

AI-driven multilingual technical communication in engineering education for sustainable development

RESEARCH

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Abstract

Multilingualism and intercultural communication have become essential components of higher education in an increasingly globalized academic landscape. Engineering institutions accommodate students from diverse linguistic and cultural backgrounds, creating both opportunities and challenges for effective technical communication. This paper examines the role of multilingual competence and intercultural communication in enhancing technical communication skills among engineering students and explores how artificial intelligence (AI)-driven technologies can facilitate multilingual learning environments. Drawing on perspectives from applied linguistics, engineering pedagogy, and digital education, the paper discusses how AI-based tools such as machine translation systems, intelligent writing assistants, and adaptive learning platforms support multilingual interaction and knowledge accessibility. The study also highlights challenges faced by students in multilingual engineering classrooms, including language barriers, limited technical vocabulary, and cross-cultural communication difficulties. Using contextual insights from engineering education in India, the paper proposes strategies for integrating multilingual pedagogical practices and AI-supported learning technologies into technical communication training. These approaches contribute to inclusive learning environments, strengthen intercultural competence, and prepare engineering graduates for global collaboration. The paper concludes that AI-supported multilingual communication strategies contribute significantly to sustainable development by enhancing knowledge dissemination, promoting global cooperation, and supporting culturally inclusive educational practices.

Keywords: *Multilingualism, engineering education, technical communication, artificial intelligence, intercultural communication, sustainable development.*

1. Introduction

Higher education has experienced significant transformation due to globalization and technological advancement (Crysta, Jenkins). Universities increasingly host students from diverse linguistic and cultural backgrounds, creating multilingual academic environments that require effective communication strategies. Engineering education, in particular, depends on

clear and precise technical communication because engineers must present complex technical ideas through reports, presentations, research papers, and collaborative discussions (Hyland). In many countries, including India, English functions as the primary language of instruction in engineering institutions. However, students frequently come from regional language backgrounds and may experience difficulty interpreting specialized technical vocabulary in English. This linguistic diversity presents both challenges and opportunities for teaching and learning. While multilingual

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classrooms can encourage diverse perspectives and collaborative learning, they may also create communication barriers that affect academic participation and comprehension (Cummins, Seidlhofer).

Recent advancements in artificial intelligence have introduced innovative tools that support multilingual communication in educational settings (Zawacki-Richter et al.). AI-driven technologies such as automated translation systems, speech recognition software, and intelligent writing assistants enable students to access technical knowledge across linguistic boundaries. These technologies provide opportunities to strengthen communication skills and promote inclusive learning environments (Warschauer, Yang). This paper explores the intersection of multilingualism, intercultural communication, and artificial intelligence in engineering education. It examines how AI-supported communication tools can enhance multilingual technical communication and contribute to sustainable development in higher education (UNESCO).

2. Literature review

2.1. Multilingualism in Higher Education

Multilingualism is widely recognized as an important feature of contemporary educational systems. Linguistic diversity enables learners to access knowledge across cultures and participates in global academic networks. According to Crystal, multilingual communication supports the exchange of ideas and promotes intellectual collaboration across societies. Research also indicates that multilingual learning environments enhance cognitive development and critical thinking skills. Cummins emphasizes that multilingual competence allows students to process information through multiple linguistic frameworks, leading to deeper conceptual understanding.

2.2. Technical Communication in Engineering Education

Technical communication is an essential professional skill for engineers. Engineers must communicate technical information clearly through written documents, oral presentations, and digital platforms. Hyland notes that academic writing plays a crucial role in professional knowledge dissemination. However, engineering students often encounter difficulties in academic writing and communication due to the simultaneous demands of technical knowledge acquisition and language proficiency. Integrating communication training into engineering curricula can significantly enhance student's professional readiness.

2.3. Intercultural Communication in Global Education

Intercultural communication refers to the ability to interact effectively with individuals from different cultural backgrounds. Byram highlights that intercultural competence involves knowledge, attitudes, and skills that enable individuals to understand cultural differences and respond appropriately in communication contexts. In engineering education, intercultural competence is particularly important because engineering projects frequently involve collaboration among professionals from diverse cultural and linguistic backgrounds.

2.4. Artificial Intelligence in Language Learning

Artificial intelligence has transformed the landscape of language learning and communication (Ouyang and Jiao, Zhai et al.). Contemporary research highlights that artificial intelligence supports both cognitive and linguistic development by offering adaptive and personalized learning experiences (Bond et al.). Learning analytics powered by AI technologies enable educators to monitor student progress and design more effective instructional strategies (Viberg et al.). AI-driven technologies provide adaptive learning experiences, automated feedback, and multilingual communication support. Digital tools such as machine

translation systems and intelligent writing assistants enable learners to improve their communication skills efficiently. These technologies also facilitate access to academic resources by enabling students to translate research materials and technical documentation into their preferred languages.

3. Conceptual framework

The conceptual framework of this study integrates three key elements.

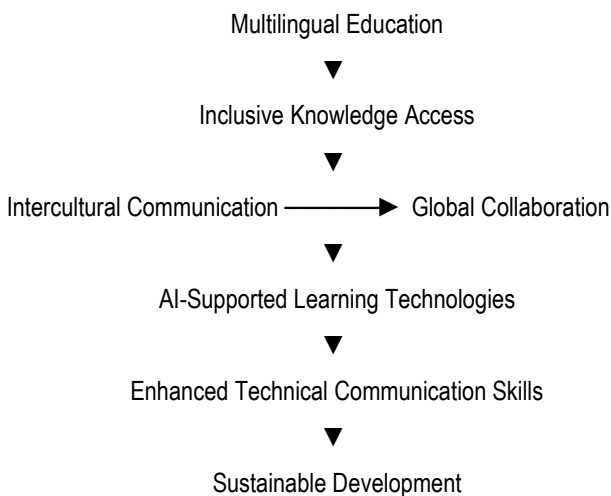


Figure 1: Conceptual framework for AI-driven multilingual technical communication in engineering education

The conceptual framework illustrates the interconnected relationship between multilingual education, intercultural communication, and artificial intelligence-supported learning technologies in enhancing technical communication skills among engineering students. Multilingual education facilitates inclusive knowledge access by enabling learners to engage with content across linguistic boundaries.

Intercultural communication further strengthens this process by promoting effective interaction among students from diverse cultural backgrounds, leading to global collaboration. Artificial intelligence-supported learning technologies act as an enabling mechanism that enhances language learning and communication efficiency. These tools

help students overcome linguistic barriers and improve their ability to express complex technical ideas. The integration of these components results in enhanced technical communication skills, which are essential for professional success in global engineering environments. Ultimately, this model contributes to sustainable development by promoting knowledge accessibility, inclusivity, and international cooperation in education and technology (Figure 1).

4. Multilingual context of engineering education in India

India is one of the most linguistically diverse nations in the world, with numerous regional languages spoken across different states. Engineering colleges attract students from various linguistic communities, resulting in highly multilingual classrooms. While English serves as the official medium of instruction, students frequently rely on their native languages for understanding complex technical concepts. This multilingual context provides opportunities for collaborative learning but may also create communication challenges in academic writing and presentations. Adopting multilingual teaching strategies can therefore enhance comprehension and participation among students from different linguistic backgrounds.

5. AI-driven tools for multilingual technical communication

The presents key artificial intelligence (AI) tools that facilitate multilingual technical communication in engineering education, highlighting their functions and pedagogical applications. These technologies play a crucial role in minimizing linguistic barriers and enhancing student's ability to comprehend and produce technical knowledge in multilingual contexts.

Table 1: AI technologies supporting multilingual communication in engineering education

AI Tool	Function	Educational Application
Machine translation systems	Translate text between languages	Understanding research papers
Intelligent writing assistants	Provide grammar and writing suggestions	Improving technical reports
Speech recognition systems	Convert speech into text	Language practice
AI tutoring platforms	Personalized language feedback	Skill development

- Machine translation systems enable learners to translate technical texts across languages, thereby improving access to academic resources such as research articles, manuals, and textbooks. This is particularly beneficial in multilingual classrooms where students rely on their first language to understand complex engineering concepts (*Warschauer*).
- Intelligent writing assistants provide automated feedback on grammar, syntax, and vocabulary usage, supporting students in producing well-structured technical documents. Such tools contribute significantly to improving academic writing skills in English, which is often the dominant medium of instruction in engineering education (*Hyland*).
- Speech recognition systems enhance oral communication by allowing students to practice pronunciation and convert spoken input into written text. These tools are especially useful for developing confidence in technical presentations and discussions (*Chapelle*).
- AI tutoring systems offer personalized feedback and adaptive learning experiences tailored to individual proficiency levels. This helps students improve their language skills efficiently and independently (*Zawacki-Richter et al.*).

Overall, the integration of these AI tools enhances multilingual communication, strengthens technical writing and speaking skills, and fosters inclusive and technology-enabled learning environments in engineering education. The integration of AI tools reflects a broader shift toward data-driven and intelligent educational systems that enhance both teaching efficiency and student learning outcomes (Table 1) (*Dwivedi et al.*).

6. Challenges in multilingual engineering classrooms

The outlines the key challenges encountered in multilingual engineering classrooms, along with their impact on learning and corresponding pedagogical strategies to address them. These challenges highlight the complexity of communication in linguistically diverse educational environments and emphasize the need for structured interventions.

Table 2: Challenges and strategies in multilingual engineering education

Challenge	Impact	Solution
Limited English proficiency	Difficulty understanding lectures	Multilingual explanations
Lack of technical vocabulary	Poor academic writing	Bilingual glossaries
Cultural communication differences	Misunderstandings	Intercultural training

- Limited English proficiency is one of the most significant barriers, as it affects student's ability to understand lectures, follow technical discussions, and engage in classroom interaction. To address this, multilingual explanations and AI-based translation tools can be integrated into teaching

practices, enabling students to access content in more familiar linguistic forms (*Cummins*).

- Another major challenge is the lack of technical vocabulary, which can hinder student's ability to produce clear and accurate academic writing. The use of bilingual glossaries and AI-supported writing tools can help students acquire domain-specific terminology and improve their communication skills (*Hyland*).
- Cultural differences in communication styles may also lead to misunderstandings during group work and collaborative projects. Incorporating intercultural communication training into the curriculum can enhance student's awareness of cultural diversity and improve teamwork effectiveness (*Byram*).

Finally, the lack of faculty training in multilingual pedagogy can reduce the effectiveness of instructional strategies. Professional development programs for educators can play a crucial role in improving teaching practices in multilingual classrooms. Overall, addressing these challenges through targeted strategies can significantly enhance technical communication skills and create more inclusive learning environments in engineering education (Table 2).

7. Strategies for enhancing multilingual technical communication

Educational institutions should integrate communication training within engineering curricula to improve student's ability to present technical ideas clearly. Digital learning tools such as AI-based translation systems and writing assistants should be incorporated into classroom instruction to support multilingual communication. Collaborative learning activities involving students from diverse linguistic backgrounds can also enhance intercultural competence and encourage knowledge exchange.

8. Discussion

The integration of multilingual communication and artificial

intelligence technologies offers significant potential for transforming engineering education. These approaches enhance knowledge accessibility, support linguistic diversity, and improve student's technical communication skills. Engineering graduates equipped with multilingual competence and intercultural awareness is better prepared to participate in international research collaborations and technological innovation. Recent studies highlight that AI-driven educational tools can significantly enhance personalized learning and student engagement in multilingual environments (*Holmes et al., Godwin-Jones*). The integration of artificial intelligence in education represents a paradigm shift from traditional teaching approaches to adaptive and interactive learning environments (*Roll and Wylie*). These technologies enable institutions to effectively address linguistic diversity and promote inclusive academic practices (*Zhai et al.*). Furthermore, AI-driven platforms facilitate collaborative learning across cultural and linguistic boundaries, enhancing global academic engagement (*Huang et al.*). However, successful implementation requires alignment with pedagogical goals and ethical considerations (*Dwivedi et al.*).

9. Conclusion

Multilingualism and intercultural communication play a vital role in preparing engineering students for global professional environments (*Byram, Jenkins*). Engineering education must therefore move beyond monolingual approaches and actively embrace linguistic diversity as a valuable educational resource, enabling students to engage more effectively in diverse academic and professional contexts (*Cummins*). Artificial intelligence technologies provide powerful tools for supporting multilingual communication and improving access to technical knowledge (*Zawacki-Richter, Yang*). AI-driven multilingual communication plays a crucial role in enhancing global knowledge exchange and academic collaboration (*Chassignol et al.*). The integration of these technologies into engineering education enhances student's communication

skills, facilitates knowledge acquisition, and promotes inclusive learning environments (*Warschauer*). Recent research further emphasizes that AI-supported language learning environments foster adaptive learning and improve linguistic competence in higher education contexts (*Kukulska-Hulme*). This study argues that, the future of engineering education lies in the meaningful integration of multilingual pedagogical practices and AI-driven communication tools. It is not sufficient to treat language merely as a medium of instruction rather, it should be recognized as a dynamic resource that shapes knowledge construction and professional identity. Institutions that strategically incorporate multilingual and technological approaches will be better positioned to produce globally competent engineers capable of addressing complex real-world challenges. Furthermore, the author argues that policy-level interventions and curriculum redesign are essential to institutionalize multilingual technical communication in engineering education. Without such systemic support, the benefits of linguistic diversity and technological innovation may remain underutilized. Thus, the integration of AI-driven multilingual communication practices is not merely an educational enhancement but a strategic necessity for achieving sustainable and globally relevant engineering education. As higher education continues to evolve, integrating artificial intelligence with multilingual pedagogical practices is essential for fostering innovation, inclusivity, and sustainable global development (*Zhai, Huang*).

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Ethical approval statement: This study is based on textual and literary analysis of published works and does not involve human participants or animals.

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