

Digital Transformation of Malay Language Services: AI Models, Usability, and Educational Impact

Mariahnie Mairan¹, Mohd Noor Fazli Mamat², Johari Mat³, Azrul Fazwan Kharuddin⁴,
Surendran Elangoven⁵

¹ Bahagian Sistem Maklumat, Dewan Bahasa dan Pustaka, Malaysia.

Email: mariahnie@dbp.gov.my

² Human Capital Development Division, Public Service Department of Malaysia, Malaysia.

³ Universiti Tun Abdul Razak, Malaysia.

Email: johari.mat@unirazak.edu.my

⁴ Universiti Tun Abdul Razak, Malaysia.

Email: azrul.fazwan@ur.unirazak.edu.my

⁵ Intelli Education Group Sdn Bhd (IEG Campus), Malaysia..

Abstract

The rapid advancement of artificial intelligence (AI) presents significant opportunities for enhancing national language governance, literacy, and educational inclusivity. This study examines *Bahasa Buddy*, an AI-powered platform developed by *Dewan Bahasa dan Pustaka* (DBP) under Malaysia's Ministry of Education, designed to automate Malay language verification, provide real-time feedback, and support language planners. Prior research underscores the potential of AI to improve literacy, contextual grammar correction, and language learning outcomes, particularly for low-resource languages like Malay. Employing a mixed-method research design, the study integrated quantitative evaluation of system performance metrics (accuracy, precision, recall, F1-score) with qualitative assessments of user experience, including surveys and interviews among 120 participants representing planners, educators, and general users. Results indicate that the hybrid AI models achieved a maximum accuracy of 94.2% and an F1-score of 93.2%, while users reported high satisfaction with system usability and response speed. Operational efficiency improved significantly, with AI-assisted processing reducing average verification time by 76.6% compared to manual procedures. These findings demonstrate that *Bahasa Buddy* not only enhances language quality and accessibility but also aligns with SDG 4: Quality Education by supporting inclusive, equitable, and efficient language services. The study concludes that AI-driven language platforms can serve as scalable tools for digital linguistic governance, educational support, and national language promotion. Recommendations include expanding domain-specific lexicons, integrating regional dialects, and embedding the platform within formal and informal educational contexts to maximize reach and sustainability....

Keywords: Bahasa Buddy, artificial intelligence, Malay language, hybrid models, automated proofreading.

INTRODUCTION

In an era marked by rapid digitalisation and the pervasive influence of artificial intelligence (AI), linguistic institutions worldwide face unprecedented opportunities and challenges in preserving and advancing national languages. In Malaysia, *Dewan Bahasa dan Pustaka* (DBP) a government agency under the Ministry of Education Malaysia has historically held a central role in regulating, developing, and promoting Bahasa Melayu as the country's national language and primary medium of communication, literature, and education. The agency is responsible for language standardisation, publication of dictionaries, glossaries, and literary works, and it also administers advisory and verification services for Malay language usage in official and public domains. Through its extensive reference portals and advisory services, DBP works to ensure linguistic consistency, cultural relevance, and compliance with national language policies and norms.

Despite DBP's longstanding contributions to Malay language governance, the increasing complexity of linguistic demands in digital content production has highlighted significant challenges. Traditional manual procedures for text verification, proofing, and advisory services are time-intensive and resource-heavy. With daily submissions for language review and certification ranging from educational materials to public signage and promotional content the existing workflow often cannot keep pace with the volume and velocity of contemporary language use in both online and offline contexts. Additionally, the prevalence of mixed language usage (*bahasa rojak*),

borrowings from English and other languages, rapid informal digital communication trends, and evolving linguistic norms have strained conventional approaches to maintaining linguistic purity and standardisation. These multifaceted pressures have underscored the need for innovative solutions that can uphold DBP's mission while adapting to a data-rich and fast-moving linguistic ecosystem.

The transformative potential of AI offers a promising avenue to reimagine language service delivery and governance. Research and sector dialogues within DBP and broader academic communities recognize that AI-driven tools including natural language processing (NLP), machine learning classifiers, and optical character recognition (OCR) can augment human expertise by automating repetitive tasks, providing real-time feedback, and extracting insights from large corpora of text and imagery. Integrating AI into language platforms not only accelerates the review and correction process but could also generate data-driven understandings of common language usage patterns, error types, and stylistic trends. However, while AI presents technical advantages, adapting these technologies to a culturally nuanced and structurally complex language like Malay raises methodological challenges around model training, contextual understanding, and the preservation of linguistic authenticity. Moreover, the integration of AI into an institutional context such as DBP demands careful alignment with organisational goals, stakeholder expectations, and ethical considerations relating to language authority and user trust.

Given these emerging dynamics, there is a clear imperative to investigate how AI can be operationalised within the framework of national language governance to enhance efficiency, accessibility, and quality of language services. The AI-Powered Language and Literature Platform: *Bahasa Buddy* initiative represents a strategic response to these challenges by introducing an integrated AI tool designed for automated text verification, real-time correction, user engagement, and analytic reporting. This research seeks to advance foundational knowledge on the development, deployment, and impact of such a platform in supporting DBP's mission while addressing the growing demands of Malay language users across educational, governmental, and public domains. The purpose of this study is to explore the design, implementation, and efficacy of the Bahasa Buddy platform as an AI-enhanced solution for automating language services, improving user experience, supporting language planners, and enabling data-driven insights that contribute to the advancement of Malay language quality and accessibility.

Literature Review

Research on AI-enhanced language processing and automated linguistic services has grown substantially in recent years, spanning natural language processing (NLP), machine learning for text correction, and AI-supported literacy education. A number of studies have focused on the application of AI technologies in Malay language contexts, illustrating both the potential and the challenges of integrating computational models with national discourse and educational goals. For example, research investigating AI application in Malay language learning demonstrated that AI tools can scaffold learners' sentence structuring, grammar correction, and vocabulary development, especially among unique learner populations such as students with hearing impairments, which resulted in improved written Malay performance following AI-assisted interventions. These findings suggest that AI systems can serve as cognitive and linguistic support structures that enhance language accuracy and learner autonomy in Malay contexts. Similarly, broader studies on AI in Malay literacy reported that NLP and automatic speech recognition technologies offer real-time feedback and personalised learning opportunities, significantly supporting foundational language skills like reading and writing, albeit with challenges related to infrastructure and linguistic complexity.

Beyond education, computational linguistics research has also addressed text classification, error detection, and low-resource language modelling, which are conceptually closely related to systems like Bahasa Buddy that automate language verification. A recent hybrid model study for low-resource languages such as Malay showed that combining rule-based linguistic features with transfer learning approaches (e.g., transformer-based architectures) can improve text classification outcomes, underlining the viability of hybrid AI models in handling complex language tasks where data scarcity is an issue. Moreover, research exploring the use of contextual language models such as BERT (Bidirectional Encoder Representations from Transformers) for misspelling correction and contextual understanding has demonstrated that pretrained deep neural models, when integrated

with algorithms like edit distance, can effectively perform contextual error correction, highlighting practical strategies for automated proofing processes.

The theoretical underpinning of AI-powered language platforms rests on foundational principles from NLP, machine learning, and cognitive computing. NLP provides the core computational structure for processing human language, including tokenisation, part-of-speech tagging, syntactic parsing, and semantic embedding. Systems such as transformer-based models (e.g., BERT) leverage contextualised embeddings, which allow a computational model to interpret meaning not just at the word level but within larger syntactic and semantic contexts a critical capability for tasks such as grammar correction, semantic verification, and stylistic refinement. Sequence-to-sequence models and hybrid approaches, which combine traditional statistical learning (e.g., Naive Bayes, Random Forest, XGBoost) with deep contextual models, have been shown to improve accuracy and robustness in language tasks, especially for languages with limited labelled data like Malay. Additionally, Optical Character Recognition (OCR) technologies a key part of automated image-to-text workflows are grounded in pattern recognition and convolutional neural networks (CNNs), enabling extraction of textual data from scanned or photographed sources for further linguistic analysis.

Conceptually, the integration of AI in language services embodies a socio-technical framework where computational efficiency and linguistic authority intersect. Platforms like Bahasa Buddy do not merely automate correction but also mediate between user language practices and institutional standards, generating analytics that reveal error patterns, common usage trends, and potential policy insights. Through dashboards and feedback loops, such systems convert raw linguistic interaction into actionable insights that support both end-users and language planners, aligning with models of human-in-the-loop AI, where automated processes augment rather than replace expert judgement.

In summary, existing research confirms that AI technologies from contextual language models to hybrid NLP systems are both theoretically and empirically suitable for enhancing language verification and learning services. These studies provide substantive justification for investigating platforms like Bahasa Buddy, which synthesise multiple AI methodologies to address practical and institutional language challenges in Malay contexts.

Research Methodology

The methodology of this study adopts a mixed-method research design that integrates quantitative and qualitative elements to comprehensively examine the development, deployment, and evaluation of the *AI-Powered Language and Literature Platform: Bahasa Buddy*. Mixed-method designs are particularly appropriate for research that involves both technological system analysis and user experience evaluation, as they enable the triangulation of computational performance metrics with human perceptions and contextual data (Creswell & Creswell, 2018). This approach allows the study to capture the dual dimensions of AI performance assessment and stakeholder engagement, reinforcing the validity and reliability of findings (Creswell & Plano Clark, 2017).

The research design is structured into four key components: *research procedure*, *sampling and data collection*, *data analysis*, and *ethical considerations*. First, the research procedure follows a systematic workflow spanning model development, system deployment, user testing, and analytical evaluation. At the outset, AI models including NLP classifiers, sequence-to-sequence grammar correction modules, and hybrid architectures are developed and trained using annotated Malay language corpora and synthetic datasets. Preprocessing techniques such as tokenisation, normalization, and n-gram feature extraction are applied to ensure data consistency before modelling (Jurafsky & Martin, 2021). For OCR integration, convolutional neural networks (CNNs) are employed to extract text from image-based sources using Tesseract and Google Vision APIs, which are benchmarked to assess extraction accuracy and error rates.

To evaluate system performance and usability, the study implements both controlled testing and field deployment phases. Controlled testing involves benchmark datasets with known linguistic errors to determine model accuracy, precision, recall, and F-score common metrics used in computational linguistics research (Manning, Raghavan, & Schütze, 2008). For example:

$$\text{Precision} = \frac{TP}{TP + FP}, \quad \text{Recall} = \frac{TP}{TP + FN}, \quad F1 = 2 \cdot \frac{\text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}}$$

where TP is true positives, FP is false positives, and FN is false negatives. These formulae provide robust measures of the model's ability to correctly identify and correct linguistic errors. Beyond performance metrics, field deployment is conducted with actual users including language planners and general public contributors to gather usability data, task completion times, subjective satisfaction scores, and qualitative feedback (Kharuddin & Ismail, 2017).

Sampling and Data Collection employ purposeful and convenience sampling to select participants for the user evaluation phase. Purposeful sampling ensures that participants have relevant experience or interest in Malay language services, a strategy widely used in educational and language technology research (see qualitative studies in language and AI integration). A sample size of at least 100 participants is targeted to ensure statistical power for quantitative surveys, while 15–20 participants are selected for in-depth interviews and focus groups. Data collection methods include structured questionnaires, pre- and post-usage performance tests, think-aloud protocols during task performance, and semi-structured interviews with language planners. Surveys incorporate Likert-scale items to quantify user perceptions on system utility, ease of use, and overall satisfaction.

Data Analysis is bifurcated into quantitative and qualitative streams. Quantitative data from system metrics and user surveys are analysed using descriptive statistics (means, standard deviations) and inferential techniques (ANOVA and regression) to identify performance differentials across user groups and usage contexts. For qualitative data, thematic analysis is employed to capture patterns and insights from interview transcripts and open-ended responses, supported by coding frameworks that highlight emergent themes related to AI trust, perceived usefulness, and cognitive workload (Braun & Clarke, 2006). NVivo or similar qualitative analysis software assists in managing and visualising coded data, thereby ensuring systematic interpretation.

Throughout all stages, ethical principles are upheld, including informed consent, anonymity, and secure data handling, consistent with research guidelines for studies involving human participants (Creswell & Creswell, 2018). By combining computational evaluation with human-centred insights, this methodology provides a comprehensive and rigorous foundation for assessing Bahasa Buddy's impact on language verification processes and user experience, offering replicable evidence for policymakers and stakeholders in language technology and governance.

Data Analysis, Results, and Findings

The primary objective of the study was to evaluate the efficacy, accuracy, and user acceptance of the *Bahasa Buddy* AI-powered language platform. Data analysis focused on three dimensions: system performance metrics, user satisfaction and usability, and operational efficiency in language verification tasks. Quantitative data from system logs and user surveys were statistically analysed using descriptive and inferential methods, while qualitative feedback from open-ended survey questions provided contextual insight. All analyses were conducted using Python (Pandas, NumPy, and SciPy) and SPSS for validation purposes.

System Performance Analysis

System performance was assessed through standard metrics in natural language processing, including accuracy, precision, recall, and F1-score. The AI models incorporated hybrid NLP approaches combining BERT-based contextual embeddings, sequence-to-sequence grammar correction, and traditional machine learning classifiers (Naive Bayes, Random Forest, XGBoost). The evaluation dataset consisted of 2,000 Malay-language sentences containing typographical errors, grammatical inconsistencies, and syntactic variations.

Table 1: System Performance Metrics

Model Type	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
BERT-only	92.5	91.8	90.6	91.2
Naive Bayes + BERT	88.4	87.2	86.1	86.6
Random Forest + BERT	90.1	89.5	88.3	88.9
XGBoost + BERT	91.3	90.7	89.9	90.3
Hybrid Ensemble (All)	94.2	93.8	92.7	93.2

The hybrid ensemble model, which integrates BERT embeddings with multiple classical classifiers, demonstrated the highest overall performance with an accuracy of 94.2% and an F1-score of 93.2%, indicating its superior ability to correctly detect and correct language errors while maintaining contextual relevance. While individual BERT models also performed strongly, the combination with traditional classifiers provided incremental improvements in error coverage, particularly for idiomatic expressions and mixed-language constructs frequently observed in Malay text.

User Satisfaction and Usability

To assess user acceptance and perceived usability, 120 participants comprising language planners, educators, and general users completed a structured survey incorporating a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) across four domains: ease of use, system reliability, response speed, and perceived helpfulness in text correction.

Table 2: User Satisfaction Survey Results (Mean Scores)

Domain	Mean Score	Standard Deviation
Ease of Use	4.52	0.42
System Reliability	4.38	0.51
Response Speed	4.47	0.45
Perceived Helpfulness	4.59	0.37

Survey results indicate that users generally reported high levels of satisfaction, with perceived helpfulness scoring the highest mean value of 4.59, suggesting that Bahasa Buddy effectively supports language verification and correction tasks. Ease of use (4.52) and response speed (4.47) scores further reflect the system's user-centered design, allowing participants to interact intuitively with the platform and receive near-instant feedback. The slightly lower score for system reliability (4.38) highlights areas for continuous refinement, particularly under high-volume submission conditions or complex grammatical structures.

Operational Efficiency in Language Verification

Operational efficiency was evaluated by comparing average processing time per text submission before and after the implementation of Bahasa Buddy. Historical DBP data indicated that manual verification typically required 12–15 minutes per submission, while AI-assisted workflows were measured during simulated deployment across 500 text samples.

Table 3: Average Processing Time per Submission

Workflow Type	Average Time (minutes)	Standard Deviation
Manual Verification	13.7	2.1
AI-Assisted Verification	3.2	0.7

Integration of the AI platform significantly reduced processing time from an average of 13.7 minutes to 3.2 minutes, representing a 76.6% improvement in operational efficiency. This reduction not only alleviates routine workload for language planners but also enables rapid turnaround for public and institutional submissions, enhancing service delivery and aligning with DBP's strategic goal of real-time language assistance.

Qualitative Insights

Open-ended responses highlighted that users valued contextually accurate corrections and the instant feedback mechanism, which reinforced learning and promoted confidence in using Malay in professional and public contexts. Participants suggested future enhancements such as integration with mobile platforms, support for regional dialects, and expanded vocabulary for technical and scientific domains, indicating opportunities for iterative platform improvement.

Discussion and Recommendations

The findings from this study indicate that the *Bahasa Buddy* AI-powered language platform effectively advances the core research objectives namely automation of language services, enhancement of user experience, support

for language planners, and the generation of data-driven insights while aligning with broader Sustainable Development Goals (SDGs), particularly SDG 4: *Quality Education* (UN, 2015) and inclusivity in language access. The performance metrics showed that the hybrid NLP model achieved high precision, recall, and F1-score, affirming the technical feasibility of automated Malaysian language verification and correction. This supports previous studies indicating that hybrid machine learning approaches, combining deep contextual models with classical classifiers, enhance error detection and contextual understanding in low-resource language settings (e.g., hybrid models demonstrated improved outcomes for Malay text classification in computational linguistics research).

From the survey and usability results, *Bahasa Buddy* garnered strong user satisfaction across ease of use, response speed, reliability, and practical helpfulness. Such high acceptance indicates that AI tools can not only enhance workflow efficiency but also empower users with instantaneous feedback and learning support. These outcomes resonate with educational technology research suggesting that AI and digital tools significantly contribute to engagement and learning outcomes, which are core to SDG 4 targets for inclusive and equitable education (e.g., educational technology enhances participation and achievement but also highlights challenges such as the digital divide).

Importantly, the operational efficiency gains demonstrated by the substantial reduction in processing time highlight the potential transformation in institutional language services. Prior to AI integration, manual verification consumed significantly more time, limiting throughput and delaying service delivery; with *Bahasa Buddy*, verifier workload decreases substantially, enabling language planners to focus on complex linguistic judgments rather than routine proofing. This outcome aligns with global perspectives that emphasize the importance of intelligent automation in education and linguistic governance to support quality service provision (e.g., UNESCO's guidance on generative AI and educational transformation).

Linking these results with the SDGs, *Bahasa Buddy*'s contribution can be situated within SDG 4 by enhancing *quality, inclusive, and equitable education* through improved language services. Language is central to learning, communication, and knowledge access; improving automatic language support contributes to equitable information access across educational and professional domains, thereby supporting lifelong learning pathways and broader educational participation (SDG 4.3 and SDG 4.4). Additionally, by enabling multilingual and culturally contextualized digital tools, *Bahasa Buddy* contributes to the spirit of UNESCO's Global Roadmap for Multilingualism in the Digital Era, which highlights language technologies as critical enablers for digital inclusion and sustainable development.

The findings further corroborate related research demonstrating the role of AI in enhancing Malay language literacy and learning. Previous studies reveal that AI technologies like NLP and speech recognition can deliver adaptive, personalized educational experiences that bolster literacy skills among students, particularly in contexts with resource constraints or where language mastery is uneven. *Bahasa Buddy*'s real-time corrections and analytics extend this educational value by serving as a continual learning aid for users beyond formal classroom settings.

Qualitative feedback also highlighted areas for improvement, such as expanding dialectal and domain-specific vocabulary, enhancing user interface integration across platforms (including mobile), and deepening engagement with diverse learner needs. Addressing these areas would not only improve user experience but also advance linguistic inclusivity, particularly for communities with varying proficiencies or underserved linguistic backgrounds.

Conclusion: Overall, the study concludes that *Bahasa Buddy* successfully meets its research objectives by delivering a robust, AI-enhanced language service that improves efficiency, supports user engagement, and aligns with SDG aims of equitable quality education and linguistic inclusion. The platform's performance and user feedback affirm its potential as a scalable model for digital language governance and support. In the context of global linguistic technology discourse which emphasizes mitigating language barriers and promoting multilingualism as crucial for sustainable development *Bahasa Buddy* exemplifies how AI can contribute to both institutional excellence and public empowerment.

Future research and development should focus on expanding the linguistic corpus to include regional dialects and specialised domains (e.g., technical/scientific Malay), improving dialectal nuance modelling, and enhancing accessibility features for diverse user groups. Institutional collaborations with academic and linguistic

communities can further refine contextual correctness and cultural relevance. Additionally, integration with educational curricula and language learning ecosystems could amplify its impact on learner outcomes. Sustained policy support and investment in digital infrastructure are also crucial to bridging any remaining digital or access divides highlighted in the education technology literature, ensuring that the benefits of AI-powered language tools contribute equitably to national and regional development goals...

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