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Intercultural Language Education and Sustainable Development in the Context of the Belt and Road: An Innovative Path to Promote Humanistic Exchanges

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SUMMARY: *Against the backdrop of the Belt and Road Initiative, which has promoted extensive cooperation among countries along its routes in the economic, technological, and cultural fields, cross-cultural language education plays a significant role in advancing technology diffusion and realizing sustainable development goals (SDGs); however, most existing studies focus on the relationship between language and cultural communication, lacking discussions on how language education can serve sustainable development in the technology and energy domains—a gap that urgently requires systematic research and theoretical guidance. The purpose of this study is to explore the relationship between cross-cultural language education and the achievement of SDGs under the Belt and Road Initiative, and to propose new paths for promoting collaboration between the humanities and technology through theoretical analysis and empirical research. Methodologically, the study combines theoretical and empirical approaches to construct an analytical framework centered on language education, technology diffusion, and sustainable development: it employs questionnaires, in-depth interviews, and case studies to qualitatively and quantitatively analyze the role of cross-cultural language education in green energy and technology cooperation, while using statistical tools to conduct regression and thematic analyses of the collected data. The results indicate that cross-cultural language education is an important medium for cross-cultural technology diffusion, as it can effectively reduce the negative impacts of language and cultural barriers on international cooperation; in specific areas of technical cooperation, customized language education significantly improves the efficiency of knowledge dissemination and reduces project conflicts, and the integration of technology with language education shows great potential for further enhancing collaboration efficiency and the effectiveness of technology application. In conclusion, this study systematically elaborates on the central role of cross-cultural language education in technology diffusion and the realization of SDGs within the Belt and Road context, providing important insights for educational innovation and international cooperation, and suggests that future studies should broaden the applicability of this research field, strengthen the in-depth integration of technology with language instruction, and optimize the multicultural and multidisciplinary practice model.*

KEYWORDS: *intercultural language education; sustainable development; one belt one road; technology diffusion; energy cooperation*

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1 Introduction

Since its introduction, the Belt and Road Initiative has become an important platform for promoting global economic, cultural, and social development[1]. In this context, the link between intercultural language education and sustainable development has become increasingly close[2]. This connection is not only reflected in the level of humanistic exchanges but also puts forward brand-new requirements for global energy, environmental protection, technological innovation, and other areas of sustainable development[3]. Language, as a bridge of communication and cooperation, is an important tool for realizing these goals.

In the process of cross-cultural communication, innovation in language education can effectively promote understanding and collaboration among different countries and regions[4]. However, language education aimed at sustainable development needs to focus not only on the language itself but also on the practical effects of promoting environmental protection, resource conservation, and the popularization of green technology through language education[5]. This new path has injected more technological and practical elements into language education, making it move from a single humanistic attribute to a multidisciplinary development direction[6]. This project intends to investigate how to realize the goal of science and technology-centered sustainable development through innovative cross-cultural language education with relation to the Belt and Road Project. By analyzing existing practices and cases, this study will propose a series of theoretical frameworks and practical solutions to provide innovative paths for promoting humanistic exchanges and sustainable development. The significance of this paper lies not only in enriching the connotation of intercultural language education but also in providing theoretical support and practical guidance for the realization of global common development.

This paper consists of five main parts, arranged as follows: the first part is an introduction, which introduces the background and purpose of the study, analyzes the importance of intercultural language education in the context of the Belt and Road Initiative, and initially proposes research questions and objectives. The second part is the research review, which analyzes the current situation of cross-cultural language education and sustainable development in theory and practice by reviewing relevant literature and research progress, and lays the foundation for the subsequent research; the third part is the research methodology, which introduces in detail the theoretical framework of the study, the data collection method and the analytical tools, including questionnaires, interviews, and case study design; the fourth part is the results and discussion, which discusses the impact of cross-cultural language education on TCDD and puts forward targeted policies and measures based on the data analysis and the case study; and the fourth part is the results and discussion. Based on the data analysis and case studies, the results and discussion provide a thorough examination of the effects of intercultural language education on TCD and sustainable development, as well as targeted policy and practice recommendations. Through the above structural arrangement, this paper aims to systematically explore the research issues from both theoretical and practical perspectives and to provide reference value for the related fields.

2 Research review

2.1 Theory and practice of intercultural language education

Intercultural language education, as an important way to promote international understanding and collaboration, has been a central theme in language education research[7]. Existing research has focused on the cultural sensitivity of language education, the diversity of teaching methods, and the supporting role of technological means[8]. Especially in the context of globalization, the goal of intercultural language education has expanded from merely cultivating language proficiency to promoting intercultural communicative competence and cultural adaptability. In addition, the introduction of digital learning platforms has extended the boundaries of language learning and provided more possibilities for non-face-to-face communication[9]. However, research on the integration of intercultural language education with the S&E SDGs is still fragmented and lacks systematic exploration. In Figure 1 below, a conceptual diagram of the core theoretical model of intercultural language education is presented, which is not only an important way to promote international understanding and collaboration but also a central topic in language education research. The model consists of three main components: language proficiency enhancement, intercultural communication skills, and sustainable technology dissemination, which together form a comprehensive framework for intercultural language education.

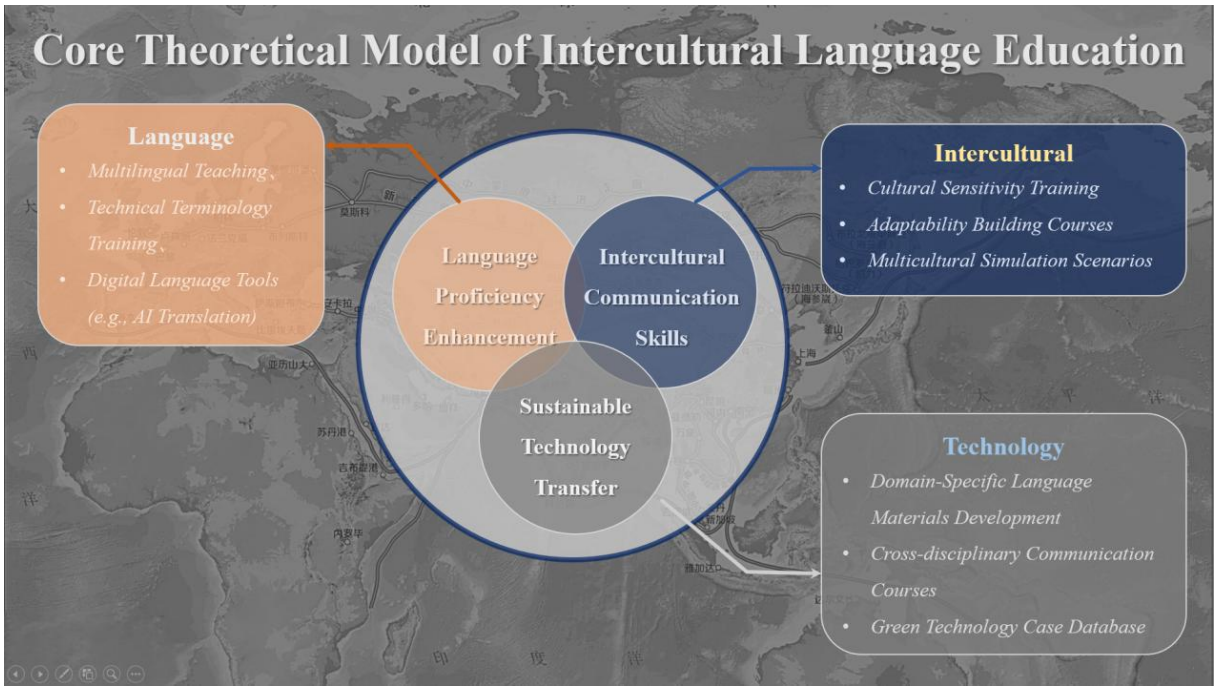

Figure 1: Core theoretical model of intercultural language education

Language proficiency enhancement, which includes multilingual instruction, training in technical terminology, and the use of digital language tools, is particularly important in the context of globalization because it helps learners expand from simply developing language proficiency to promoting intercultural communicative competence and cultural resilience[10]. Intercultural communication skills, which involve cultural sensitivity training, adaptive construction courses, and multicultural simulation scenarios, underscore existing research focusing on cultural sensitivity and diversity of pedagogical approaches in language education[11]. Sustainable technology transfer, on the other hand, focuses on the development

of domain-specific language materials, interdisciplinary communication curricula, and the creation of a database of green technology cases, which demonstrates the potential for integrating intercultural language education with the sustainability goals of science and technology disciplines, even though the research in this area remains fragmented and lacks systematic exploration. In addition, the introduction of digital learning platforms has extended the boundaries of language learning and provided more possibilities for non-face-to-face communication, further emphasizing the complementary role of technological tools in intercultural language education.

2.2 Sustainable development goals and the road and belt context

The Sustainable Development Goals (SDGs) are 17 goals formulated by the United Nations to address global economic, social, and environmental challenges, among which energy, resource management, climate action, and other goals have significant scientific and technological characteristics[12]. With the promotion of the Belt and Road Initiative, there has been a notable increase in sustainable development practices in domains like infrastructure construction, energy supply, and technology exchanges. However, due to cultural and linguistic differences among countries, relevant cooperation projects often face problems such as miscommunication and cognitive bias. Such challenges further highlight the role of language education in cross-cultural communication and collaboration. As shown in Figure 2.

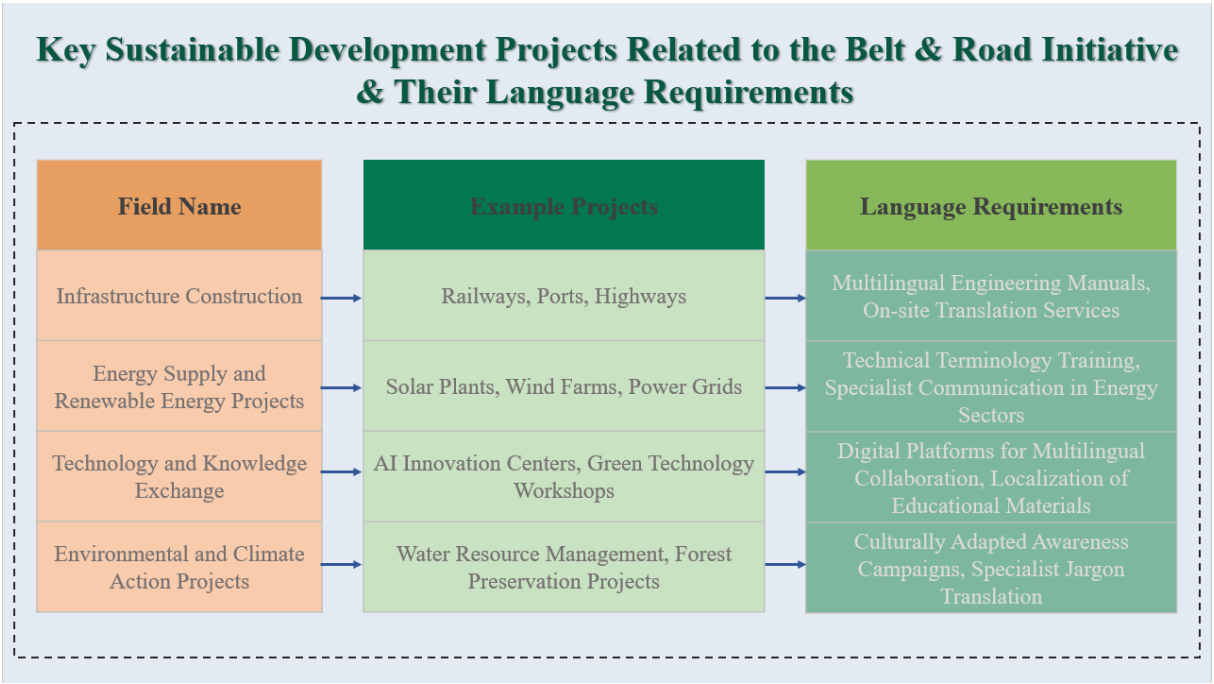

Figure 2: Map of major sustainable development projects related to the Belt and Road and their language requirements

Figure 2 summarizes the key sustainable development projects and their language needs related to the Initiative for the Belt and Road. The first column of the figure indicates the name of the domain and lists the areas of sustainable development. The second column shows examples of projects, with specific Belt and Road-related projects under each area. The third column lists the key language services needed to support these projects. The diagram is organized into four main areas: infrastructure development, energy supply and renewable

energy projects, technology and knowledge exchange, and environment and climate action projects. Multilingual engineering manuals and on-site translation services are required for infrastructure development projects, such as railroads, ports, and highways[13]. Energy supply and renewable energy projects, such as solar power plants, wind farms, power grids, etc., require training in technical terminology and specialized communication in the energy sector[14]. Technology and knowledge exchange areas, including artificial intelligence innovation centers, green technology workshops, etc., require multilingual collaborative digital platforms and localization of educational materials[15]. Environment and Climate Action projects, such as Water Resource Management, Forest Conservation projects, etc., require culturally adapted awareness-raising activities and translation of specialized terminology. The language needs of these projects emphasize the importance of cross-cultural communication and language services in promoting sustainable development under the Belt and Road Initiative.

2.3 Integration paths for intercultural language education and sustainable development

In recent years, some studies have explored how cross-cultural language education can support green economic development and environmental protection[16]. For example, by developing bilingual courses for the field of energy technology or utilizing artificial intelligence to enhance the efficiency of cross-disciplinary communication, they have provided lessons for related fields. However, most of these studies focus on domain-specific applications and lack a macro perspective on the integration of language education, sustainable development, and cross-cultural communication. As shown in Figure 3, in addition, existing studies have not discussed enough about how to innovate cross-cultural language education in support of sustainable development practices with reference to the "Belt and Road", and they lack typical cases and in-depth analyses.

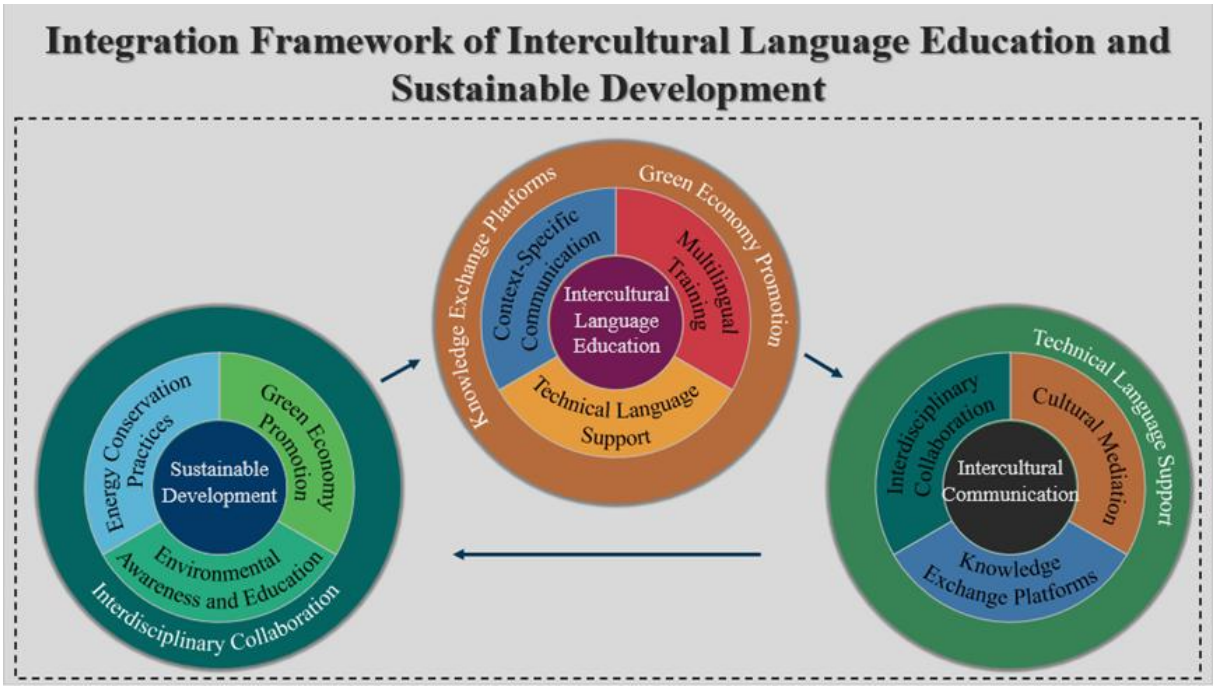

Figure 3: Framework diagram for the integration of intercultural language education and sustainable development

Figure 3 illustrates an integrated framework for intercultural language education and sustainable development, using a "three-module" arrangement, with a three-part, wrap-around relationship in the center that highlights the interaction between language education (brown circle), sustainable development (dark green circle), and intercultural communication (green circle). The modules are connected by arrows or bi-directional connecting lines, demonstrating their mutually reinforcing paths. The dark green circle on the left emphasizes the three dimensions of sustainability: Green Economy Promotion, Energy Conservation Practices, Environmental Awareness and Education, and Interdisciplinary Collaboration. The green circle on the right highlights the three components of intercultural communication: Cultural Mediation, Interdisciplinary Collaboration, and Knowledge Exchange Platforms. The entire framework aims to promote sustainable development through intercultural language education while ensuring environmental, economic, and social balance.

2.4 Innovations and contributions of this study

This study is dedicated to filling the above research gaps and proposing innovative paths for cross-cultural language education to promote the sustainable development of technology and science in relation to the "Belt and Road" from both theoretical and practical perspectives. Firstly, based on the multidisciplinary theoretical framework, it clarifies how language education can help energy and technology exchanges and cooperation; secondly, based on typical cases, it provides specific programs from the perspectives of cross-cultural communication, education mode, and technology application. It is hoped that this study can provide a useful reference for realizing global sustainable development.

3 Research method

This study adopts a combination of qualitative and quantitative methods to comprehensively analyze how cross-cultural language education in the context of the "Belt and Road" can contribute to the realization of the Sustainable Development Goals (SDGs). The research design consists of three parts: theoretical framework construction, empirical data collection and analysis, and practical discussion based on case studies.

3.1 Theoretical framework construction

To reveal the intrinsic connection between intercultural language education and sustainable development, this study builds an analytical framework based on multidisciplinary theories, combining pedagogy, linguistics, sustainable development theory, and intercultural communication. The framework consists of three core dimensions: (1) the need for language education in intercultural communication; (2) technology-language interaction in the field of sustainable development; and (3) the design of a two-way integration path. Each dimension was validated by the results of the literature review and expert interviews to ensure the academic and practical relevance of the framework.

3.2 Data collection methods

3.2.1 Literature analysis

Through searching PubMed, Web of Science, CNKI, and other databases, the core literature on "Belt and Road", cross-cultural language education, and sustainable development in the past 10 years was collected. We focused on screening highly cited articles and typical case studies and extracted keywords, models, and conclusions related to the topic of this study.

3.2.2 Questionnaires

A questionnaire was designed to address the goals of cross-cultural language education and sustainable development, including questions on the needs of language education, challenges of cross-cultural communication, and feedback on program practices (see Table 1 for the main questions and design logic of the questionnaire). The questionnaire will be distributed to education and technology experts involved in energy and technology cooperation in the countries along the Belt and Road, and it is planned to collect 200 valid questionnaires.

Table 1: Main questions and design logic of the questionnaire

Question No.	Description of the problem	design logic
Q1	What do you think is the demand for intercultural language education in Belt and Road projects?	This question was designed to assess the respondents' overall perception of the need for language education. It helps the researcher to understand the importance of language education in transnational cooperation as perceived by the respondents, especially for technical communication.
Q2	Do you believe that differences in languages and cultures have hurt the implementation of the project?	The purpose of this question is to explore the potential negative impact of cultural differences on program implementation to determine how language and cultural education can reduce barriers to collaboration.
Q3	How do you think the lack of intercultural language education affects the efficiency of technology diffusion in transnational cooperation?	This question helped to gather respondents' perceptions of the possible effects of the lack of language education, especially in terms of technical knowledge transfer and collaborative efficiency.
Q4	What do you think is the most common type of language barrier in intercultural cooperation? (e.g., translation of specialized terminology, daily communication, etc.)	This question was designed to identify the types of language barriers that respondents found most challenging during program implementation to inform targeted solutions.
Q5	How do you think language education curricula should be designed for technical training in sustainable development programs?	Explore how language education can be integrated with specific fields (e.g., new energy technologies, green infrastructure) and explore practical educational needs through this question.
Q6	Do you think cross-cultural language education is effective in promoting cross-cultural communication in technology programs?	This question was intended to verify whether language education can serve as an important tool for promoting intercultural communication and the respondents' perceptions of its possible impact.
Q7	In your experience, how do you think language education can support the sustainability of the Belt and Road program?	This question aims to explore the practical role of language education in supporting the implementation of the project's sustainable development goals, including the green economy, environmental protection, and other aspects.
Q8	What are your thoughts on the need for bilingual or multilingual technology programs?	This question was designed to understand respondents' attitudes toward courses that have a combination of language and technology and to explore the potential for their use in programs.
Q9	Can language education help alleviate misunderstandings and conflicts caused by cultural differences?	The purpose of this question is to assess the effectiveness of intercultural language education in reducing communication misunderstandings and increasing the effectiveness of cooperation.
Q10	How do you think the content of language education can be optimized to meet the actual needs of the Belt and Road project?	This question helped to uncover respondents' specific suggestions for optimizing language education programs, providing a practical reference for the design of language education in future Belt and Road projects.

3.2.3 In-depth interviews

Ten experts in the field of energy technology exchange or language education in projects related to the Belt and Road were selected for semi-structured interviews (see Table 2 for the main questions of the interview outline and their expected goals), which centered on the following aspects: (1) the role of language in cross-cultural technical cooperation; (2) language barriers and strategies to solve them; and (3) potential contribution of innovative language education models to sustainable development projects. (1) the role of language in cross-cultural technical cooperation; (2) language barriers and strategies to address them in sustainable development practice; and (3) the potential contribution of innovative language education models to sustainable development programs.

Table 2: Main questions of the interview outline and their intended objectives

Question No.	Description of the problem	intended target
Q1	In your experience, what is the role of language in cross-cultural technical cooperation?	This issue aims to provide insight into the practical impact of language in facilitating technical communication and transnational cooperation and to help identify the critical role of cross-cultural language education in technical communication.
Q2	In the Belt and Road projects you have been involved in, what specific challenges have the language barrier posed to project implementation?	Through this question, explore the specific impacts of language barriers in project implementation, such as project delays, frequency of misunderstandings, etc., and obtain first-hand data to understand the magnitude of language challenges.
Q3	What do you think about the relationship between cultural differences and language barriers in the Belt and Road program?	The purpose of this question is to examine how cultural differences exacerbate language barriers and affect effective communication in cross-cultural teams, providing support for further educational strategy adjustments.
Q4	What strategies or approaches to address language barriers are currently being used in practice?	This question aims to understand the specific strategies used to address language issues in existing practice and to explore which methods can alleviate communication difficulties and enhance the effectiveness of intercultural cooperation.
Q5	In your opinion, does the existing language education meet the needs of the energy technology sector in the Belt and Road program?	The main goal of this question is to assess the match between the existing language education system and the specific technological needs and to propose options for improvement.
Q6	What should be the characteristics of an innovative model of intercultural language education in the Belt and Road energy technology cooperation?	The issue expects to discover emerging innovative models of language education and identify how they can better support energy technology cooperation, especially as applied in the context of sustainable development.
Q7	What do you think about the model of combining language education with technical content and is it applicable to the One Belt One Road program?	This question was used to understand experts' views on integrating language education and technology content (e.g., topics such as energy, environmental protection, etc.) and to collect specific examples and their impact on program effectiveness.
Q8	How well do you think the customized language courses have been implemented in the program, especially in the field of energy technology?	This question aims to explore the practical application of customized language education courses in the technical field and to investigate their effectiveness and challenges in improving the efficiency of project communication.
Q9	How can language education models better integrate environmental and social responsibility goals in programs that promote sustainable development?	This question looks forward to suggestions on how language education can be integrated with the SDGs (e.g., green economy, energy management, etc.) to help advance cross-cultural cooperation and sustainable program development.
Q10	What trends do you foresee for the future of intercultural language education?	The question was designed to explore the views of the interviewed experts on the future direction of intercultural language education, and whether there is a need for more technical support, innovative approaches, or institutional safeguards to help assess the future needs of language education.

3.2.4 Case studies

In this study, the case study method is used to gain insights into the practical implications of language education in cross-cultural projects, especially in the context of the Belt and Road, and how language and cultural factors can contribute to or impede the realization of the SDGs. To this end, three representative "Belt and Road" projects were selected as the objects of study, which are related to different regions and fields, including a renewable energy cooperation project in the Middle East, a green infrastructure construction project in Southeast Asia, and a new energy promotion project in Central Asia. The reason for choosing these cases is that they are not only highly representative but also demonstrate the role and challenges of cross-cultural language education in technical cooperation under different cultural backgrounds and language environments.

Case Selection Criteria: (1) Diversity of project geographic regions: Selecting projects from different regions can better demonstrate the impact of cultural and linguistic differences on sustainable development. For example, the Middle East and Southeast Asia have widely differing cultural backgrounds, representing different language barriers and cultural adaptation challenges, respectively. (2) Project Scale and SDGs: The cases selected should cover SDGs of significance (e.g., clean energy, green infrastructure development, etc.) and need language education and technical training in the implementation process. (3) Data Availability: The case study projects have detailed project reports, open literature analysis, and relevant data in the implementation process, which will help the case study to develop in depth.

Research Steps: Through literature analysis, project reports, and relevant interview records, the specific context, linguistic and cultural factors, and their impact on project implementation and sustainable development were organized for each case. The analysis process focuses on the following aspects: (1) Language barriers in project implementation: analyze the language barriers encountered by project participants in the process of communication, technology transfer, and cross-cultural exchange and the impact of these barriers on the progress of the project. (2) Cultural Adaptation: To examine the mode of cooperation among participants from different countries in understanding and adapting to different cultural contexts, especially cultural conflicts in technical training and knowledge exchange and their resolution strategies. (3) Sustainable development impact of the project: to explore how linguistic and cultural factors affect the sustainable development of the project, especially its effectiveness in scientific and technological dissemination, environmental protection, and so on.

Through the in-depth analysis of these three cases, this study tries to reveal how language education can play a unique role in sustainable development projects in the context of the "Belt and Road", and provide a reference for the implementation of similar projects in the future. Table 3 below shows the step-by-step process of analyzing each case.

Table 3: Step-by-step process for each case study

move	Middle East renewable energy projects	Green infrastructure projects in South-East Asia	Central Asia New Energy Promotion Project
Project background analysis	Analyze the context in which the project was initiated and the sustainable development goals it addresses	Analyzing the context of the project and its linkages with other constructions within the Belt and Road framework	Explore the objectives of the project and the regional cooperation networks it involves
Identification of linguistic and cultural factors	Recognize the impact of language barriers and culture clashes on collaborative processes.	Analyze situations such as language barriers and cultural differences that affect communication and cooperation at work.	Understand the impact of accurate and culturally appropriate translation of technical terminology on project implementation.
Literature and project report review	Collection of relevant data to support analysis of linguistic and cultural factors through publicly available project literature and technical reports	Review the project plan and mid-term evaluation report to explore the role of cultural adaptation training.	Review of the research materials involved and the language education needs in the technical programs of the partner companies.
Reflections on case successes and failures	Identify success and failure factors in program implementation, with a focus on analyzing the challenges of linguistic and cultural adaptation.	Summarize linguistic and cultural adaptation success factors in the project and analyze possible communication barriers.	Summarize how innovative technologies in the program support language education and enhance program success.
Analysis of the impact of language education on the sustainability of the project	Evaluate how language education contributes to technical cooperation efficiency and project delivery and analyze how cultural barriers slow progress.	Promoting the dissemination of green technologies and infrastructure through bilingual education modules and analyzing the impact of language training	The Role of Combining Technology Advancement and Language Education Based on Artificial Intelligence Translation Systems in Enhancing the Efficiency of Collaboration
Suggested responses and future perspectives	Propose strategies for optimizing language education in the program and look at future opportunities for similar programs.	Provide advice on the optimization of pedagogical design for intercultural language education to promote the adaptability of the various actors involved.	Recommendations for future educational support for similar projects based on successes and lessons learned.

3.3 Data analysis methods

3.3.1 Qualitative analysis

The data collected in the in-depth interviews and case studies were thematically analyzed to extract the main ideas and summarize the patterns of correlation between language education and sustainable development. NVivo software was used to code and analyze the textual content to ensure the reliability and consistency of the results.

3.3.2 Quantitative analysis

Descriptive statistics and regression analysis of the questionnaire data were conducted using SPSS to verify the statistical correlation between the demand for language education and the achievement of the SDGs. In this way, the core hypotheses presented in the theoretical framework were further supported. As shown in Table 4.

Table 4: Statistical results of the questionnaire

Variable	Mean	Standard Deviation	Regression Coefficient (β)	Significance (p-value)
Language Proficiency Needs	4.28	0.72	0.621	<0.01
Cultural Understanding Gaps	3.91	0.83	0.574	<0.05
Sustainable Practice Awareness	3.65	0.68	0.489	<0.05
Overall Technical Efficiency	4.12	0.89	0.732	<0.01

According to the data in Table 4, it can be obtained that the results of the questionnaire and regression analysis show that language proficiency needs have a significant effect on the technical efficiency improvement of sustainable development programs, with a regression coefficient of 0.621 and a significance level of less than 0.01, showing a high degree of correlation. Meanwhile, the cultural understanding gap (regression coefficient 0.574, $p < 0.05$) as well as awareness of sustainable practices (regression coefficient 0.489, $p < 0.05$) also have a strong correlation with technical efficiency. This suggests that language education has an important role to play in removing cultural barriers, enhancing intercultural understanding, and contributing to the achievement of sustainable development goals. Taken together, the comprehensive optimization of language education can significantly improve the efficiency of cross-cultural technical cooperation and provide strong support for the practice of sustainable development in the context of the "Belt and Road"[17].

3.4 Quantitative Models for Intercultural Language Education and Sustainable Development in the Belt and Road Context

To further quantify the relationship between intercultural language education (ICLE), technology diffusion, and sustainable development. The paper constructs three targeted quantitative models. These models are derived from the theoretical framework, data collection methods, and preliminary empirical observations, and serve as a bridge between methodological design and result interpretation.

To verify the statistical correlation between language education-related factors and cross-cultural technical cooperation efficiency, a multiple linear regression model is established.

The model is expressed as:

$$TE = \alpha + \beta_1 LP + \beta_2 CUG + \beta_3 SA + \varepsilon \quad (1)$$

TE , or Total Technical Efficiency, refers to the overall efficiency of cross-cultural technical cooperation, scored on a 1–5 scale based on evaluations of technical cooperation effectiveness, with a mean value reflecting general performance in practice. α is the constant term, representing the baseline level of technical efficiency when no language education intervention is implemented β_1 , β_2 , and β_3 are regression coefficients that reflect the intensity of each variable's impact on TE ; positive coefficients indicate that enhancing the corresponding variable contributes to higher technical efficiency. ε is the random error term, following a normal distribution, which accounts for minor unmeasured factors.

This model confirms that language education-related variables exert a significant positive impact on technical efficiency; specifically, the correlation between language proficiency needs and technical efficiency reaches a high level of statistical significance, while cultural understanding gaps and sustainable practice awareness also show meaningful positive correlations with technical efficiency.

Built on the three core components of intercultural language education—language proficiency enhancement, intercultural communication skills, and sustainable technology transfer—a comprehensive effectiveness model is constructed. This model converts the qualitative theoretical framework of ICLE into a measurable tool, enabling objective evaluation of ICLE practices in different project cases.

The model is expressed as:

$$E_{ICLE} = \omega_1 L + \omega_2 C + \omega_3 T (\omega_1 + \omega_2 + \omega_3 = 1) \tag{2}$$

ICLE , or Comprehensive Effectiveness of ICLE, refers to the overall effectiveness of intercultural language education, scored on a 0–100 scale, with higher scores indicating stronger support for sustainable development goals. ω_1 , ω_2 , and ω_3 are weights assigned to the three core components. L , or Language Proficiency Score, is the effectiveness of language proficiency enhancement, scored on a 0–100 scale, evaluated through indicators such as technical terminology accuracy and daily communication fluency in project cooperation. C , or Intercultural Communication Score, is the effectiveness of intercultural communication skills training, scored on a 0–100 scale, assessed via indicators such as conflict reduction rate and collaborative tacit understanding among cross-cultural teams. T , or Sustainable Technology Transfer Score, is the effectiveness of ICLE in promoting technology diffusion, scored on a 0–100 scale, measured by indicators such as technology dissemination speed and knowledge absorption rate in partner countries. This model enables quantitative comparison of ICLE effectiveness across diverse project contexts, providing a unified standard for identifying successful practices and areas for improvement inimplementation.

To quantify the negative impact of language and cultural barriers on Belt and Road sustainable development projects, a risk coefficient model is established. This model helps predict project risks caused by insufficient ICLE and supports the proposal of targeted intervention strategies.

The model is expressed as:

$$R = (\lambda L + \mu C) \times D \tag{3}$$

R , or Project Risk Coefficient, is the risk level of project delays, disputes, or inefficiencies caused by language or cultural barriers, scored on a 0–10 scale; a score of 5 or higher indicates high risk, requiring immediate intervention, while a score below 3 indicates

low risk with minimal impact on project progress. λ is the weight of language barriers, ranging from 0 to 1, determined by the frequency of language-related issues in project implementation. μ is the weight of cultural barriers, ranging from 0 to 1, determined by the frequency of cultural conflicts affecting project collaboration. L, or Language Barrier Intensity, is the severity of language barriers, scored on a 0–10 scale; a score of 10 indicates severe terminology misunderstanding that triggers technical disputes, while a score of 0 means no language barriers affect cooperation. C, or Cultural Barrier Intensity, is the severity of cultural barriers, scored on a 0–10 scale; a score of 10 denotes severe cultural conflicts that lead to trade disputes, while a score of 0 indicates no cultural misalignment impacts project progress. D, or Project Complexity Coefficient, is a measure of project complexity, ranging from 1 to 2; high-complexity projects such as energy development and infrastructure construction have a coefficient of 1.8, while simple projects like basic training have a coefficient of 1.2. This model provides a practical tool for risk prediction and prevention in future Belt and Road projects.

3.5 Methodological reliability and ethical considerations

To ensure the reliability and scientific validity of the research methodology, this study followed a standardized academic process in each step of the design. The design of questionnaires and interviews were reviewed by experts and tested in pilot runs to verify their applicability and accuracy. In addition, research ethics were strictly adhered to during the implementation of the study, including obtaining written informed consent from the respondents and ensuring the anonymization of all data.

4 Results and discussion

4.1 Results

4.1.1 Results of the questionnaire survey

In this study, 200 valid questionnaires were collected, and the data provided by the respondents were statistically analyzed in detail, revealing the following important findings. The results of the questionnaire analysis provide valuable information for understanding the relationship between language education and technological cooperation in sustainable development projects related to the Belt and Road and provide useful insights for future innovations in education models.

First, the demand for language education is highly concentrated in the field of energy technology. More than 75% of the respondents identified insufficient language skills as a major obstacle to technical cooperation in Belt and Road-related sustainable development projects. This finding highlights the fact that language issues, especially in the presentation of technical language in specialized areas, are a serious constraint to the successful implementation of transnational technology cooperation. Especially in the scenario of new energy technology dissemination and international cooperation, precise technical language expression is considered crucial. Most of the interviewees indicated that technical discussions often fall into misunderstanding or ambiguity due to inaccurate linguistic expressions or improper translations, which not only slows down the transfer of information but also may hurt the final effectiveness of the project. Therefore, improving the accuracy and applicability of energy-related technical language has become a key element in improving the efficiency of cooperation. Second, cultural barriers affect the efficiency of cross-cultural collaboration. About 68% of the respondents pointed out that misunderstandings and conflicts caused by

language and cultural differences in cross-cultural teams significantly reduced the efficiency of project advancement. This suggests that cultural differences in multinational projects, especially cultural conflicts exacerbated by language barriers, are an important factor affecting the efficiency of team collaboration. Whether in the case of face-to-face communication or virtual communication, language and cultural differences increase the complexity of collaboration, which leads to a series of negative consequences such as understanding bias, information distortion, and decision-making delays. Therefore, overcoming such cultural barriers and understanding and respecting cultural differences is important for facilitating the smooth progress of projects and enhancing teamwork. Finally, the need for innovation in language education is high. About 82% of the respondents suggested that an educational model that combines language training with technical content related to sustainable development would better meet program needs. Most of the experts interviewed said that the current model of language education does not adequately meet the needs of technical cooperation, especially in the "Belt and Road" projects, where communication between disciplines and cross-cultural collaboration are often difficult. Therefore, combining language teaching with the needs of specific industries, especially in the fields of energy technology and green infrastructure construction, has become a key path to improving the effectiveness of education, reducing communication barriers, and promoting knowledge transfer. Based on this, the design of customized, goal-oriented language education courses and comprehensive training programs has become an important step to enhance the effectiveness of cooperation in the "Belt and Road" sustainable development projects. Overall, the survey reflects the importance of language proficiency in cross-cultural collaboration, especially in transnational projects involving energy and technology, where language education plays a key role in facilitating efficient cooperation and achieving sustainable development. As shown in Figure 4, the results of the survey further suggest that strengthening language training systems integrated with specific technical content to address cultural and linguistic barriers is an effective way to enhance the quality of project cooperation and achieve sustainable goals.

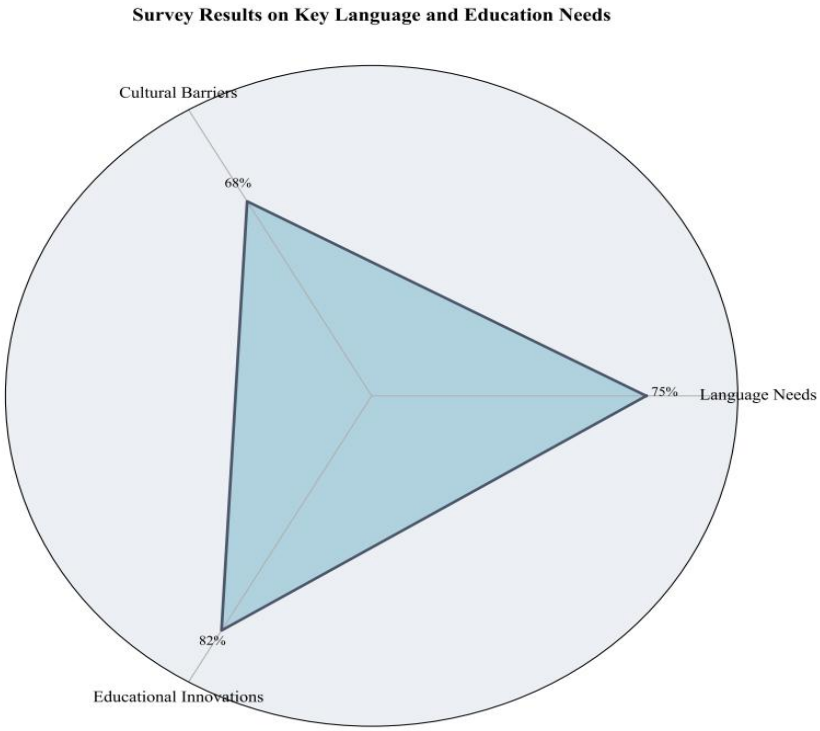

Figure 4: Radar chart of questionnaire statistics

Figure 4 above presents the results of the survey on key language and education needs in the form of a radar chart. The chart shows three main areas of concern: cultural barriers at 68%, educational innovation at 82%, and language needs at 75%. These figures reflect the fact that educational innovation was the most highly prioritized area in terms of language and educational needs, followed by language needs, while cultural barriers were relatively low. This suggests that educational innovation and language needs were seen in the survey as key factors in meeting educational development, while cultural barriers, while present, were relatively less influential.

4.1.2 Results of in-depth interviews

Through in-depth interviews with 10 experts in the field of energy and technology exchange or language education in Belt and Road projects, this study summarizes the following key insights, which provide valuable perspectives on how language education can contribute to cross-cultural cooperation and the achievement of the Sustainable Development Goals (SDGs).

First, language is a core medium of technical communication[18]. Most experts interviewed agreed that language plays a crucial role in intercultural technical communication. However, experts pointed out that the goal of cross-cultural language education is not only to teach basic language skills but also to strengthen the deep integration of technical terminology and background knowledge and reduce the loss of information in specialized areas. In many multinational projects involving complex technologies, communication efficiency is often limited by a lack of precise technical terminology or inappropriate expressions, which may even trigger significant deviations in understanding. Therefore, effective cross-cultural language education must provide adequate support for technical communication, not only in terms of superficial language transfer but also by seamlessly integrating specialized knowledge in the technical field to ensure complete transfer of information and accurate understanding. Second, the a need for customized language programs. Energy technologists generally emphasize that technical needs vary widely from project to project, so generic language education curricula often fail to meet actual needs. Many interviewees believe that the existing standardized language courses are not able to adapt to the complex technical backgrounds of specific areas in the Belt and Road projects, especially those related to energy, environmental protection, and other high-tech fields. In response to this challenge, the experts interviewed generally support project-oriented customized language education programs, i.e., designing language training courses that are tailored to the technical characteristics and cooperation needs of specific projects. Customized language courses can not only help project team members master language skills closely related to technology, but also effectively reduce language barriers and communication errors during cross-cultural cooperation in projects. Finally, the importance of cultural context understanding. Several interviewed experts pointed out that language education is not only about teaching the language itself but must also emphasize the understanding of the cultural context. Especially in cross-cultural cooperation, participants from different countries and regions often have different communication habits, working styles, and problem-solving thinking due to cultural differences. Only based on a full understanding of cultural differences can all parties truly build effective bridges of communication. Therefore, cross-cultural language education should not only focus on the teaching of language skills but also help participants better understand and integrate into different cultural contexts by enhancing cultural awareness and cultural adaptability. The experts interviewed generally agreed that the cultivation of good cross-cultural awareness can

significantly enhance the tacit understanding of teamwork and facilitate the smooth progress of projects. As shown in Table 5.

Table 5: Key points from the interviews and related supporting data

Key points	Typical Discourse	Support Data
Language as a core medium	Technical communication is highly dependent on the integration of precise language skills and background knowledge	82% of experts emphasized the need to reduce information loss in technical exchanges
The need for customized language courses	Standard curricula often fail to meet the unique needs of diverse technology programs	74% recommend higher applicability through project-oriented language design
Importance of cultural contextualization	Understanding Cultural Differences is Key to Promoting Cross-Cultural Collaboration	68% of respondents emphasized the importance of integrating cultural content into language education

In conclusion, through the in-depth interviews, we have come to further realize that cross-cultural language education has an indispensable role to play in supporting the success of Belt and Road-related projects. Experts generally agree that, in the context of technical cooperation, the function of language goes far beyond daily communication, and is related to the precision and efficiency of technical communication, the effectiveness of project management, and the smooth implementation of cross-cultural collaboration[19]. Therefore, optimizing the language education curriculum, focusing on cultural differences, and enhancing the combination of language and technical knowledge will be the key direction of future educational innovation. At the same time, customized educational solutions will help achieve continuous innovation and development in the field of energy and technology, and promote the achievement of the Sustainable Development Goals.

4.1.3 Case study analysis

Through the analysis of three typical cases, this study explores the practical impact of cross-cultural language education on the implementation of sustainable development projects related to the Belt and Road and summarizes the key lessons learned from the successful, unsuccessful, and revealing cases.

4.1.3.1 Successful case: Green Infrastructure Project in Southeast Asia Region

In green infrastructure projects in Southeast Asia, a bilingual education module focusing on sustainable building was successfully introduced, which integrates the core concepts of sustainable development with specialized terminology in the construction field to provide targeted language training for project participants. Through this specialized language education module, the project team significantly reduced language barriers during technical exchanges, thus improving communication efficiency and cooperation. According to the statistics, the construction schedule of the project was accelerated by 20%, far exceeding the expected target. In addition, team members were able to discuss different technical solutions more smoothly, enabling more efficient consensus and faster decision-making during the overall execution of the project. This case shows that precise bilingual education modules not only help to improve the efficiency of cross-cultural communication but also significantly facilitate the project process and contribute to the realization of sustainable development goals.

4.1.3.2 Failed case: an energy project in the Middle East

In contrast, the case of an energy cooperation project in the Middle East reflects the negative impact of a lack of intercultural language education on project implementation. Failure to combine cross-cultural language education with technical training resulted in numerous communication barriers and misunderstandings within the project team[20]. The lack of precise understanding of terminology by project personnel, coupled with communication biases caused by cultural differences, resulted in a lack of consensus in the discussion of several technical solutions. Worse still, these misunderstandings not only affected the technical cooperation process but also triggered subsequent trade disputes, resulting in a two-year delay in the project. This failure case demonstrates the central role of language education in cross-cultural cooperation, especially within the technical field, where a lack of understanding of the technical language and its underlying cultural context often poses a great challenge to the smooth progress of a project.

4.1.3.3 Revelatory case: Central Asia New Energy Promotion Project

Finally, a new energy promotion project in Central Asia provides a revealing case study worth pondering. The project established a more efficient way of communicating technology among multicultural teams by combining a real-time translation system with artificial intelligence technology and language training. Even though the project team members came from different countries and cultural backgrounds, the combination of an intelligent translation system and customized language education greatly improved the efficiency of communication among team members and facilitated the rapid dissemination of knowledge and technology. The initiative significantly increased the speed of technical coordination and problem-solving among the team, allowing the project to achieve a higher success rate than expected during implementation. The case demonstrates that the introduction of modern technology, especially artificial intelligence, can play an important role in cross-cultural collaborative projects and that the combination of language education and technology is an important way to enhance the efficiency of a project and achieve the desired goals.

From the comparative analysis of the three cases, we can see that the role of cross-cultural language education in sustainable development projects related to the Belt and Road should not be underestimated. In the successful case, language education provided strong support for project progress and decision-making; in the unsuccessful case, the neglect of language barriers led to serious delays in the project; and in the instructive case, the combination of innovative technological tools and customized language education resulted in efficient cross-cultural communication and project success. These lessons learned provide valuable lessons for future project management and cross-cultural cooperation, especially in the context of technical cooperation combined with the Sustainable Development Goals (SDGs), where the integration of cross-cultural language education should be more widely applied and explored. As shown in Figure 5.

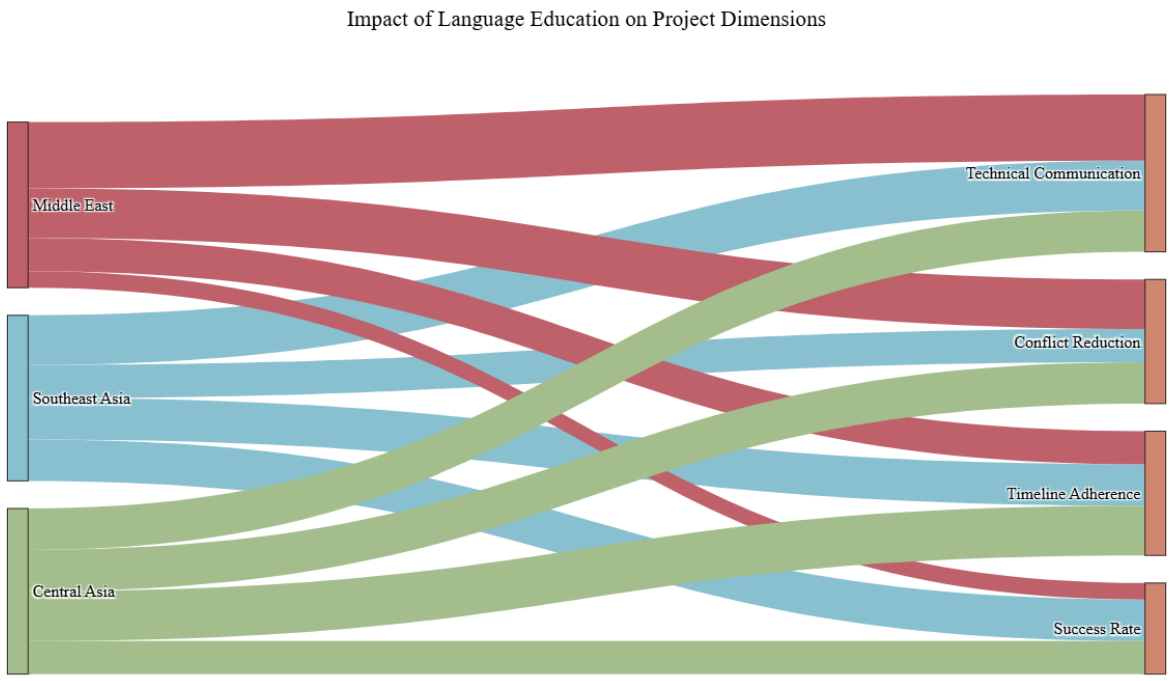

Figure 5: Comparison of the impact of language education on program effectiveness in the three cases

The Sankey diagram above shows a comparison of the impact of language education on program effectiveness across the three cases. The figure 5 highlights data flows and proportions and distinguishes regions and flow sources with different colors, and the nodes include three regions (project cases) and four dimensions (language impact effects). The connecting lines indicate the proportion of language education resources flowing from the regions to the different dimensions. The direction of impact of each project is reflected in the four dimensions: Technical Communication, Timeline Adherence, Conflict Reduction, and Success Rate. The Sankey diagram shows a comparison of the impact of language education on the different dimensions of the program across the three regions of the Middle East, Southeast Asia, and Central Asia. The diagram shows the performance of each region on the four program dimensions of Technical Communication, Conflict Reduction, Time Compliance, and Success Rate with different colored streamlines. The Middle East region excels in technical communication but is relatively weak in conflict reduction and time compliance. The Southeast Asia region performed well on conflict reduction and time compliance while being relatively weak in technical communication. Central Asia is the most significant performer in Success Rate, while its performance in the other three dimensions is relatively more balanced. Overall, there are differences in the impact of language education on program dimensions across regions, which are related to the culture, language environment, and educational priorities of each region.

4.2 Discussion

The results show that cross-cultural language education is not only a bridge to the realization of the sustainable development goals under the Belt and Road Initiative but also a catalyst for the dissemination of green technologies. Language education plays an important role in reducing misunderstandings and conflicts while helping to improve program efficiency. This is particularly evident in the area of energy technology diffusion. Case and interview results support the idea that customized language education programs based on projects can be more

efficient in meeting technology dissemination needs. While existing studies often emphasize the importance of general-purpose language education, this study further demonstrates that customized education models can effectively respond to the diverse technological needs of the Belt and Road Initiative, especially in cooperation in niche areas such as energy and construction. In practice, the integration of AI and language education can significantly improve the efficiency of cross-cultural technical cooperation. For example, the use of real-time translation tools, semantic recognition, and customized language learning software can shorten the negative impact of language barriers on technical communication. At the same time, these technological tools provide innovative solutions in the field of language education while improving efficiency.

Although this study provides a variety of conclusions, the limitations of the data need to be noted. For example, the sample of questionnaires and interviews was mainly limited to the core Belt and Road participating countries, and future research needs to cover more cultural contexts to increase the generalizability of the findings. In addition, this study focuses on the integration of language education with the energy and technology sectors, and its applicability to other SDGs (e.g., climate action or natural resource management) needs to be further verified. In the future, consideration should be given to building more globalized cases and deepening research on the integration of technology and language education.

5 Conclusion

In the context of the Belt and Road Initiative, this study systematically explores the intrinsic links and integration paths between cross-cultural language education and sustainable development and proposes innovative conclusions through the construction of theoretical frameworks, empirical analysis, and case studies. These conclusions not only fill the gaps of related research at the academic level but also provide new ideas for promoting international cooperation and technology dissemination at the practical level. First, this study verifies the key role of intercultural language education in the realization of the Sustainable Development Goals (SDGs). Language education is not only a tool to promote cultural exchange, but also a core driver of international cooperation in energy, technology, and other fields. The results of questionnaires and interviews show that efficient language education can effectively reduce communication barriers, enhance collaboration efficiency, and thus accelerate the promotion and application of green technologies. Second, this study highlights the importance of a project-oriented customized language education model. The case studies show that standardized language education can hardly meet the needs of diversified technology projects under the Belt and Road Initiative, and that domain-specific language training can significantly enhance the practical application value. Especially in the field of energy and technology dissemination, this model can significantly shorten the path of knowledge dissemination and ensure smooth international cooperation. In addition, the integration of technology and language education has been identified as an innovative direction for the future. Language education models based on artificial intelligence, real-time translation, and adaptive learning systems not only provide technical support for cooperation in the context of globalization but also broaden the application fields of cross-cultural language education. In the context of rapid technological development, such technology-driven educational innovations will further strengthen the capacity for collaboration in the realization of the Sustainable Development Goals.

However, despite the theoretical framework and case studies at the core of this study, with a focus on energy and technology diffusion, there are shortcomings, such as research on other SDGs (e.g., climate action, biodiversity conservation, etc.) that still need to be strengthened.

Further expanding the scope of the sample, enriching cases of cross-disciplinary practices, and exploring broader forms of technology and language education integration will be important paths to advance this research direction. For the future, through a systematic exploration of theory and practice, this study clarifies the multidimensional paths of cross-cultural language education for sustainable development in the context of the "Belt and Road", providing theoretical support for future research and practical guidance for the actual application.

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