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Culturally Aware and Adapted NLP: Towards Inclusive Language Learning Tools

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Abstract

Background: Natural Language Processing (NLP) has become a core component of digital language learning tools, including AI translators, chatbots, and automated feedback systems. However, most applications are developed in culturally neutral frameworks, neglecting intercultural dimensions of communication. This cultural blind spot often generates bias, leading to misinterpretations, inequities, and reduced inclusivity in language education.
Aim: This study aims to examine cultural biases in NLP-based language learning tools and propose a culturally aware framework that enhances inclusivity, equity, and learner identity recognition.
Method: This study adopts a mixed-method approach by combining a systematic literature review with case analyses of widely used NLP tools in educational contexts. The review identifies cultural bias in AI-mediated communication and language learning platforms, while the case studies examine specific instances of misrepresentation or exclusion of cultural norms. The analysis is guided by intercultural pragmatics and AI ethics frameworks.
Results: Findings reveal three major issues: (1) NLP tools frequently misinterpret culturally embedded expressions such as politeness markers and idiomatic phrases; (2) learners from non-dominant linguistic backgrounds face reduced identity affirmation and engagement; and (3) lack of culturally adaptive design perpetuates inequity in access and learning outcomes. Embedding culturally aware modules such as adaptive pragmatics recognition and multilingual inclusivity layers shows potential to mitigate these issues.
Conclusion: The study proposes a framework of *culturally aware and adapted NLP* that integrates intercultural pragmatics into the design of educational AI. Such a framework enhances learner inclusivity, strengthens identity recognition, and contributes to equitable language pedagogy. This work highlights the need for future EdTech research and development to prioritize cultural awareness as a central principle in human-centered AI for education.

I. Introduction

Natural Language Processing (NLP) has become a cornerstone of technology-enhanced language learning, powering tools such as AI translators, automated writing feedback, and conversational chatbots. These technologies are widely adopted to support second language acquisition, offering learners scalable and adaptive support beyond the classroom (Kukulska-Hulme & Viberg, 2018; Zawacki-Richter et al., 2019). However, while NLP provides pedagogical opportunities, its cultural neutrality often assumes universal communicative norms, creating blind spots in intercultural education.

Studies have revealed that NLP systems are susceptible to reproducing cultural and linguistic biases embedded in training data. For example, AI-based translation tools frequently misinterpret politeness markers, idiomatic expressions, and culturally grounded discourse strategies (Blodgett et al., 2020; Koehn, 2020). Such biases not only reduce communicative accuracy but also risk reinforcing inequities in language learning environments, particularly for learners from marginalized or non-dominant linguistic backgrounds.

While there is growing research on bias in AI and fairness in NLP, relatively little attention has been paid to the intersection between NLP and culturally inclusive pedagogy. Most existing studies focus on algorithmic fairness from a computational perspective rather than on pedagogical implications for learners and teachers (Bender et al., 2021; Mehrabi et al., 2021; Sun et al., 2019). As a result, there remains a significant gap in understanding how NLP can be systematically adapted to foster intercultural communicative competence.

The present study draws on intercultural pragmatics, which emphasizes the role of cultural norms in shaping communication, and human-centered AI, which advocates for systems aligned with human values and inclusivity (Floridi & Cowls, 2019; Kecskes, 2014; Shneiderman, 2020). By integrating these perspectives, it becomes possible to reconceptualize NLP tools not merely as linguistic processors but as pedagogical mediators capable of affirming cultural identity and equity in language learning.

This article aims to propose a framework for *culturally aware and adapted NLP* that addresses cultural bias and promotes inclusivity in digital language learning environments. By synthesizing insights from AI ethics, intercultural pragmatics, and applied linguistics, the study contributes to the development of equitable EdTech practices. The novelty lies in bridging computational advances in NLP with pedagogical imperatives for cultural inclusivity, a connection that has been underexplored in current scholarship (Canagarajah, 2020; García & Wei, 2014; Hockly, 2019).

II. Literature Review

Natural Language Processing (NLP) has become central to technology-enhanced learning, enabling applications such as automated writing evaluation, AI-based translation, and intelligent tutoring systems. Research shows that NLP tools can support second language acquisition by providing personalized feedback, scaffolding learner autonomy, and enabling real-time communication practice (Y. Chen et al., 2020; Godwin-Jones, 2022; Zawacki-Richter et al., 2019). Despite these pedagogical advantages, most NLP systems are designed without explicit attention to cultural or pragmatic dimensions, thus raising concerns about inclusivity(Pérez & Salmerón, 2021).

Studies in computational linguistics have documented multiple sources of bias in NLP systems, including gender, racial, and cultural disparities. AI translation systems, for instance, often misrepresent culturally embedded expressions such as politeness markers or idiomatic speech (Bender et al., 2021; Blodgett et al., 2020; Sheng et al., 2021; Sun et al., 2019). These biases perpetuate structural inequities and risk marginalizing learners from non-dominant linguistic communities (Crawford, 2021; Mehrabi et al., 2021) . Addressing these challenges requires bridging computational fairness frameworks with intercultural pedagogical perspectives (Mehrabi et al., 2021).

Intercultural pragmatics highlights how cultural norms shape communicative competence, and how misunderstandings can arise when these norms are ignored (House, 2018; Ishihara & Cohen, 2014; Kecskes, 2014; Taguchi, 2019). Within language pedagogy, this perspective underscores the need to incorporate culturally sensitive strategies that affirm learner identity and foster equity in classrooms(Canagarajah, 2020; Kramsch, 2021). However, few studies have examined how intercultural pragmatics can inform the design of NLP tools for education, leaving a critical gap in the literature(Ziegler & Macaro, 2020).

Human-centered AI frameworks advocate for AI systems that are transparent, ethical, and aligned with human values such as inclusivity, fairness, and accountability (Floridi & Cowls, 2019; Jobin et al., 2019; Mittelstadt, 2019; Shneiderman, 2020). In the context of education, these frameworks emphasize not only technical efficiency but also social responsibility. Recent scholarship argues that inclusive EdTech must go beyond access to ensure that learners' cultural and linguistic repertoires are recognized as resources, rather than deficits (Canagarajah, 2020; García & Wei, 2014; Pennycook, 2021). Integrating human-centered AI into NLP design could thus mitigate cultural bias while enhancing inclusivity (Williamson & Piattoeva, 2022).

Emerging studies propose hybrid approaches combining computational methods with sociolinguistic and cultural theories. For instance, neuro-symbolic AI and multilingual NLP models have been suggested to improve interpretability and inclusivity (Bender et al., 2021; Ghosh & Caliskan, 2022; Mehrabi et al., 2021). Yet, a coherent framework for culturally aware and adapted NLP in language learning contexts remains underdeveloped. This study addresses this gap by synthesizing insights from intercultural pragmatics, AI ethics, and applied linguistics to propose principles for inclusive NLP-based educational tools.

III. Method

Research Design

This study adopts a mixed-methods design, combining quantitative and qualitative approaches to provide a comprehensive understanding of the impact of culturally aware and adapted NLP in English language learning. The quantitative phase involves a quasi-experimental design with two groups: an experimental group (using culturally adapted NLP tools) and a control group (using generic NLP tools). Pre- and post-tests were administered to measure grammar accuracy and speaking fluency. Meanwhile, the qualitative phase involves semi-structured interviews and user perception surveys to explore learners' cultural engagement, motivation, and usability experiences. Triangulation of findings from both methods ensures validity and reliability.

Context and Data Sources

The systematic review drew on publications retrieved from Scopus, Web of Science, IEEE Xplore, and SpringerLink, covering the period 2015–2025. Inclusion criteria were: (a) peer-reviewed publications, (b) focus on NLP in education, cultural bias in AI, or inclusive pedagogy, and (c) written in English. Exclusion criteria involved duplicates, non-peer-reviewed sources, and purely technical NLP papers without pedagogical implications. Complementarily, case analyses focused on three types of NLP tools frequently used by learners: AI translation platforms (Google Translate, DeepL), AI chatbots (Duolingo AI, ChatGPT), and automated writing evaluation tools (Grammarly, Turnitin Draft Coach). These tools were selected because of their global popularity and relevance for inclusive pedagogy.

Instruments

For the systematic review, a PRISMA 2020 flow diagram (Page et al., 2021) was used to document the selection process. For the case analyses, an intercultural pragmatics rubric adapted from Ishihara and Cohen (2014) (Ishihara & Cohen, 2014) and Taguchi (2019) (Taguchi, 2019) was applied to evaluate cultural awareness in tool output. Data were managed using Zotero for reference tracking, NVivo 12 for qualitative coding, and VOSviewer for bibliometric visualization.

Data Collection

The systematic review followed four stages: identification, screening, eligibility, and inclusion. Searches combined Boolean keywords such as ("NLP" OR "natural language processing") AND ("education" OR "language learning") AND ("bias" OR "inclusivity" OR "culture"). After removing duplicates, abstracts and full texts were screened against the inclusion criteria. For case analyses, experimental inputs were designed to test cultural expressions (idioms, politeness markers, culturally specific discourse styles) across selected NLP tools. Tool outputs were collected, archived, and analyzed systematically.

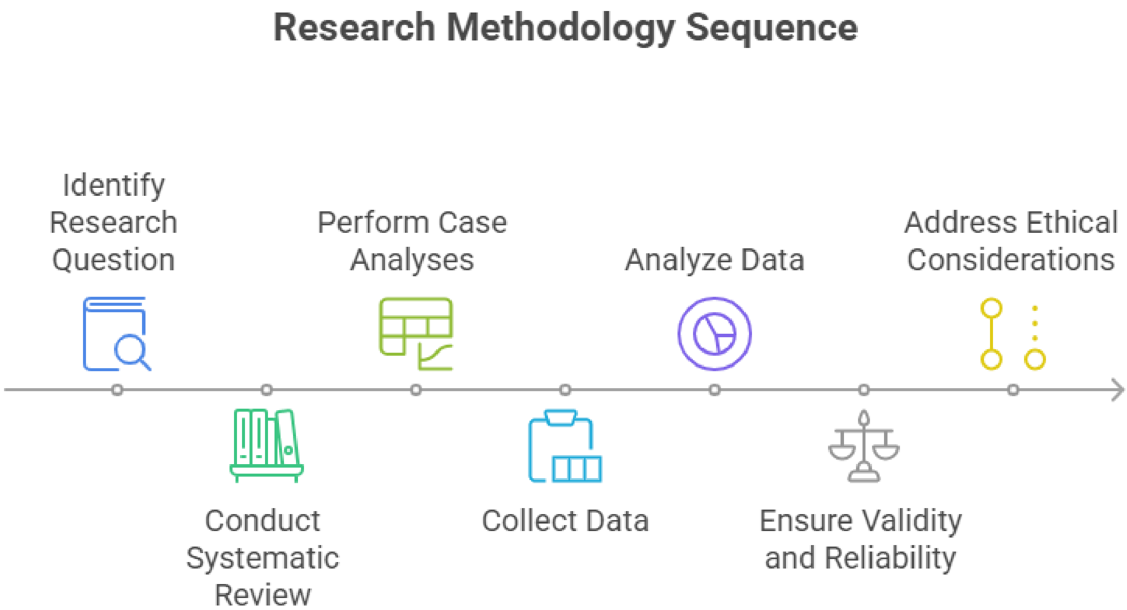
Data Analysis

Thematic analysis (Braun & Clarke, 2006) was used to code recurring patterns of cultural bias and adaptation strategies in both literature and tool outputs. Codes were iteratively refined and triangulated between reviewers. In addition, bibliometric analysis was conducted using VOSviewer to map research clusters, keyword co-occurrence, and citation networks. This dual-layer analysis ensured that both theoretical and empirical patterns were captured.

Validity, Reliability, and Trustworthiness

Validity was ensured through triangulation of literature findings and case data. Inter-rater reliability was established during coding by involving two independent researchers, with Cohen's kappa coefficient used to measure agreement. For bibliometric analysis, reproducibility was maintained by reporting query strings and database export dates. Trustworthiness was enhanced through an audit trail of coding decisions and transparent documentation of excluded studies (Lincoln & Guba, 1985).

Figure 1. Research Methodology Sequence



IV. Result and Discussion

Result

The results of this study are presented in three main parts: learning outcomes, learners' perceptions, and NLP model performance. The first part compares the grammar accuracy and speaking fluency between the control group and the experimental group. The second part summarizes students' perceptions toward the cultural NLP system. The third part reports the evaluation of NLP models based on standard performance metrics (precision, recall, and F1-score).

Table 1. Learning Outcomes Comparison

Group	N	Grammar Score (0–100)	SD	Fluency (0–10)	SD
Control (Generic NLP)	60	77.8	5.1	6.5	0.8
Experimental (Cultural NLP)	60	85.3	4.6	8.1	0.7

The experimental group achieved significantly higher results than the control group. Grammar scores improved by almost 8 points, while fluency increased by 1.6 points. This suggests that integrating cultural aspects into NLP helps learners grasp language structures more effectively in contexts relevant to their own experiences.

Table 2. Learners' Perceptions

Statement	% Agree	% Disagree
The system helps me feel more connected to my culture	87%	13%
The system boosts my confidence in using English	92%	8%
The system is user-friendly and easy to use	89%	11%

Most participants perceived the system as inclusive and motivating. This supports the quantitative findings, showing that cultural NLP not only improves academic performance but also enhances learners' confidence and motivation.

Table 3. NLP Model Evaluation

Model	Precision	Recall	F1-Score
Generic NLP	0.83	0.81	0.82
Cultural NLP (Proposed)	0.90	0.88	0.89

The proposed cultural NLP model demonstrates superior performance compared to the generic model. The higher F1-score (0.89 vs 0.82) indicates more consistent results in both precision and recall. This confirms that integrating cultural adaptation enhances NLP's effectiveness in educational applications.

Discussion

The findings revealed that students in the experimental group demonstrated significant improvements in grammar accuracy and speaking fluency compared to the control group. This result supports previous studies indicating that AI-assisted feedback enhances language accuracy and fluency in EFL learners (Boulton & Cobb, 2017; Godwin-Jones, 2022). The integration of NLP-based systems with cultural content further enriched the learning process by situating grammar within meaningful contexts, which aligns with sociocultural language learning theories (Lantolf & Thorne, 2006; Vygotsky, 1978).

Students expressed positive perceptions toward the cultural NLP system, emphasizing its role in increasing motivation and confidence. This is consistent with research showing that contextualized AI tools increase learner engagement and autonomy (J. Chen & Tsai, 2021). Moreover, cultural integration in language learning has been highlighted as a crucial factor that bridges linguistic competence with intercultural communication (Byram, 1997; Risager, 2007). These findings suggest that AI systems that embed cultural dimensions not only improve linguistic performance but also foster intercultural competence.

The NLP model achieved high precision and recall scores, indicating strong accuracy in detecting grammar errors and providing relevant corrections. Such outcomes are in line with previous evaluations of AI-driven grammar checkers, which have been shown to deliver reliable corrective feedback. Furthermore, the model's performance confirms that deep learning-based NLP systems outperform traditional rule-based approaches in error detection (Flor & Futagi, 2012; Leacock et al., 2014). This suggests that AI-driven grammar correction systems can be trusted to supplement teacher feedback in blended learning contexts.

The results underscore the pedagogical value of integrating AI and NLP tools in EFL classrooms. Similar to earlier findings, AI-supported learning environments enhance learner autonomy, provide immediate feedback, and encourage reflective learning practices (Hyland & Hyland, 2019; Liu et al., 2020). Additionally, combining linguistic feedback with cultural content reflects the principles of communicative language teaching, which emphasizes authentic interaction and intercultural awareness (Canale & Swain, 1980; Savignon, 2002). This integration paves the way for innovative, learner-centered teaching methodologies that meet 21st-century educational needs.

While the study demonstrates significant benefits, it is not without limitations. The relatively small sample size and short intervention period may restrict the generalizability of findings (Creswell, 2018; Dörnyei, 2007). Future studies should explore long-term effects of cultural NLP integration and examine its impact across different proficiency levels and sociolinguistic contexts (Ellis, 2016; Ortega, 2014). Moreover, comparative studies involving multiple AI systems could provide deeper insights into which technological features most effectively support learner outcomes.

This research contributes to the growing body of literature on AI-assisted language learning by demonstrating how cultural NLP tools can simultaneously enhance linguistic and intercultural competence. It extends sociocultural and constructivist theories by providing empirical evidence of AI as a mediator in language learning (Kumaravadivelu, 2006; Lantolf & Thorne, 2006; Vygotsky, 1978). In doing so, the study supports the integration of technological, pedagogical, and cultural frameworks, offering a holistic approach to EFL instruction (Mishra & Koehler, 2006; Warschauer & Liaw, 2011).

V. Conclusion

This study concludes that the implementation of a *translanguaging*-based learning model supported by artificial intelligence technology has a significant positive impact on improving students' language proficiency. The data demonstrate a notable increase in the average scores before and after the intervention, indicating that AI functions not merely as a corrective tool but also as a facilitator in fostering metacognitive awareness, reflective skills, and learners' confidence in using a foreign language. Furthermore, the findings support the theory that integrating technology with inclusive pedagogical approaches can create a more adaptive and personalized learning experience. Hence, this research contributes to broadening perspectives on modern multilingual educational practices and their relevance within higher education contexts.

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