Transforming Translation Education: A Bibliometric Analysis of Artificial Intelligence's Role in Fostering Sustainable Development

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Abstract. This bibliometric analysis focused on the potential and difficulties of implementing artificial intelligence (AI) in translation education. This study aligns with Sustainable Development Goal 4 (Quality Education), which emphasizes inclusive and equitable learning opportunities. It investigated the effects of AI tools on teaching methods, student engagement, and language skill development, including generative artificial intelligence (generative AI). Through co-citation and co-occurrence analysis of 281 Web of Science articles (2020–2024), this study identified key research trends, gaps, and interdisciplinary linkages. While AI research in education was extensive, its application in translation education remained fragmented and lacked a cohesive theoretical framework. This study extended AI adoption models by incorporating ethical considerations and pedagogical challenges, addressing gaps in prior research. The findings highlighted the need for institutional support, targeted training, and interdisciplinary cooperation to facilitate AI integration. This study identified gaps in AI-driven translation pedagogy and proposed a framework to enhance integration, particularly in teaching methodologies, ethics, and interdisciplinary collaboration. While AI fosters creativity in curriculum design, personalized learning, and multilingual communication, over-reliance on

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AI tools may weaken language proficiency. To address inequalities in AI access, inclusive and ethical AI integration strategies aligned with Sustainable Development Goal 10 (Reduced Inequalities) are crucial. This study reinforced the importance of institutional support, targeted training, and resource development to ensure sustainable AI adoption in translation education. It calls for informed policies and interdisciplinary cooperation to advance sustainable and equitable education while optimizing AI-driven learning environments.

Keywords: artificial intelligence; translation education; ethics; sustainability

1. Introduction

At present, the research trend in AI emphasizes the development of large language models, ethical AI, personalized learning, and interdisciplinary applications. In this context, in addition to examining the challenges and transformative potential of AI, the study concentrates on its pedagogical integration into translation education and its broader impact on educational quality, curriculum design, and technological adaptation. Both business professionals and academic researchers are interested in the subject, as AI-driven tools increasingly shape interdisciplinary educational frameworks and redefine learning methodologies (Adıgüzel, Kaya, & Cansu, 2023; Baidoo-Anu & Ansah, 2023). Thanks to the rapid advancement of AI and machine learning, conventional educational paradigms are being altered by AI tools such as ChatGPT, a generative artificial intelligence (AI) model developed by OpenAI. (Chen et al., 2020; Zawacki-Richter et al., 2019). Due to AI-driven innovations, translation education is evolving. These innovations are anticipated to significantly alter teaching methods by improving personalization, operational efficiency, and interactive engagement. The integration of AI tools in translation education helps bridge critical gaps in resource availability and accessibility. For instance, generative AI models support various tasks, such as improving comprehension abilities, encouraging student participation, and processing language in real time. However, the use of these technologies has brought to light concerns about trust in AI, ethical issues, and the dangers of relying too much on automated systems (Dwivedi et al., 2023; Lim et al., 2023). Traditional technology adoption models, such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), focus on user perceptions of usefulness and ease of use, but they frequently overlook ethical and pedagogical concerns in AI-driven education. This study contributes to theoretical advancements by extending AI adoption frameworks to incorporate ethical considerations—such as data privacy, algorithmic bias, and trust—alongside technological affordances. Moreover, it provides an interdisciplinary perspective that integrates pedagogical methodologies with AI functionalities, addressing gaps in prior research on AI governance in translation education.

Furthermore, there are growing discussions about how AI might affect the development of traditional skills critical to translation education, such as cultural interpretation, in-depth linguistic analysis, terminology management, and contextual adaptation. (Kasneci et al., 2023). Addressing these challenges is crucial

to ensuring that AI serves as an effective pedagogical tool rather than a substitute for essential human cognitive and interpretative skills. The study also highlights the necessity of balancing technological assistance with human expertise to maintain the integrity of translation education. Beyond their pedagogical applications, AI tools influence education more broadly by promoting interdisciplinary cooperation and pushing teachers to reconsider conventional approaches (Adıgüzel, Kaya, & Cansu, 2023). Despite these benefits, educational institutions and instructors frequently lack the resources and training required for the effective integration of AI into their teaching methods (Celik et al., 2022; Zawacki-Richter et al., 2019). Current research on AI in translation education remains fragmented, with limited focus on its pedagogical integration. Most existing studies center around AI's utilization in translation practice rather than its effect on curriculum design, student engagement, and skill development. Furthermore, while ethical concerns and institutional challenges associated with AI in education are widely recognized, there is a scarcity of comprehensive frameworks for its responsible implementation in translation education. This study employs bibliometric analysis to systematically examine research trends and insights on AI in translation education. The purpose of this study is to systematically investigate the integration of AI in translation education by answering the following two research questions:

RQ1: What are the most prominent research trends, influential studies, and theoretical frameworks in AI-powered translation education?
RQ2: What emerging themes and interdisciplinary connections can be identified using co-occurrence analysis, and how do they influence future research?

By identifying emerging themes through co-occurrence analysis, this study provides forward-looking insights into the evolving landscape of AI in translation education. The findings offer a roadmap for future research by highlighting underexplored interdisciplinary connections, informing pedagogical strategies, and guiding policy development. This approach ensures that educational institutions and educators can proactively adapt to AI advancements rather than reacting to technological disruptions.

2. Literature Review

Translation quality, post-editing effectiveness, and student engagement are all impacted by the growing integration of AI technologies into translation education (Amaro & João Pires, 2024; Wang, 2023; Li et al., 2023). The growing reliance on AI tools in translation education raises serious concerns about their pedagogical effectiveness, ethical implications, and long-term impact on translation competency. Various adoption models like the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) have been widely used to explain the adoption of digital tools in education. However, these models primarily focus on user perceptions such as usefulness and ease of use, while leaving out pedagogical and ethical considerations in AI-driven translation education (Almogren & Aljammaz, 2022; Su & Yang, 2023). Recent research has critiqued UTAUT's static nature, emphasizing that while it offers insights into early-stage adoption, it does not adequately capture the evolving nature of AI adoption, where users must continuously adapt to changing

functionalities, policies, and ethical considerations (Dwivedi et al., 2019). Similarly, while TAM has been widely used in educational technology research, it has been criticized for failing to incorporate ethical considerations, particularly in AI-driven decision-making. According to Shin (2020), user trust in AI systems is influenced by fairness, accountability, transparency, and explainability, in addition to usefulness and ease of use. Problems like algorithmic bias, opaque decision-making, and data privacy directly affect user engagement and pedagogical efficacy in AI-assisted translation education. Recent studies indicate that integrating AI into education is a dynamic process that calls for constant adjustment (Baidoo-Anu & Ansah, 2023). Given that AI adoption is not a one-time decision but rather a continuous, adaptive process, there is a growing need for a more dynamic theoretical model that incorporates pedagogical strategies, AI functionalities, and ethical concerns as evolving, interdependent factors rather than static constructs.

Existing research has examined AI's role in translation learning, with studies focusing on machine translation post-editing (MTPE), translation competence development, and human-AI collaboration (Liu & Afzaal, 2021; Wang, 2023). Researchers argue that AI can enhance translation accuracy and efficiency, yet its influence on translation cognition and student decision-making processes remains underexplored. While AI-enabled translation tools can speed up processes, they may also hinder students' critical thinking and problem-solving skills, especially if they become overly reliant on automated results (Amaro & João Pires, 2024). This issue emphasizes the importance of combining AI-assisted learning with traditional pedagogical approaches to maintain students' cognitive engagement in translation tasks. Despite AI's potential, scholars have raised concerns regarding data privacy, algorithmic bias, and over-reliance on AI-generated translations (Akgun & Greenhow, 2022; Chiu, 2023). AI-based translation models rely on vast datasets, which can introduce biases based on linguistic patterns present in the training corpus. Such biases could have a detrimental effect on translation quality and reinforce stereotypes in translated content if they are not addressed (Holmes et al., 2022). Ethical concerns also include data ownership and academic integrity, as AI-generated translations blur the line between student work and machine-generated results. These ethical challenges highlight the need for a more structured AI governance framework in educational settings (Holmes et al., 2022). Furthermore, interdisciplinary collaboration, integrating expertise from computational linguistics, translation studies, and educational technology, has been suggested as a key factor in ensuring AI's responsible and effective use in translation programs (Chan, 2023).
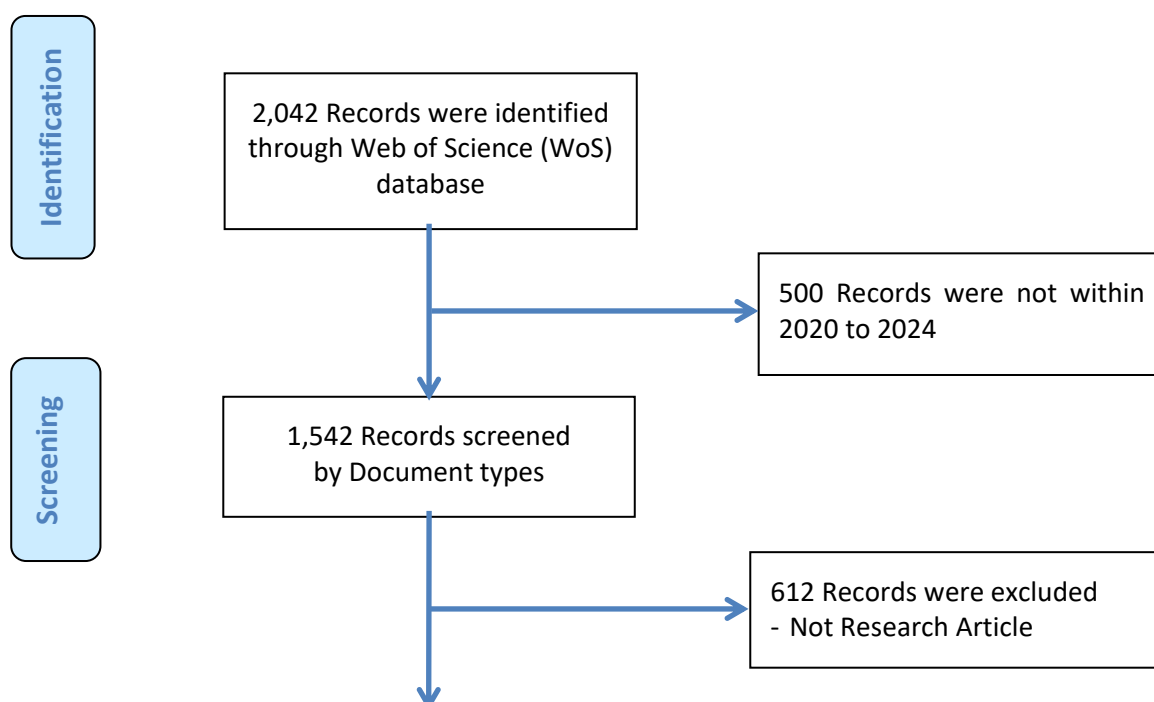
The existing literature shows that while AI has been integrated into translation education, research is still fragmented. Theoretical models like TAM and UTAUT provide fundamental insights, but they do not fully capture the complexities of AI adoption in translation learning environments. Additionally, while AI's potential to enhance translation efficiency and personalized learning is widely acknowledged, ethical concerns regarding bias and data privacy remain unresolved. Moreover, the pedagogical implications of AI-assisted translation tools require further investigation, particularly in terms of their effects on translation competence, decision-making, and student engagement. Future

studies should focus on developing a more unified framework that considers pedagogical, technological, and ethical factors in AI-driven translation education.

3. Method

Bibliometric analysis offers a systematic method for examining the corpus of research on AI in translation education by evaluating publications, citations, and keyword co-occurrences with statistical techniques. Web of Science (WoS) was selected because of its extensive coverage of high-impact, peer-reviewed journals in the fields of translation studies and AI. This ensures a robust dataset for bibliometric analysis, maintaining consistency in citation indexing and metadata structure. A systematic screening process was carried out using the PRISMA framework, employing specific search parameters, including time frame, document type, language, and access type. English-language and open-access publications were prioritized to enhance research accessibility, standardization, and comparability. The initial dataset of 2,042 articles produced by this method was reduced to 281 pertinent publications to ensure the inclusion of high-quality, peer-reviewed studies aligned with the research focus. The methodical screening procedure is graphically depicted in Figure 1, which breaks it down into four essential steps:

- (Identification) A total of 2,042 records were retrieved through comprehensive search strategies.
- (Screening) After applying temporal filters (2020–2024), 500 records remained.
- (Eligibility) This stage further excluded records that were non-research articles, non-English, or not Open Access, reducing the count to 930 full-text articles assessed.
- (Inclusion) Finally, 281 high-quality research articles meeting the criteria of relevance and rigor were selected for bibliometric analysis.
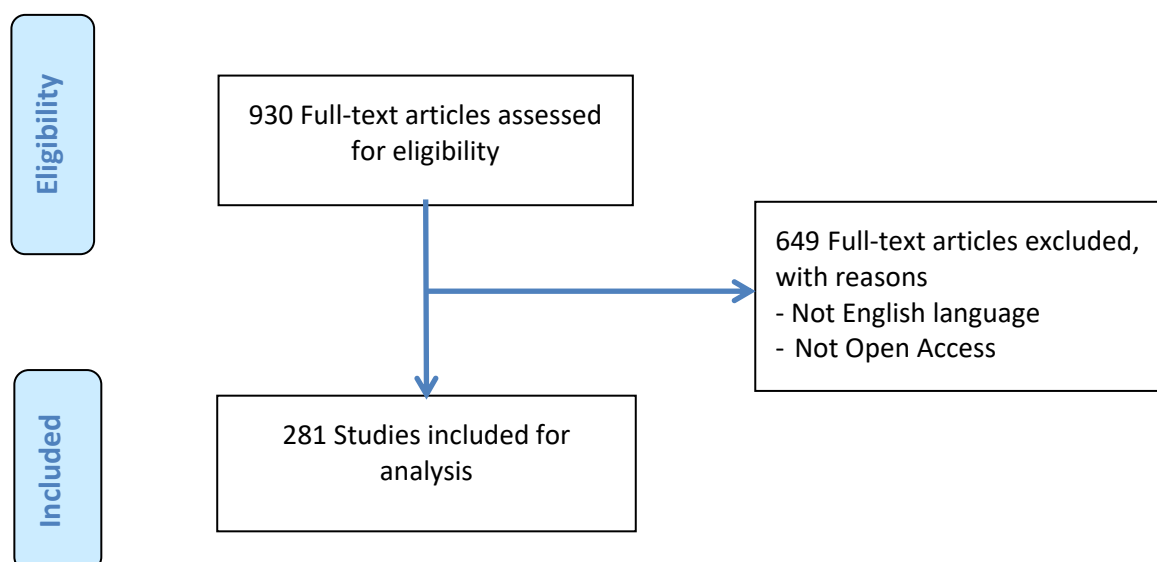
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┌─────────┐          ┌──────────────────────────┐
│         │          │  930 Full-text articles   │
│Eligibility│        │  assessed for eligibility │
│         │          │                          │
└─────────┘          └──────────────────────────┘
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Figure 1: PRISMA Flowchart

Bibliometric analysis was conducted using VOSviewer to generate citation, co-citation, and co-occurrence networks. Citation analysis was conducted to assess the most influential studies in AI-driven translation education by examining the number of citations received by each publication in the dataset. Co-citation analysis was used to identify influential authors and foundational studies in AI-driven translation education. Co-occurrence analysis mapped thematic structures and emerging research trends by analyzing keyword relationships across publications. Trend analysis was performed to examine the evolution of research focus areas over time. By highlighting significant works, well-known authors, and related themes, this methodology offers insightful information about the development of the field (Wider et al., 2024). Researchers can find groups of significant studies by using co-citation analysis to find connections between frequently cited works. To illustrate the interdisciplinary nature of the field, studies examining ethical issues and pedagogical frameworks are frequently cited alongside foundational works on AI applications in education (Dwivedi et al., 2023; Kasneci et al., 2023). Conversely, co-occurrence analysis maps the field's semantic structure by looking at the relationships and frequency of terms like "generative AI," "translation pedagogy," and "student engagement" (Chen et al., 2020; Ouyang, Zheng, & Jiao, 2022). The study examined data from 281 publications to identify new trends and areas that require further investigation. According to Baidoo-Anu and Ansah (2023) and Lim et al. (2023), the findings are meant to close significant knowledge gaps and direct the development of workable plans for integrating AI into translation instruction. Furthermore, this bibliometric approach aided in the assessment of research impact and helped policymakers and educators adopt AI-driven methodologies in a responsible manner. This bibliometric analysis highlighted the importance of mapping out academic progress in order to navigate the difficulties that AI presents for translation education.

3.1 Search Strings
The primary objective of this study's bibliometric analysis technique was to locate and review literature regarding the application of AI in translation education. The

search focused on papers published between 2020 and 2024 and was conducted using the Web of Science (WoS) database. To obtain a large number of relevant papers, a carefully constructed search string was used, utilizing keywords such as "AI," "translat*," and "educat*" in the title search field (TI). This approach ensured that all variations of these terms were included, expanding the scope of the literature reviewed. Bibliometric analysis is particularly useful for identifying influential authors, core research areas, and collaboration networks, ensuring a systematic exploration of existing literature.

To maintain high academic rigor and relevance, the inclusion criteria were refined to only include peer-reviewed, English-language review papers. Table 1 listed the specific criteria used in the selection process, including language requirements, peer-reviewed status, and inclusion in SSCI or SCI-Expanded, ensuring that only high-quality scholarly studies are considered. By concentrating on high-impact articles, this methodology effectively mapped the research landscape of AI in translation education, offering insights into significant contributions and emerging trends in this area.

Table 1. Inclusion Criteria for Bibliometric Analysis

WoS Database	ALL
Time period	2020 to 2024
Search field	TI
Search keywords	"AI" OR "translat*" "educat*"
Citation Topics Meso	ALL
Document type	Article
Language	English
Open Access	All Open Access
Web of Science Index	SSCI or SCI-EXPANDED

4. Results

The bibliometric analysis of AI in Translation Education revealed a specific scholarly landscape, as reflected in the title's use of keywords such as "AI," "translat*," and "educat*." The analysis, which highlighted current developments and trends in the field, covered the years 2020–2024. The inclusion criteria prioritized articles that were indexed in the SSCI or SCI-EXPANDED databases of the Web of Science database to guarantee academic rigor and relevance.

The study promoted increased accessibility and visibility by concentrating on English-language, open-access publications, which advances our knowledge of the relationship between AI, translation, and education. In AI-driven translation education, this methodological framework provided a solid foundation for identifying significant trends, emerging themes, and potential research gaps. It also highlighted how interdisciplinary the field is and how the research landscape is evolving. The academic community's increasing productivity and interest in this crucial area was demonstrated by these metrics and filters, which paved the way for further study and noteworthy contributions.

The bibliometric analysis of the field of AI in translation education offered useful metrics that highlighted the influence and development of this field of study. The identification of 281 publications from the Web of Science database between 2020 and 2024 produced a significant citation footprint. In particular, these articles have received 2,807 citations overall (2,715 citations if self-citations are excluded), with an average of 9.99 citations per publication. The research's depth and impact were demonstrated by the H-index of 25, meaning that at least 25 of these articles have each been cited at least 25 times. The H-index is a widely used metric that assesses both the productivity and citation impact of a researcher or a body of work.

Figure 2 presents the trend of publications and citations from 2020 to 2024. The bars (in light purple) represent the number of publications, while the line (in dark blue) represents the number of citations. It indicates that citations and publications have been steadily increasing, reaching a sharp peak in 2024 with 2,066 citations and 140 publications. This trend shows a steady rise in academic interest in the field, as more studies contribute to ongoing discussions and research developments. This pattern suggests that people are becoming more aware of the value of AI-driven developments in translation education. Strong citation counts and the growing amount of scholarly work highlights the field's dynamism and scholarly importance while also pointing to areas for further research and development. The productivity and impact of researchers in this multidisciplinary field are reflected in these findings, which offer a thorough grasp of the academic environment.
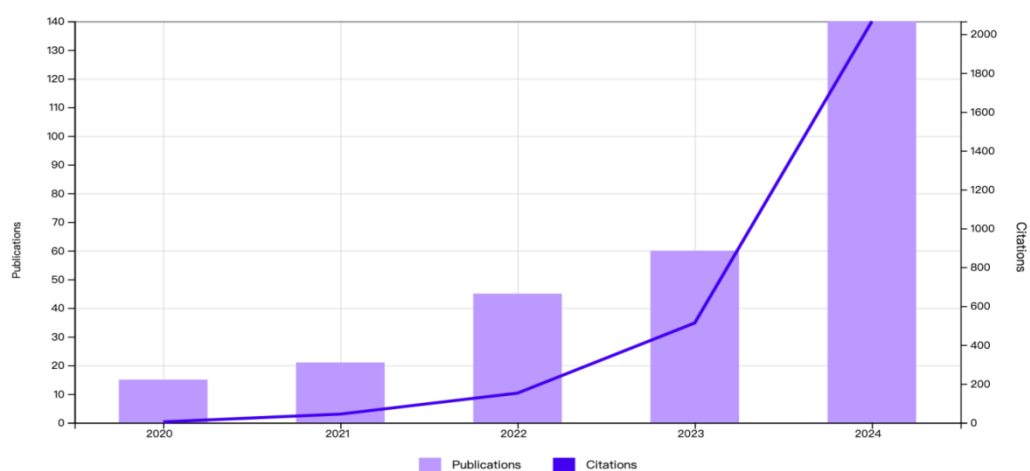

Figure 2: Quantity of publications and citations between 2020 and 2024

4.1 Performance Analysis
The performance analysis of AI in translation education highlighted significant contributions across key domains—documents, sources, authors, organizations, and countries—revealing the depth and breadth of research in this area. To ensure a structured presentation, the following data is presented first before proceeding with the analysis and interpretation:
- **Documents**: Number of publications over time and citation impact.
- **Sources**: Key journals and conferences contributing to AI in translation education research.

- **Organizations**: Leading universities and research institutions producing the most work in this area.
- **Countries**: Geographical distribution of research contributions.

Following this, an in-depth analysis and interpretation of the results will be provided, identifying key trends and emerging research directions.

4.1.1 Documents

The most frequently cited articles highlighted the significance of incorporating AI technologies into education and their ramifications. Leading contributions included Chan and Hu (2023) on AI policy education frameworks and Chan (2023) on students' perceptions of generative AI, with 176 and 172 citations respectively. In addition, Lim et al. (2023) centers on the transformative potential of generative AI in education and has been cited 277 times. The high citation frequency of these works underscores the increasing focus on AI's practical applications in translation education and its ethical implications. The range of subjects covered, from ethical integration to AI policy, demonstrates the complexity of this field of study.

4.1.2 Sources

Important journals such as Sustainability, featuring 27 documents and 242 citations, and the International Journal of Educational Technology in Higher Education with 5 documents and 406 citations have become significant channels, demonstrating their influence on disseminating information about AI in education. These journals highlighted the role of AI in educational technology and sustainability, reflecting interdisciplinary research intersections. The European Journal of Education with 5 documents and 133 citations and Education and Information Technologies, featuring 13 documents and 145 citations were other noteworthy sources that highlighted the field's technical and policy-related facets.

4.1.3 Authors

Table 2 lists the top 10 most cited authors, their publication years, document counts, and citation totals, highlighting key contributors to AI in education. Leading the scholarly conversation were well-known authors like Cecilia Ka Yuk Chan, with 348 citations in 2 documents, reflecting significant influence in AI-driven education. Similarly, Giora Alexandron accounted for 2 papers and 92 citations and Mutlu Cukurova took up two documents and 91 citations, both of whom have made notable contributions to the integration of AI in educational research. Their works highlighted teamwork in developing AI's educational applications. The recurrent appearance of these authors in the literature suggested that a specialized group of researchers is driving progress in AI-enhanced pedagogy and educational applications.

Table 2. Top 10 most cited authors and their publication years

Rank	Authors (Year)	Documents	Citations
1	Cecilia Ka Yuk Chan (2023)	2	348
2	Giora Alexandron (2023)	2	92
3	Mutlu Cukurova (2022)	2	91
4	Jussi S. Jauhiainen(2022)	2	27

5	Miltiadis D. Lytras(2021)	2	24
6	Gabriela Lima de Melo Ghisi (2021)	2	21
7	Sherry L. Grace (2021)	2	17
8	Paul Oh (2023)	2	17
9	Artem Artyukhov (2024)	2	13
10	Nadiia Artyukhova (2024)	2	13

4.1.4 Organizations
Universities like the National University of Singapore (NUS), with 4 documents and 76 citations, and University College London (UCL), with 183 citations in 4 documents, demonstrate their leadership in AI and education research. Their contributions have been instrumental in advancing AI-assisted learning methodologies, particularly in adaptive learning technologies and AI-driven language processing models. Monash University and King's College London are two other noteworthy contributors, with 5 articles and 58 citations at Monash University and 36 documents with 5 citations at King's College London separately, demonstrating the international cooperation in this area. These institutions actively collaborate on interdisciplinary AI research, fostering the integration of machine learning and natural language processing into translation education. These establishments serve as centers for state-of-the-art AI applications in learning environments, encouraging creativity and information exchange.

4.1.5 Countries
With 66 publications and 621 citations, China led the field, demonstrating its significant investment in educational AI research, followed by Australia with 24 documents and 410 citations, and the United States, which ranked third with 44 documents and 402 citations. These countries were the two other noteworthy contributors. Furthermore, contributions from smaller but significant nations like Finland and Malaysia demonstrated a global dedication to AI in education.

4.2 Co-Citation Analysis
In this study, we used Co-citation and Co-occurrence analyses to examine the relationships between key studies and keywords in AI translation education. Co-citation refers to how often two papers are cited together, reflecting their academic connection and influence in the field. Co-occurrence, on the other hand, examines how frequently specific keywords appear together in the same document, highlighting the thematic relationships between the concepts they represent.

Table 3 ranked these studies by citation count, covering themes like AI-driven instructional design, generative AI in pedagogy, ethical concerns, and policy development. It illustrates research trends and shows how scholars have addressed AI integration, guiding future research in AI-enhanced translation education. The top ten articles on AI's application in translation education in this table demonstrates the growing role of AI in educational settings and offer a multidisciplinary understanding of the field. Key theoretical, empirical, and practical contributions to the conversation are highlighted in these works, emphasizing the difficulties and possibilities of incorporating AI technologies into educational frameworks.

Table 3. Co-citations (Top 10 Articles)

Rank	Authors	Title	Citations	Total Link Strength
1	Kasneci et al. (2023)	ChatGPT for good? On opportunities and challenges of large language models for education	17	84
2	Chen et al. (2020)	Artificial intelligence in education: A review	14	35
3	Chen et al. (2020)	Examining science education in ChatGPT: An exploratory study of generative artificial intelligence	13	68
4	Dwivedi et al. (2023)	Opinion Paper: "So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy	13	67
5	Chan, (2023)	A comprehensive AI policy education framework for university teaching and learning	11	49
6	Lo (2023)	What is the impact of ChatGPT on education? A rapid review of the literature	11	41
7	Ouyang, Zheng, & Jiao (2022)	Artificial intelligence in online higher education: A systematic review of empirical research from 2011 to 2020	11	46
8	Baidoo-Anu, & Ansah (2023)	Education in the era of generative artificial intelligence (AI): Understanding the potential benefits of ChatGPT in promoting teaching and learning	10	47
9	Lim et al. (2023)	Generative AI and the future of education: Ragnarök or reformation? A paradoxical perspective from management educators	10	44
10	Adıgüzel, T., Kaya, M. H., & Cansu, F. K. (2023)	Revolutionizing education with AI: Exploring the transformative potential of ChatGPT.	9	39

Lim et al. (2023) explores the transformative potential of generative AI in education, discussing its paradoxical implications for management educators.

With 10 citations, this study highlights the evolving discourse on AI's role in shaping pedagogy and institutional policies. With a focus on its potential for individualized learning, Kasneci et al. (2023) examine the advantages and disadvantages of generative AI, including ChatGPT. In a bid to maximize learning outcomes, this study, which has 17 citations, promoted combining AI with pedagogical techniques. Chen et al. (2020) thoroughly analyzed AI in education, emphasizing its potential, drawbacks, and moral implications. This article, with 14 citations, is an essential resource for comprehending the systemic effects of AI on educational practices. Adıgüzel et al. (2023) examine the impact of ChatGPT in revolutionizing education, emphasizing its transformative potential in personalized learning. With 9 citations, this study provides a contemporary perspective on AI adoption in educational settings, replacing earlier models like the Technology Acceptance Model.

Examining ChatGPT's effects on science education, Cooper (2023) highlighted the potential benefits and difficulties of generative AI in developing critical thinking abilities. This article offered practical advice for utilizing AI in subject-specific contexts (13 citations). Dwivedi et al. (2023) discussed the implications for society and policy in their multidisciplinary analysis of generative AI. This 13-citation paper emphasized the significance of adopting AI in education in a balanced manner. Chan's (2023) AI policy framework for university instruction highlighted the ethical and practical aspects of integrating AI. This work provided a road map for institutions to handle the challenges of adopting AI was provided by this work (11 citations). In his review of ChatGPT's effects on education, Lo (2023) examined its advantages and disadvantages in transforming conventional teaching methods. This article (11 citations) added to the current debates concerning the use of generative AI in the classroom.

With a focus on its transformative potential, Ouyang, Zheng, & Jiao (2022) conducted a systematic review of empirical research on AI in online higher education. This work, which has eleven citations, demonstrates how AI can improve accessibility and participation in online learning settings. The advantages of generative AI for individualized education were highlighted in Baidoo-Anu and Ansah's (2023) discussion of the technology's role in advancing teaching and learning. The significance of teacher training in maximizing AI's educational impact was emphasized in this article (10 citations). Considering the theoretical, empirical, and practical aspects of AI in education, these articles collectively constitute significant contributions to the field. From promoting personalized learning to addressing ethical issues, they draw attention to the advantages and disadvantages of incorporating AI technologies, offering a strong basis for further study and the creation of new policies.

4.2.1 Co-Citation Analysis by Clusters.
Based on data retrieved from the Web of Science (WoS) database, VOSviewer was used for co-citation clustering. The method used is the Leiden algorithm, with a minimum co-citation threshold of 56 to ensure meaningful grouping. Each cluster was derived from keyword co-occurrence and representative publications within the cluster. Figure 3 visualizes co-citation relationships, mapping how studies

were linked based on shared citations. The co-citation analysis of AI in translation education (Figure 3) identified four important clusters that illustrated how academic work and its thematic focus areas were interconnected. These clusters offered information about the field's intellectual framework. It highlighted influential research areas including AI-assisted translation, machine learning in education, and AI ethics, and offered a clearer view of major research trends and collaboration networks in the field. Table 4 categorized key research clusters on AI in education, classifying studies into four groups: AI foundations, generative AI's impact, policy frameworks, and AI literacy. Each cluster highlighted influential studies that contributed to understanding AI's role in education, offering a comprehensive understanding of the opportunities and challenges of AI in transforming modern education.

Building on these insights, Cluster 1 included systematic reviews and foundational studies that investigated the theoretical foundations of AI applications in education. Among the exemplary works were Holmes et al. (2022) and Nazaretsky et al. (2022), who examined the integration of AI in education, highlighting a disconnect between teacher participation and technology developments. Chen et al. (2020) produced a comprehensive analysis of the opportunities, difficulties, and uses of AI in education. Ouyang, Zheng, and Jiao (2022) provided a ten-year perspective on the transformative potential of AI, with an emphasis on empirical research in online higher education. The historical development and significant obstacles in the adoption of AI technologies were highlighted in this cluster. According to the studies, integrating AI tools in educational settings requires a methodical approach, ethical considerations, and active educator participation.
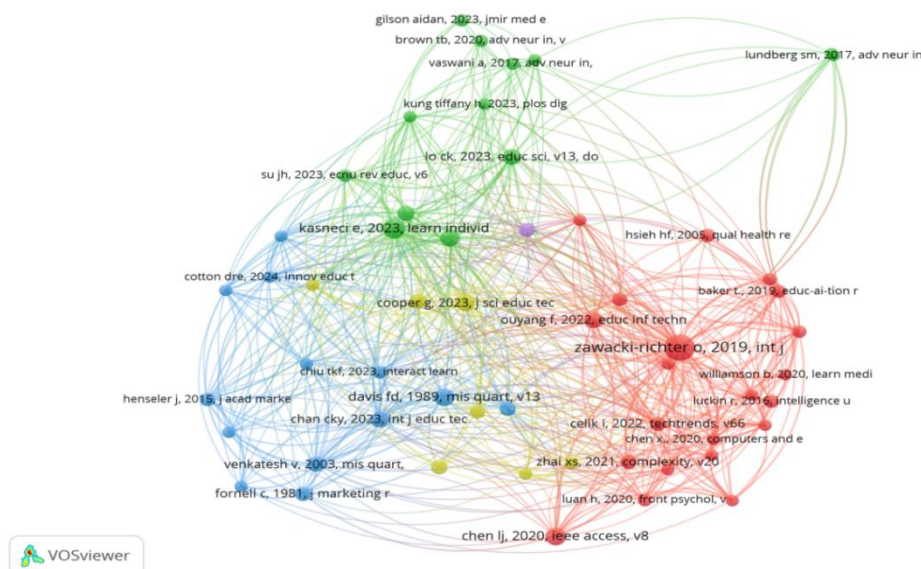

Figure 3. Co-citations Analysis (VOSviewer Visualisation)

The impact of ChatGPT and other generative AI tools on education was the main focus of Cluster 2. Kasneci et al. (2023) discussed the possibilities and difficulties presented by large language models. Dwivedi et al. (2023) looked at the societal,

ethical, and policy ramifications of generative AI from a multidisciplinary standpoint. A quick analysis of the research on ChatGPT's impact on teaching methods was conducted by Lo (2023). The cutting-edge AI research in education was represented by this cluster, which focused on how generative AI can transform conventional teaching strategies. From concerns about misuse and ethical ramifications to personalized learning experiences, it emphasized the dichotomy of opportunities and challenges. In the co-citation network, larger nodes represent highly cited studies, indicating their influence in the field. Stronger connections between nodes show frequently co-cited papers, highlighting intellectual linkages. Cluster 2 was identified based on the close citation relationships among studies discussing ChatGPT's impact on education, ethics, and personalized learning. This clustering suggests that these themes form a significant research focus in AI-driven education.

The theoretical developments and policy-focused research served as the foundation for Cluster 3. Farrokhnia et al. (2024) examined the adoption and implications of ChatGPT in education through a SWOT analysis, providing insights into how users perceived and interacted with AI tools in educational settings. Both Farrokhnia et al. (2024) and Cotton et al. (2024) explored how users engaged with AI tools like ChatGPT in education, analyzing their acceptance, challenges, and implications for academic integrity. Chan (2023), on the other hand, created a framework for AI policies to ensure their moral and successful incorporation into college instruction. Chiu (2023) analyzed how generative AI tools like ChatGPT affected research and policy. This cluster emphasized how crucial it was to develop strong theoretical frameworks and policy recommendations to guarantee the ethical and successful integration of AI. It showed a continuous attempt to align technological advancements with academic goals and social standards.

Cluster 4 focused on building AI literacy and competencies in both teachers and students. Typical research projects, such as those by Cooper (2023) examined ChatGPT's function in science instruction and its capacity to promote critical thinking. The future of generative AI in education was examined from a management standpoint by Lim et al. (2023). Additionally, Long and Magerko (2020) defined AI literacy and the competencies needed for its successful application. This cluster highlighted the importance of equipping teachers and students the tools they need to use AI technologies efficiently. In order to prepare students for an AI-shaped future, it promoted the creation of educational frameworks that incorporated AI literacy into curricula.

Table 4. Co-citation Cluster

Cluster No and Colour	Cluster Labels	No. of Articles	Representative Publications
Cluster 1 (Red)	Foundations of AI in Education	21	Holmes et al. (2022) Chen et al. (2020); Ouyang, Zheng, & Jiao (2022); Celik et al. (2022); Zhai et al. (2021); Hwang, G. J., & Chang, C. Y. (2023). Nazaretsky et al. (2022); Huang et al. (2022); Williamson, B., & Eynon, R. (2020). Luan et al. (2020); Akgun & Greenhow (2022).
Cluster 2 (Green)	Generative AI and Educational Transformation	13	Kasneci et al. (2023); Dwivedi et al. (2023); Lo (2023); Baidoo-Anu & Ansah (2023); Brown et al. (2020); Su & Yang (2023).
Cluster 3 (Blue)	Theoretical Frameworks and Policy Development	13	Chan (2023); Adıgüzel et al. (2023); Chiu (2023); Cotton et al. (2024); Farrokhnia et al. (2024); Kohnke et al. (2023).
Cluster 4 (Yellow)	AI Literacy and Competency Development	7	Cooper (2023); Lim et al. (2023); Long & Magerko (2020); Tlili et al. (2023);

4.3 Co-Occurrence Analysis

Table 5 shows the findings of a co-occurrence analysis of keywords in AI in education, highlighting key research trends and the connections between major concepts in this field. The co-occurrence analysis in Table 5 identified important new directions in the field of AI in education. With 1,501 keywords in total and a threshold of 56, the analysis focused on terms that have been used at least ten times, indicating connections between important concepts and scholarly interests. Additionally, 1,017 links and a total link strength of 2,684 highlighted how closely related these keywords are to one another, indicating how thorough and integrated the research is in this emerging academic field. The term 'total link strength' refers to how closely keywords are related based on how frequently they appeared together in literature. A stronger link strength demonstrated a closer connection, assisting in identifying key research trends and areas where topics in AI education overlap. Table 5 also shows the 15 most common keywords and key themes in AI education. Terms like 'artificial intelligence' and 'generative AI' reflected its expanding role, whereas 'higher education' and 'students' emphasized its significance. 'Acceptance' and 'model' referred to ongoing discussions about AI adoption and implementation.

Table 5. The 15 most frequent keywords in the co-occurrence analysis

Rank	Keyword	Occurrences	Total Link Strength
1	artificial intelligence	69	128
2	artificial-intelligence	35	72
3	education	32	57
4	generative ai	24	41
5	chatgpt	22	52
6	higher education	20	40
7	students	20	60
8	ai	19	27
9	knowledge	16	27
10	artificial intelligence (ai)	14	23
11	model	14	41
12	acceptance	11	40
13	translation	11	4
14	chatbot	10	18
15	machine learning	9	15

The most frequently mentioned keyword, "artificial intelligence," was mentioned 69 times and had a total link strength of 128. The finding suggested that current educational research is heavily focused on this topic. Studies that examine the use of AI in higher education, emphasizing both its transformative potential and ethical implications, include Zawacki-Richter et al. (2019). The high frequency of related terms like "education" (32 occurrences), "generative AI" (24 occurrences), and "ChatGPT" (22 occurrences) indicates that academic literature was particularly interested in these AI-driven tools and concepts.

With a link strength of 40 and 20 occurrences, the keyword "higher education" highlights how AI is influencing learning environments in the future. As evidenced by studies on personalized learning (Chen et al., 2020) and AI policy frameworks (Chan, 2023), scholarly conversations are becoming more and more focused on the opportunities and difficulties of integrating AI technologies in education. Since these terms are commonly associated with ideas like "students" and "knowledge," it further demonstrates how AI can improve educational opportunities.

Other noteworthy terms that indicate a persistent interest in the ways AI technologies contributed to various educational applications included "machine learning" (9 occurrences) and "translation" (11 occurrences). As demonstrated by studies such as Farrokhnia et al. (2024), the focus on "models" (14 occurrences) and "acceptance" (11 occurrences) reflected continued attention to user engagement and the adoption of AI systems in educational contexts, promoting a more inclusive and adaptive learning mechanism.

4.3.1 Co-Occurrence Analysis by Clusters

Figure 4 visualizes how keywords co-occurred in academic literature, mapping their frequency and relationships. This clustering revealed key research areas, including AI-assisted learning, student engagement, and AI ethics, which help to identify emerging trends and gaps in the field. Table 6 further analyzes these clusters, illustrating how different research themes are interconnected. By mapping these relationships, the table provides a structured overview of current AI research directions in education and highlighted key areas for future exploration. The co-occurrence analysis in Figure 4 identified discrete thematic clusters, each focused on particular keywords that emphasize key research topics pertaining to the incorporation of AI in education. These clusters examine the opportunities and difficulties of implementing AI in educational settings were examined in detail (Table 6) by these clusters, which offered a thorough understanding of how academic research responded to the changing needs of digital learning environments.

Cluster 1 (21 keywords) explored how AI, including tools like ChatGPT, is revolutionizing education through the use of generative AI. The integration of AI technologies into learning environments was explored in representative works like Williamson and Eynon (2020), and Chen et al. (2020), which highlighted the technologie's potential to improve accessibility and personalized learning. The terms "education" and "generative AI" were frequently used, suggesting that research was focused on using these technologies to enhance educational results. The ethical opportunities and challenges of AI in the classroom were discussed in studies like Holmes et al. (2022), which highlighted the technology's crucial role in the future of education.
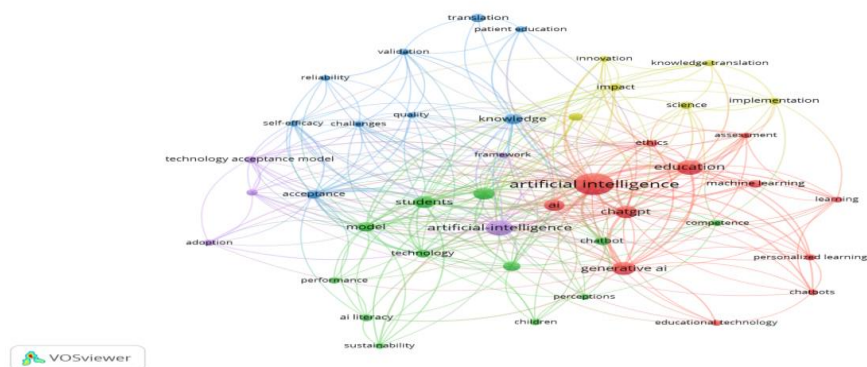

Figure 4. Co-Occurrence Analysis of AI in translation education (VOSviewer Visualisation)

Cluster 2, which consisted of 19 keywords, emphasized the use of AI in higher education and how it affected instruction and learning. Terms such as "students," "higher education," and "model" indicated a focus on how colleges were using AI technologies to help students succeed academically. Exemplary works that focused on user engagement and system adoption, like Chan (2023) and Farrokhnia et al. (2024), analyzed frameworks related to AI adoption in education, discussing factors influencing the acceptance and implementation of ChatGPT in learning environments. Additionally, research demonstrated useful applications

such as chatbots and adaptive learning systems, highlighting their increasing impact on higher education environments.

With 16 keywords, Cluster 3 focused on user viewpoints and theoretical frameworks for the adoption of AI in translation education. Words like "knowledge," "acceptance," and "translation" emphasized how crucial it is to comprehend how educators and students view and use AI tools. Farrokhnia et al. (2024) conducted a notable study examining AI acceptance in education, analyzing factors influencing the adoption of ChatGPT through a SWOT framework, similar to prior acceptance models, while Chiu (2023) talked about how AI could promote critical thinking and knowledge acquisition. This cluster emphasized how crucial user-centric strategies are for optimizing the advantages of integrating AI.

Cluster 4, which focused on the use of AI in medical education and its wider effects on scientific learning, contained nine keywords. "Medical education," "impact," and "science" were representative terms that highlighted how AI was changing teaching strategies and enhancing student outcomes. Particularly in specialized fields like medicine, studies such asLim et al. (2023) and Tlili et al. (2023) explored the role of AI-driven chatbots in education, examining their potential impact on student engagement, problem-solving, and learning experiences.

Cluster 5, the smallest, delved into the theoretical and technological dimensions of AI in education and had five keywords. Terms like "AI in education" and "technology acceptance model" refer to the frameworks that were used to examine the adoption of AI and its applications. Research by Chan (2023) and Farrokhnia et al. (2024) highlighted how crucial it was to create systems that are not only efficient but also generally embraced by teachers and students. This cluster emphasized how technological innovation and real-world application interacted in the field of education.

Table 6. Co-Occurrence Analysis on AI in translation education

Cluster No and Colour	Cluster Label	Number of Keywords	Representative Keywords
1 (Red)	Artificial Intelligence, Education, and Generative AI	12	"artificial intelligence" "education" "generative ai" "chatgpt" "ai" "machine learning"
2 (Green)	Higher Education, Students, and AI Implementation	12	"higher education " "students" "artificial intelligence (ai)" "model" "chatbot"

			"technology"
3 (Blue)	Knowledge, Acceptance, and AI in Translation Education	9	"knowledge"
			"acceptance"
			"translation"
			"challenges"
4 (Yellow)	Medical Education, Impact, and Science	6	"patient education"
			"medical education"
			"impact"
			"science"
5 (Purple)	AI in Technology, Models, and Acceptance	5	"artificial-intelligence"
			"technology acceptance model"
			"ai in education"

5. Discussion

The findings of this study, which included a bibliometric analysis of the integration of AI in education, have far-reaching implications for educational institutions, policymakers, and technologists. The research identifies key areas that require attention to improve the effective adoption of AI technologies in education, especially with regard to user acceptance, ethical considerations, and personalized learning outcomes. The findings are discussed in accordance with the study's objectives and in comparison, with prior research to determine how they align or diverge from existing literature.

5.1 Theoretical Implications

This study makes a substantial contribution to theoretical frameworks by emphasizing the intricate relationship between user acceptance, ethical considerations, and educational outcomes. According to the Technology Acceptance Model (TAM), user adoption of new technologies is primarily influenced by perceived ease of use and usefulness. Our findings, however, show that the adoption of AI in translation education is a dynamic process that is impacted by perceptions, institutional support, ethical considerations, and interdisciplinary collaboration. This is consistent with models of technological change that emphasize continuous adaptation over static acceptance. Dwivedi et al. (2019) propose a revised technology adoption framework that goes beyond individual user perceptions (TAM) to include institutional and contextual factors. Their findings back up our contention that AI adoption in translation education is shaped by ethical concerns, institutional policies, and the changing role of interdisciplinary collaboration in pedagogy.

Furthermore, our co-citation and co-occurrence analyses demonstrate that AI research in translation education remains fragmented, with limited integration of theoretical models from translation studies and educational technology. This suggests the necessity of a more thorough theoretical framework that incorporates user engagement, technological effectiveness, and pedagogical strategies. Representative studies such as Chan (2023) and Zawacki-Richter et al. (2019) reinforce the need for an integrated approach, considering pedagogical methodologies, AI functionalities, and ethical dimensions in a unified manner.

Our findings also suggest that AI's role in translation education extends beyond passive technology adoption and influences pedagogical transformation, requiring educators to reconsider traditional instructional strategies and learning assessment models.

This bibliometric analysis generates another theoretical contribution by emphasizing ethical considerations in AI adoption. While traditional technology acceptance models frequently disregard ethical considerations, our findings highlight critical issues like data privacy, algorithmic bias, and equitable access. Shin (2020) and Chiu (2023) discovered that trust in AI systems hinges on transparency and fairness. The prominence of AI ethics in co-citation analysis highlights a gap in technology adoption models. While TAM focuses on perceived usefulness and ease of use, our findings suggest that trust, data privacy, and algorithmic bias have a significant impact on AI adoption in translation education. This emphasizes the importance of AI adoption models that incorporate ethical considerations as well as technological capabilities. These findings imply that ethical principles should be integrated into existing AI adoption frameworks with the goal of ensuring inclusive and responsible use of AI in education.

5.2 Practical Implications

Based on the findings, educational institutions must develop structured AI training modules to ensure successful AI adoption. Universities ought to establish specialized AI literacy programs that incorporate user-centric training services, such as workshops and hands-on sessions for both faculty and students (Celik et al., 2022; Chan, 2023). These programs should address concerns related to data privacy and ethics while also providing clear guidelines on the responsible use of AI tools like ChatGPT in translation education. To assess the effectiveness of these programs, institutions can incorporate pre- and post-training evaluations, user feedback surveys, and real-time AI-assisted assessment tools.

These training programs can be structured into different levels in order to effectively improve AI literacy effectively:

- **Basic Level:** Introduction to AI applications in translation, with a concentration on ethical concerns and data privacy.
- **Intermediate Level**: Learn how to use AI-powered tools like ChatGPT and DeepL for bettering translation and post-editing workflows.
- **Higher Level**: Practical AI integration projects in which students and faculty work together to improve AI-assisted translation systems. To measure program effectiveness, universities can employ pre-and post-training assessments, feedback surveys, and AI-assisted translation performance evaluations

Additionally, this study underscores the importance of interdisciplinary collaboration in AI adoption. AI-integrated translation labs could be established, bringing together students studying translation, computational linguistics, and computer science to improve AI-assisted translation workflows. Such initiatives are consistent with previous findings (Zawacki-Richter et al., 2019; Chen et al., 2020) that interdisciplinary collaboration promotes AI adoption by bridging the gap between technological development and pedagogical implementation. To further strengthen AI literacy, universities should team up with professional

translation organizations to ensure that AI is employed ethically and in accordance with industry best practices. These interdisciplinary initiatives may take the form of:

To further strengthen AI literacy, universities should team up with professional translation organizations to ensure that AI is employed ethically and in accordance with industry best practices. These interdisciplinary initiatives may take the form of:

- **AI-Integrated Translation Labs**: Collaborative spaces where translation students collaborate with computer science students to develop AI-powered translation solutions.
- **Cross-disciplinary Workshops**: students majoring in translation and computer science co-develop AI-driven translation strategies.
- **Partnerships with Translation Technology Companies**: Cooperating with industry leaders to create AI translation tools tailored for educational settings.

This study also highlights the importance of individualized academic support in ensuring that AI is used as a learning tool rather than a substitute for critical translation skills (Adıgüzel et al., 2023; Almogren & Aljammaz, 2022). AI-driven tutoring systems, such as Intelligent Tutoring Systems (ITS), could provide adaptive exercises based on students' translation errors, helping them refine post-editing skills while minimizing over-reliance on AI-generated outputs. Furthermore, AI-driven learning analytics could track student engagement with AI tools, enabling instructors to refine curricula based on real-time performance data. Future research should investigate how AI-powered feedback mechanisms can support differentiated instruction based on individual learners' translation competency levels. Examples of AI-driven individualized academic support include:

- **AI-Powered Feedback Systems**: Automated translation assessments that provide real-time feedback and suggestions for improvement.
- **AI Learning Assistants**: ChatGPT-powered virtual assistants offer real-time translation guidance and best practices.
- **AI-Enhanced Language Partners**: AI tools that allow students to practice and improve their skills in a simulated real-world and interactive environment of translation scenarios.

Educational institutions can ensure that AI adoption in translation education is both effective and ethically responsible by implementing these structured training programs, interdisciplinary initiatives, and personalized AI-driven support systems.

5.3 Limitations
While this study offers valuable insights, several limitations must be acknowledged. First and foremost, the analysis was based on a specific database (Web of Science), which may have affected the comprehensiveness of the findings. The study's temporal scope (2020–2024) also limits the ability to capture long-term trends in AI adoption in translation education. Furthermore, qualitative insights

that could offer a deeper comprehension of the pedagogical and ethical implications of AI integration are not included in this bibliometric analysis. Furthermore, the generalizability of the results may be impacted by regional differences in institutional policies, technological infrastructure, and educational contexts. To offer a more comprehensive view of AI's role in translation education, future research should broaden the dataset by incorporating several databases, using mixed-method approaches, and investigating AI implementation in various linguistic and educational contexts.

6. Conclusion

The bibliometric analysis of AI in translation education offers a thorough grasp of the field's thematic focus, research trends, and intellectual structure. Through analyzing co-citation, co-occurrence, and performance metrics, the analysis demonstrates how AI technologies such as ChatGPT and machine learning are transforming translation education. These findings contribute to the existing body of literature by addressing the underexplored role of AI in translation education, providing novel insights into the use of AI-driven tools in pedagogy and curriculum design. This research fills a gap in the literature, which has largely focused on general education and translation practice, rather than AI's pedagogical applications in translation education. The analysis highlights obstacles, including user acceptance, ethical issues, like, data privacy and algorithmic bias, and the need for effective frameworks for AI adoption. Overcoming these barriers is essential for AI's successful integration into higher education. Practical recommendations include training programs and cross-disciplinary collaborations to foster trust and ethical AI adoption in higher education contexts.

In line with Sustainable Development Goal 4 (Quality Education), AI offers opportunities to improve the quality of translation education, build lifelong learning, and provide inclusive and equitable education. AI's role in enhancing personalized learning, particularly in multilingual and cross-cultural contexts, is significant in ensuring equitable access to education. Resolving inequalities in access to AI-powered tools also aligns with Sustainable Development Goal 10 (Reduced Inequalities), ensuring equal opportunities and reducing educational disparities. Future studies should explore concrete research questions such as "How can AI tools be adapted for multilingual education environments?" and "What are the long-term impacts of AI-driven translation tools on student outcomes?" These areas of research will guide the continued exploration of AI's potential in transforming translation education.

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