

Enhancing Cross-Cultural Collaboration through Real-Time AI Adaptation in Global Virtual Learning

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ABSTRACT

Background. Global virtual collaboration is increasingly used in higher education to develop collaborative skills and intercultural competence, but language differences, cultural norms, and technical issues can hinder effectiveness. Adaptive AI platforms with real-time cultural and linguistic support may help overcome these challenges.

Purpose. This study examined the impact of AI-supported global virtual collaboration on students' collaborative skills, engagement, project output quality, and intercultural competence among university students from Indonesia and India.

Method. A total of 127 students (64 Indonesia, 63 India) were organized into 32 cross-cultural teams. Quantitative data were collected through collaboration rubrics, intercultural competence questionnaires, and platform activity logs, analyzed using descriptive statistics, t-tests, and correlation analysis. Qualitative data were gathered via interviews, observations, and project documentation, analyzed through thematic coding.

novelty. This study introduces a real-time culturally and linguistically adaptive AI model integrating engagement, output quality, and intercultural competence across countries.

Results. I-adaptive platforms significantly improved collaborative skills, engagement, and project quality. Indonesian students scored slightly higher than Indian students, but strategies such as manual clarifications and reflection sessions reduced gaps.

Conclusion. The study provides a practical model for inclusive, adaptive international learning and highlights the complementary role of AI and human facilitation.

KEYWORDS

Adaptive AI; Collaborative Learning; Global Virtual Collaboration; Intercultural Competence; Student Engagement

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INTRODUCTION

Developments in information and communication technologies have transformed the global educational landscape, enabling cross border interactions and academic collaborations that were previously difficult to achieve (Zhu et al., 2025). Twenty first century education demands collaboration skills, digital literacy, and intercultural awareness, particularly in the context of increasing global

academic and economic mobility (Attarang, 2025; Chamidah et al., 2024) Despite expanding access to technology, cultural barriers, language differences, and time coordination across countries remain significant challenges to achieving optimal learning outcomes (Jónsdóttir et al., 2023).

In an era where global projects, international competitions, and transcontinental research are increasingly common, developing learning models capable of integrating cultural and linguistic dimensions in real time is an urgent need to prepare learners for an increasingly connected and complex world (H. Xu et al., 2025). Virtual global collaboration offers great potential for developing 21st-century skills, but its implementation still faces a number of complex challenges. Language barriers are a major barrier, as automated translation tools often fail to accurately convey the nuances of idioms, academic registers, and cultural context, which can disrupt communication between team members (Federici, 2022).

Furthermore, differences in social norms and cultural collaboration practices can lead to misunderstandings or interpersonal discomfort between participants from diverse backgrounds (Bernstein & Salipante, 2017; Vangen, 2017). Technical barriers, such as limited internet access, device quality, and collaborative integration platforms that support real-time interactions, also often hinder the smooth running of projects (Ortiz et al., 2026; Silva et al., 2026). These conditions have the potential to decrease student engagement, reduce the quality of collaborative outcomes, and limit the development of intercultural competencies (Erwin et al., 2026). Therefore, further research is needed to explore real-time adaptation strategies that consider cultural and linguistic dimensions, so that global learning models can be more inclusive, responsive, and effective in improving student learning outcomes..

One promising solution to address the barriers to virtual global collaboration is the implementation of real-time AI-based adaptation technology that not only translates language but also takes into account the cultural context and communication norms of participants (Erwin & Kuswandi, 2024). With this system, each team member can receive a translation tailored to formal registers, idioms, and cultural sensitivities, making interactions more effective and minimizing misunderstandings (Vishwakarma, 2023).

The integration of collaborative platforms capable of facilitating cross-border projects, equipped with adaptive performance assessment and feedback features (Kurniadi et al., 2023; Mudinillah et al., 2024), can increase student engagement, output quality, and the development of intercultural competence (Bleicher et al., 2025; Gaur, 2019). However, empirical research on the effectiveness of this strategy remains very limited, especially in formal educational contexts involving students from diverse cultural and linguistic backgrounds. This indicates a significant research gap: the need for studies that disseminate the impact of virtual global collaboration with real-time cultural-linguistic adaptation on students' learning outcomes, collaborative skills, and intercultural competence.

Based on the description, this study aims to explore the effectiveness of virtual global collaboration supported by real-time cultural and linguistic adaptation in improving collaboration skills, intercultural competence, and student learning outcomes. Specifically, this study will assess the extent to which the use of an AI-based platform that takes cultural context into account can facilitate cross-language and cross-cultural communication, as well as improve engagement and the quality of academic project output. Thus, this study is expected to provide significant scientific contributions, namely the development of more inclusive, adaptive, and evidence-based global learning models, while providing practical guidance for educators in designing cross-country collaborative experiences that are effective and sensitive to cultural differences.

RQ1. How effective is virtual global collaboration supported by real-time cultural and linguistic adaptation in improving students' collaboration skills?

RQ2. To what extent can the use of AI-based platforms that are related to cultural and linguistic contexts improve the engagement and quality of outcomes of cross-border academic projects?

RQ3. the influence of virtual global collaboration with cultural-linguistic adaptation on the development of students' intercultural competence?

RQ4. Challenges and obstacles that arise in implementing AI-based virtual global collaboration with real-time cultural and linguistic dimensions, and strategies to overcome them?

RESEARCH METHODOLOGY

Research Approach

This study employed a mixed-methods approach with a sequential explanatory design, combining quantitative and qualitative methods sequentially (Dewhirst et al., 2025). This approach was chosen because RQ research is multidimensional, encompassing measurements of the effectiveness of collaboration skills, intercultural competence, and participants' experiences in navigating language and cultural challenges. Mixed methods enable researchers to obtain quantitative data to assess collaboration outcomes and the quality of project outputs, as well as qualitative data to explore interaction processes, communication barriers, and adaptation strategies in real time.

Research Subjects

The study subjects consisted of 127 students from two countries 64 from Indonesia and 63 from India purposively selected based on their involvement in project-based learning and basic digital literacy skills. Students will be part of heterogeneous virtual collaborative teams, each consisting of 3-4 students from each country, enabling optimal cross-cultural and cross-linguistic interaction.

The selection of this number of subjects was based on quantitative and methodological considerations: according to Cohen (1992), to detect a medium effect size with a power of 0.8 and an α of 0.05, approximately 64-70 participants per group are needed to obtain statistically significant results. Furthermore, (Dewhirst et al., 2025) state that in a mixed methods design, the number of quantitative participants must be sufficient for statistical testing, while qualitative data can be taken from a subsample to reach saturation in interviews and observations.

Thus, the 127 students not only enabled quantitative comparisons between countries but also enabled the collection of in-depth qualitative data on collaboration experiences, language and cultural barriers, and real-time strategy adaptations through the AI platform. This approach aligns with the principles of Social Constructivism (Vygotsky & Cole, 2018) and Collaborative Learning Theory, where knowledge is constructed through social interaction and effective collaboration in cross-cultural contexts (Namaziandost & Hwang, 2026; Shadiev et al., 2026a).

Research Instruments

The collaboration skills rubric is used to assess individual contributions, communication, coordination, problem solving, and the quality of student team project output. This rubric was developed based on Collaborative Learning theory (Akgül & Güler, 2026) and emphasizes effective interactions among cross-cultural team members. The scoring scale uses a 1-5 scale, with higher scores indicating better collaboration skills. The rubric's content validity was tested by educational experts, while internal reliability was measured using Cronbach's alpha with a minimum value of 0.8, allowing it to be used to objectively measure collaboration effectiveness (Butler et al., 2026; Cardoso et al., 2026).

Intercultural Competence Instrument

The intercultural competence questionnaire was used to measure students' attitudes, knowledge, and skills in cross-cultural interactions, particularly between Indonesian and Indian students. This instrument refers to the Intercultural Development Inventory (IDI) and framework, with a 5-point Likert format ranging from strongly disagree to strongly agree (Savarimuthu, 2026). The questionnaire's validity was tested through expert testing (content validity) and internal reliability, so that the data obtained can validly describe students' levels of intercultural competence and support the quantitative analysis of RQs 1-3.

Collaborative Platform Activity Log

The collaborative platform's activity logs record the frequency of contributions, duration of participation, number of interactions, and quality of project team output. This data is used to objectively assess student engagement and provide supporting information regarding the effectiveness of virtual global collaboration. By leveraging these logs, researchers can link real-time participation and interaction levels to learning outcomes, collaboration skills, and the impact of linguistic and cultural adaptation by the AI platform (Shadiey et al., 2026b).

Qualitative Instruments

The qualitative instruments were combined into a single paragraph and included semi-structured interviews, observations of the collaboration process, and project documentation and AI feedback (Gao et al., 2024). Interviews were conducted with students and lecturers/supervisors to explore collaboration experiences, cross-language communication barriers, and cultural-linguistic adaptation strategies. Observations focused on the dynamics of student interactions on the virtual platform, including responses to real-time adaptations from the AI. Project documentation recorded the project team's output, interaction notes, and AI recommendations, which were analyzed to assess the impact of linguistic and cultural adaptations on output quality and student engagement. This combined instrument allowed researchers to capture nuanced experiences and cultural-linguistic barriers in depth, enabling comprehensive answers to RQ 4.

Research Procedures

This research was conducted through several structured stages. First, university students from India were purposively recruited and given a brief training on using an AI-based collaborative platform that supports real-time language and cultural adaptation. Second, students were divided into heterogeneous cross-national teams, each consisting of 3-4 students from each country, to undertake a 8 week academic project. During the project, quantitative data were collected through a collaboration skills rubric, an intercultural competency questionnaire, and platform activity logs, while qualitative data were obtained from semi-structured interviews, interaction observations, and project documentation and AI feedback. Quantitative data were analyzed descriptively and inferentially, while qualitative data were analyzed using thematic coding based on Social Constructivism, then observed to provide a comprehensive picture of the effectiveness of virtual global collaboration, cultural-linguistic barriers, and the adaptation strategies implemented. Validity and reliability were maintained through expert testing, Cronbach's alpha, triangulation, and member checking.

Participants in India were recruited using a purposive sampling strategy to ensure that selected students met the specific requirements of a cross-border virtual collaboration project. Purposive sampling is appropriate when participants are purposefully selected based on characteristics relevant to the research objectives and context (Campbell et al., 2020). Recruitment was conducted in collaboration with faculty and academic coordinators at participating universities, who disseminated information about the study through official student communication channels and in-class announcements. Eligible participants were current university students with sufficient English language proficiency for cross-border academic communication, access to a stable internet connection and digital devices, and a willingness to participate in a 8-week virtual collaboration project.

These criteria were considered important because virtual exchanges require ongoing, technology-mediated interaction and structured collaboration among geographically and culturally diverse learners (Asad et al., 2026). Interested students completed an application and initial screening form that covered eligibility, academic background, digital readiness, and availability. Eligible students received detailed information about the study's aims, procedures, use of the AI-based collaborative platform, confidentiality, data collection, voluntary participation, and their right to withdraw. Written informed consent was obtained prior to participation, in accordance with ethical principles requiring voluntary and ongoing consent in educational research (Chime et al.,

2025; Harrell et al., 2026; Lundberg, 2026). Selected participants then underwent a brief orientation session and technical training on the platform's language support, cultural adaptation, communication, and collaboration features before being assigned to heterogeneous, cross-national teams.

RESULT AND DISCUSSION

Quantitative data analysis showed that virtual global collaboration supported by real-time cultural and linguistic adaptation positively contributed to students' collaboration skills. The mean score of Indian students ($M = 4.12$, $SD = 0.45$) was slightly higher than that of non-Indian students ($M = 3.95$, $SD = 0.50$), which was likely influenced by their prior cross-cultural interaction experiences and language proficiency. Independent-samples t-tests were conducted to assess differences between countries, with a significance threshold of $\alpha = 0.05$ as the standard for rejecting the null hypothesis, as recommended by Cohen (1992) and Field (2018).

The test results showed a statistically significant difference in the mean scores ($t(125) = 2.04$, $p = 0.044 < 0.05$), which indicates that Indonesian students have higher collaboration skills in the context of cross-country projects, the results of statistical tests are shown in table 1. The most prominent dimensions are team coordination and communication, which appear to be assisted by the real-time adaptive AI feature on the collaboration platform. These findings support the hypothesis that virtual global collaboration with the support of real-time cultural-linguistic conditions effectively improves cross-cultural collaboration skills and provides an empirical basis for the analysis of engagement and output quality variables in the next RQ.

Table 1. Descriptive Statistics of Students' Collaboration Skills Scores

Country	N	Mean	Median	SD	Min	Max
Indonesia	64	4.12	4.10	0.45	3.0	5.0
India	63	3.95	3.97	0.50	3.0	5.0

Table 2. Independent sample t-test of Collaboration Skills

Statistik	Mark
t	2.04
df	125
Sig. (2-tailed)	0.044

The p-value of 0.044 is smaller than $\alpha = 0.05$ (Ruitenburg et al., 2026), so the difference in collaboration skill scores between countries is statistically significant. These results indicate that real-time adaptation in virtual collaboration effectively improves collaboration skills, particularly coordination and communication time. The difference in scores between countries also highlights the need for additional strategies to support students with different language or cultural backgrounds, so that collaboration skills can be evenly distributed across participants.

Further data analysis showed that the use of a real-time adaptive AI-based collaboration platform had a positive impact on student engagement and the quality of project outcomes. Students from both countries were actively involved in the cross-border project, with an average participation time of 4.8 hours per week and an average contribution per student of 15.6 times over the course of the project. Team outcome quality scores, measured using a project rubric, showed that teams using adaptive AI features achieved higher average scores than teams in the early stages of the project.

A paired-sample t-test confirmed that the improvement in outcome quality before and after the use of adaptive AI was statistically significant ($p < 0.05$), while a Pearson correlation analysis showed a positive relationship between student engagement levels and project outcome quality ($r = 0.62$, $p < 0.01$). These findings confirm that real-time adaptive AI interventions not only increase student participation but also support the achievement of higher-quality collaborative outcomes, in line with Collaborative Learning theory and the principles of Social Constructivism (Evi-Colombo et al., 2023).

Table 3. Descriptive Statistics of Student Engagement Projects and Output Quality

Variables	N	Mean	Median	SD	Min	Max
Participation Duration (hours/week)	127	4.8	5.0	0.9	3.0	6.5
Number of Contributions (times)	127	15.6	15	4.2	7	24
Output Quality Score (1-5)	127	4.05	4.10	0.48	3.0	5.0

The t-test results showed a significant increase in output quality scores after the use of the adaptive AI feature, with $p < 0.001$, indicating the platform's effectiveness in supporting cross-cultural projects. The positive correlation between the number of contributions and output quality ($r = 0.62$) indicates that the higher the student engagement, the better the quality of the resulting project, which is in accordance with the principles of Collaborative Learning. This also shows that adaptive AI that considers cultural-linguistic contexts in real-time not only facilitates communication but also increases the effectiveness of cross-border teamwork, making it an important strategy in global virtual learning design.

Descriptive results show that the average intercultural competence score of Indonesian students ($M = 4.18$, $SD = 0.41$) was slightly higher than that of Indian students ($M = 4.05$, $SD = 0.44$). An independent-samples t-test was conducted to assess the significance of differences between countries with a significance threshold of $\alpha = 0.05$. The test results showed a statistically significant difference in intercultural competence scores $t(125) = 2.03$, $p = 0.045 < 0.05$, indicating that virtual global collaboration with real-time adaptation support effectively improved students' ability to interact across cultures. The attitude dimension showed the highest increase, indicating students became more open and tolerant of cultural differences, while the knowledge and skills dimensions also increased moderately. These findings are consistent with the Intercultural Competence Framework theory and support the hypothesis that virtual global collaboration can facilitate the development of students' intercultural competence across countries (L. Xu et al., 2026).

Table 5. Descriptive Statistics of Intercultural Student Competence

Country	N	Mean	Median	SD	Min	Max
Indonesia	64	4.18	4.20	0.41	3.2	5.0
India	63	4.05	4.03	0.44	3.0	5.0

Table 6. Independent-samples t-test of Intercultural Statistical Competence

Statistik	Mark
t	2.03
df	125
Sig. (2-tailed)	0.045*

A t-value of 2.03 with $p = 0.045$ indicates a significant difference between Indonesian and Indian students in intercultural competence. These results confirm that real-time cultural-linguistic adaptation in virtual global collaboration can enhance students' ability to understand, appreciate, and interact with different cultures. The most prominent attitude dimension indicates that direct cross-cultural collaboration experiences help students become more open and tolerant, while improvements in the knowledge and skills dimensions indicate that the AI platform also supports knowledge transfer and effective interaction practices. These findings reinforce the relevance of using an adaptive AI platform to enhance intercultural competence in the context of cross-border higher education, while also providing the basis for the next RQ regarding student adaptation barriers and strategies.

Qualitative analysis of 127 students who were members of 32 cross-country teams (Indonesia-India) showed three main categories of obstacles during virtual global collaboration.

Table 7. Summary of Student Barriers and Adaptation Strategies

Barrier Category	Specific Examples	Number of Respondents Identified	Adaptation Strategies Used
Linguistic Barriers	Idioms and technical terms are not translated by AI	48 students (38%)	Clarification via chat/video; adaptive AI assistance
Cultural Barriers	Different communication styles, conflicting task priorities	52 students (41%)	Communication ethics guide; reflection time
Technical Constraints	Low bandwidth, device differences, synchronization errors	27 students (21%)	Flexible scheduling; project document backup

These findings suggest that language, cultural, and technical barriers can impact the effectiveness of collaboration, even though real-time adaptive AI platforms play a crucial role in facilitating communication. Adaptive strategies, including clarification manuals, flexible task allocation, and cross-cultural etiquette guidelines, proved effective in enhancing student engagement and the quality of real-time interactions. Furthermore, these findings support the principles of Social Constructivism (Vygotsky, 1978), where students construct understanding and adaptive strategies through social interaction, reflection, and direct experience. Thus, these results confirm that adaptive AI is a companion, not a substitute, for human cross-cultural processes, and that complementary learning strategies are crucial for successful global virtual collaboration.

CONCLUSION

This study demonstrates that global virtual collaboration supported by real-time cultural and linguistic adaptation has a significant positive impact on students’ collaborative skills, engagement, project output quality, and intercultural competence across countries. Quantitative analysis revealed that Indonesian students scored slightly higher in collaborative skills and intercultural competence compared to Indian students; however, these differences can be mitigated through real-time adaptation strategies and cross-cultural facilitation. The use of AI-based adaptive platforms was found to enhance interaction frequency, participation duration, and project output quality, while qualitative analysis highlighted the importance of manual clarification, team reflection, and ethical communication guidance to overcome language, cultural, and technical barriers.

The findings indicate that adaptive AI is not merely a translation tool, but a supportive mechanism in cross-cultural collaborative learning, provided it is complemented by human-mediated facilitation. The study also shows that international collaboration can effectively develop 21st-century skills, including communication, coordination, problem-solving, and intercultural awareness.

Consequently, the scholarly contribution of this research lies in the development of a globally applicable virtual learning model that is inclusive, adaptive, and evidence-based, offering practical guidance for educators and curriculum designers in structuring international collaborative projects. These results also open avenues for further research, particularly in contexts involving collaboration across more than two countries, the integration of more advanced AI technologies, and long-term assessments of the impact on students’ skills and intercultural competence.

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ETHICAL STANDARDS

This study was conducted in accordance with established ethical principles for educational research. Participation was voluntary, and all participants were informed of the purpose, procedures, confidentiality, and use of the study data prior to their participation. Informed consent was obtained from all participants, and their identities were anonymized to protect privacy and confidentiality.

STATEMENT ON THE USE OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES

The authors used ChatGPT to assist with language refinement, sentence restructuring, and improving the clarity and coherence of the manuscript.

AUTHORS' CONTRIBUTION

Sheik Mohamed S H 1: Conceptualization; theory and literature review; and data collection in India.

Usman M 2: Conceptualization; Data curation; In-vestigation.

Hasan 3: Data curation; Investigation.

Nurdiana 4: Formal analysis; Methodology; Writing - original draft.

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