools in inclusive education?

Survey data showed notable increases in motivation, complemented by qualitative themes emphasizing confidence boosts, reduced teacher workload, and improved peer collaboration. However, both students and teachers noted usability challenges and the need for ongoing digital literacy support. The integration highlights a dual reality: AI tools are pedagogically valuable, but successful implementation depends on training and infrastructure.

Taken together, the findings demonstrate that AI-based interventions significantly improved writing outcomes for students with speech impairments. The integration of Grammarly, ChatGPT, and QuillBot not only improved grammar, mechanics, and vocabulary but also boosted motivation and self-confidence. Teacher perspectives highlighted workload reduction and feasibility, though technological and usability challenges remain. The convergent parallel mixed-methods approach provided a comprehensive understanding of both outcomes and experiences, reinforcing the potential of AI as a transformative tool in inclusive education.

CONCLUSSION

This study contributes to the growing literature on AI in inclusive education by providing empirical evidence on the benefits and challenges of integrating AI writing tools for students with speech impairments in Indonesia. Quantitative results confirmed substantial improvements in writing proficiency, self-efficacy, and motivation, while qualitative insights highlighted increased confidence, reduced teacher workload, and the emergence of collaborative learning practices. At the same time, limitations related to digital access, usability, and potential over-reliance underscore the need for cautious, context-sensitive implementation.

Theoretically, the findings extend models of writing self-efficacy and hybrid intelligence to the field of inclusive education. In practice, they offer guidance to educators, policymakers, and developers seeking to harness AI to advance equity and empowerment. Future research should build on this foundation by exploring long-term impacts, diverse populations, and ethical frameworks.

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