

## Do AI-Powered Translation systems reflect crosslinguistic influence? Examples of translations of PT/EN texts using ChatGPT-3.5/ChatGPT-4

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### ABSTRACT

This study investigates whether AI-powered translation systems—specifically ChatGPT-3.5 and ChatGPT-4—reproduce patterns of Crosslinguistic Influence (CLI) in translations between European Portuguese and English. Two research questions guided the analysis: (1) To what extent do AI-generated translations reflect negative CLI? and (2) How does identifying and correcting such phenomena support the development of critical AI literacy and translation competence among students? A qualitative case study was conducted with 101 higher education students, all native speakers of Portuguese with C2 proficiency in English, enrolled in a Translation Practices course over two academic years. Students individually analysed AI-generated translations of satirical and opinion texts, identifying errors related to morphology, syntax, semantics, and cultural non-equivalence. Findings revealed recurrent patterns of negative CLI, such as incorrect verb moods, literal word order, misleading lexical choices, and culturally inappropriate expressions. While ChatGPT-4 produced more fluent texts than ChatGPT-3.5, both models reproduced similar CLI-related patterns. Pedagogically, these results underscore the value of integrating AI translation outputs into translator training as resources for error analysis, thereby fostering students' critical engagement with technology and strengthening their professional competences.

**Keywords:** AI assisted translation; Crosslinguistic influence; Translator training; Error analysis; Portuguese/English translations.

### 1. Introduction

Artificial Intelligence (AI) is increasingly shaping higher education and professional practice, including the field of translation. Tools such as ChatGPT are now part of everyday life, transforming the ways in which we work, learn, teach, and communicate. Authors such as Mikropoulos and Natsis (2011) note that AI tools provide students with more hands-on and practical learning experiences, enhancing their learning processes. Similarly, Chassignol et al. (2018) define AI as “a way of creating computer systems that can do things people usually do, like recognizing images or speech, making decisions, and translating between languages” (p. 17). In the translation domain, these tools offer both opportunities and challenges.

One key issue is how AI-powered translation systems handle *Crosslinguistic Influence* (CLI) - the transfer of linguistic features from one language to another. Although CLI has long been studied in second language acquisition, its presence in translation studies and, more specifically, AI-generated translations remain underexplored, particularly in the Portuguese–English language pair.

This study addresses that gap by examining whether AI-generated translations produced by ChatGPT-3.5 and ChatGPT-4 reproduce CLI phenomena. More specifically, our research was guided by two central questions: (1) To what extent do AI-powered translation systems reflect negative CLI in European Portuguese–English translations? and (2) How does students' identification and correction of these issues contribute to their development of critical AI literacy and translation competence?

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Our research involved higher education students enrolled in the curricular unit *Translation Practices PT/EN and EN/PT* a compulsory subject in the Foreign Languages and Cultures degree at *Escola Superior de Educação* (ESE) at the Polytechnic of Porto (IPP). These students, all native Portuguese speakers with C2 proficiency in English, analysed AI translations of Portuguese opinion and satirical texts and were tasked with identifying and correcting instances of morphological, syntactic, semantic, and cultural transfer. Their analyses provided qualitative evidence of how CLI manifests in AI outputs and how translation students engage with these phenomena.

From a pedagogical perspective, the study highlights the importance of integrating AI translation into translator education. The recurrent errors observed in AI-generated texts are not merely flaws but valuable learning tools, reinforcing the role of error analysis in translation training. By working with authentic AI outputs, students develop critical AI literacy, acquire strategies to evaluate and refine translations, and gain awareness of the cultural and linguistic subtleties involved in professional practice.

The following sections present a review of relevant literature on CLI and AI translation, describe the methodological framework adopted, analyse the results obtained, and discuss their pedagogical implications. The study concludes with reflections on its limitations and suggestions for future research.

## 2. Literature review

### 2.1. Crosslinguistic influence

Language transfer refers to the process by which individuals use their existing knowledge of one language (usually the L1) to aid in the acquisition of another (later an L2). Over the years, ideas around this concept have shifted, especially in terms of how someone's L1 may affect learning an L2.

In the 1950s, Weinreich (1953) connected negative transfer, or interference, to behaviourism. The latter perceived language learning as a process of habit forming, implying that if someone picked up “bad habits” from their L1, those could make learning a new language harder. Behaviourism and structuralism dominated the 1950s and 1960s, emphasising that language consisted of conditioned habits and that transfer was largely negative. During this same period, *Contrastive Analysis* (CA) focused on comparing languages to predict learning difficulties based on similarities and differences between the L1 and the target language (TL). *Error Analysis* (EA) also emphasised the negative aspects of transfer by analysing learner errors to improve teaching methods.

In the 1960s, mentalists viewed language acquisition as the creative construction of linguistic rules, arguing that humans have an innate language ability governed by universal grammar rules (Chomsky, 1976). They believed that children did not rely on L1 transfer but on their ability to construct an L2 independently. This led to the hypothesis that L1 and L2 learning were governed by universal norms, minimising the role of transfer. The limitations of the mentalist view led to the rise of cognitivism in the 1970s, which suggested that language learning involved cognitive processes similar to those used in other knowledge areas. Cognitive linguists examined factors influencing SLA, emphasising how and when learners used their native language. They considered multiple factors affecting interlanguage development, including linguistic, psychological, social, and developmental influences (Ringbom & Jarvis, 2009).

Key findings in language transfer research highlight its complexity, involving learners' perceptions, conceptualisations, mental associations, and individual choices. This has dispelled myths and inaccuracies, showing that language transfer is not merely habit-related or simple interference from the L1. Jarvis and Pavlenko (2008) introduced the term *Crosslinguistic Influence* (CLI) to describe more dynamic processes of language transfer, introducing notions such as reverse transfer, bidirectional transfer, and lateral transfer, and redefining prior concepts while excluding outdated notions of habit formation and interference (Odlin, 1989).

Empirical studies have shown that CLI affects both the rate and route of language acquisition and that learners' perceptions of transferability also play a crucial role (Ringbom, 2007). More recent findings include recognising the positive effects of transfer, often resulting in avoidance or overproduction rather than errors (Barking et al. 2025). Additionally, research has highlighted the importance of considering both similarities

and differences between languages, individual learner differences, and the dynamic nature of transfer over time. These advances have significantly contributed to the field of crosslinguistic research, offering a more nuanced understanding of language transfer.

## 2.2. AI-Powered Translation systems and CLI

Multiple connections may be established between CLI and AI-powered translation systems. AI systems use patterns and data they have previously processed to produce language, much like human learners do. These translation systems process vast data volumes by accessing extensive databases to generate precise translations (Omar & Salih, 2024). People usually use their L1 as an aid when they learn an L2, which parallels how AI translation systems function. AI translation systems perform better when working with similar languages but face difficulties when the languages differ significantly (Sachan & Neubig, 2018). For example, if two languages share similar structures, translations are likely to be more accurate; conversely, when there are substantial grammatical or syntactic differences, results can be awkward or inaccurate.

AI systems also involve machine learning (Koka et al., 2023), which mirrors certain aspects of the ways humans learn languages. For example, AI systems take new data and learn to use it over time, in much the same way that human learners improve through practice. This process connects to the cognitive perspective of second language acquisition (SLA), which attends to properties such as memory, attention, perception, and problem-solving. Some machine learning systems are advanced enough to account for context, adjusting meanings based on specific communicative situations (Sangeetha et al., 2023). Other AI systems trained on multilingual and polylingual data are able to adapt idioms or aspects of cultural and linguistic context accordingly. These capabilities reflect principles in cognitive linguistics, which view language learning as influenced by a variety of processes.

Certain contemporary systems, such as neural machine translation (NMT) models, are now able to provide better treatment of idioms and figurative meanings than earlier generations of machine translation (Hu & Li, 2023). This demonstrates a deeper understanding of CLI, as developers use translation errors to fine-tune AI systems, paralleling the role of error analysis in language teaching. AI systems can also identify which language features can be transferred safely from one language to another, learning which forms, structures, and meanings are least likely to cause confusion. While AI does not have personal traits like humans do, it can simulate different ways of processing language by using algorithms tailored to specific language pairs. This adaptability reflects how human learners bring their own strategies and strengths to language learning.

Since AI systems are built on real data and are constantly updated, they follow a similar path to empirical SLA research, which helps us better understand CLI. In many respects, AI-powered translation systems enact CLI by using what is already known, adapting as they go, taking different factors into account, and improving through ongoing analysis. They capture many of the same challenges and strategies that arise in human language learning and transfer, and they remain prone to making similar errors—a phenomenon this study will examine in detail.

While these parallels illustrate AI's growing sophistication, they also underscore persistent challenges in handling crosslinguistic transfer, particularly in educational contexts. Recent research emphasises that even advanced systems such as ChatGPT remain susceptible to transfer-related issues. Pym and Hao (2024) argue for integrating machine translation literacy into translator education so that students learn not only to use AI tools but also to critically evaluate their outputs. Moorkens (2022) raises ethical and professional considerations, warning that over-reliance on AI can erode critical judgment if not accompanied by explicit training in error analysis. Shahmerdanova (2025) discusses the opportunities and risks of AI in translation and advocates for hybrid models that combine human expertise with automated output to preserve cultural sensitivity and accuracy. Rothwell et al. (2023) situate translation technologies within a broader set of digital competences and argue for curriculum renewal to prepare translators for emerging challenges. Gaspari et al. (2015) further note that machine translation competence is increasingly recognised as a core component of translator training. Recent empirical work on AI-mediated feedback and student engagement in translation revision (Xu et al., 2024) shows that framing AI output as a site for reflection can boost engagement and deepen learners' analytical skills.

Accordingly, AI-powered translation systems can be seen as both practitioners and subjects of CLI. They use what is already known, adapt as they process new data, take different linguistic and cultural factors into account, and improve through ongoing analysis. At the same time, they remain prone to many of the same transfer-related errors made by human learners. This duality underpins the rationale for the present study, which investigates how such errors manifest in AI translations and how their identification and correction can contribute to the development of translator competences and critical AI literacy.

The intersection of CLI and AI translation represents a fertile ground for translator education. As Gaspari et al. (2015) note, machine translation competence is now recognised as a core component of professional translator training. However, much remains to be studied about how students identify and correct AI-induced CLI phenomena and how this process promotes their professional skills. This is particularly relevant in fast-evolving contexts, where translation students must not only master linguistic transfer but also learn to evaluate and refine the output of AI systems.

By investigating Portuguese–English AI translations and involving students directly in the detection and correction of CLI-related errors, the present study contributes to this emerging field. It connects the theoretical tradition of CLI research with the pressing need for pedagogical strategies that prepare future translators to critically engage with AI translation tools.

### 3. Methodology

This section details the methodological approach adopted to investigate the manifestation of CLI in AI-powered translations and the role of students in their analysis.

#### 3.1. Research design

By employing rigorous and appropriate methods, researchers can ensure that their findings accurately reflect the reality studied and are trusted by colleagues and stakeholders. With these factors in mind, we decided to design a case study and follow a qualitative research methodology to generate valuable knowledge, contribute to theory development, and advance understanding of the issue.

Among many authors who have studied this topic, Creswell (2014) presents a rather encompassing definition of case study strategy.

Case Studies are a qualitative design in which the researcher explores in depth a program, event, activity, process, or one or more individuals. The case(s) are bound by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time. (p. 241)

Similarly, Yin (2014) indicates that a case study can be descriptive, explanatory, or exploratory, with the latter aiming to investigate a phenomenon in order to identify new research questions for future, more comprehensive studies

Considering these elements, we opted for an exploratory stance, as our main goal while designing and conducting this case study was to achieve a deep contextual understanding of the phenomena under study and foster new questions for future research. The qualitative approach allowed for the exploration of nuances in AI-generated translation errors and of how students identified and analysed them - elements that would be difficult to capture through purely quantitative approaches.

Ethical considerations were integral to the research design. We kept in mind the ethical implications for participants, selecting methodologies that prioritised informed consent, anonymity, and voluntary participation among our students. This aligns with guidelines for purposeful sampling, a qualitative research technique for identifying and selecting the most meaningful cases for effective use of resources (Patton, 2002). As Creswell and Plano Clark (2017) note, purposeful sampling involves identifying and selecting individuals or groups that are knowledgeable about, or experienced with, the phenomenon of interest.

### 3.2. Participants

The sample comprised 101 students enrolled in the curricular unit Translation Practices (PT/EN and EN/PT), a compulsory third-year course in the bachelor's degree in Foreign Languages and Cultures at Escola Superior de Educação (ESE), Polytechnic of Porto (IPP). All participants were native speakers of European Portuguese and had demonstrated C2 proficiency in English according to institutional assessment. Participant selection occurred through non-probabilistic sampling, via an invitation for voluntary participation in the context of regular teaching activities.

2023/2024 cohort: 57 students (average age 20), who worked with ChatGPT-3.5

2024/2025 cohort: 44 students (majority aged 20–21), who worked with ChatGPT-4

Students were provided with a set of opinion and satirical texts originally published in Portuguese newspapers. These were translated into English using ChatGPT-3.5 or ChatGPT-4, depending on the cohort. Each student worked individually on the same set of AI-generated translations to ensure comparability. Their task was to identify and correct instances of negative CLI, focusing on four categories: morphological, syntactic, semantic, and cultural.

### 3.3. Data collection

As part of their assessment, we gave students a set of texts originally written in European Portuguese and translated into English using an AI-powered engine. All students worked with the same set of texts to ensure comparability across analyses. Students were asked to examine the translated texts and identify, from both linguistic and contextual perspectives, the main translation challenges and make the appropriate corrections. Our aim was thus to detect negative CLI in the AI-generated translations.

We selected our source texts (STs) from daily or weekly newspapers, written in a style typical of contemporary European Portuguese. Based on the stylistic and linguistic features and substantial cultural references within the chosen articles, we anticipated that these texts would induce negative CLI in the AI translations. We deliberately opted for humorous or opinion-based articles on current affairs related to Portugal for this reason.

The target texts (TTs) of these STs were produced by the ChatGPT-3.5 model (for the 2023/2024 group) and the ChatGPT-4 model (for the 2024/2025 group), focusing on the European Portuguese–English language pair. The primary data for the study consisted of the students' written records of their analyses and corrections of these AI-generated translations, where they identified and justified instances of negative CLI.

The students' analyses were collected as written assignments forming the primary dataset and were examined using a qualitative content analysis approach. Each correction was categorized according to four predefined types of negative CLI: morphological, syntactic, semantic, and cultural, with errors systematically coded according to the predefined CLI categories. This classification enabled the identification of recurring patterns and pedagogically significant trends. The findings from this analysis are presented and discussed in the following section, where representative examples illustrate the nature and implications of these cross-linguistic influences.

Corrections were supervised by the course instructors, who provided guidance during the process, and the students' analyses were formally graded. This ensured that students approached the task critically and systematically.

## 4. Results and discussion

The analysis of AI-generated translations revealed consistent patterns of crosslinguistic influence (CLI), confirming that both ChatGPT-3.5 and ChatGPT-4 reproduce structural and cultural transfers from Portuguese into English. Morphological errors (e.g., incorrect verb moods), syntactic transfers (e.g., literal word order), semantic mismatches (e.g., misleading cognates), and cultural non-equivalences (e.g., inadequate idiomatic renderings) demonstrate the persistence of L1 interference even in advanced neural machine translation

(NMT) systems. While ChatGPT-4 displayed greater fluency, both models exhibited similar types of transfer-related errors.

We selected some examples of how AI translation systems mirror many of the same crosslinguistic transfer challenges faced by human learners. To support clarity and consistency, the selected examples have been compiled in Tables 1 and 2, alongside some of the correction proposals we suggest.

A key finding concerns students' difficulty in detecting errors when translations appeared fluent and grammatically correct. This underscores a central pedagogical risk: the illusion of reliability in AI outputs. When surface accuracy masks underlying pragmatic or cultural inaccuracies, students may accept translations uncritically, weakening their evaluative judgment. Closely linked to this is the risk of technological dependency. If learners habitually rely on AI systems without questioning their limitations, they may privilege post-editing machine outputs over developing independent translation strategies, potentially undermining long-term professional competence.

Another critical issue involves cultural and ideological bias. AI systems are trained on large-scale multilingual corpora that privilege dominant linguistic and cultural norms. In this study, culturally embedded Portuguese expressions were either flattened (e.g., food-related terms) or misrepresented in English, often erasing local nuance. Such distortions risk reinforcing Anglophone-centric perspectives and highlight the necessity of cultivating cultural sensitivity in translator education.

At the same time, these weaknesses illustrate the pedagogical potential of AI outputs. Translation errors provide authentic material for error analysis and reflective practice, allowing students to confront the limits of automated systems while sharpening their diagnostic skills. By explicitly engaging with AI outputs, students learn to distinguish between acceptable variation and erroneous transfer, an ability central to professional translation. This aligns with calls for machine translation literacy (Pym & Hao, 2024), which emphasise not only the technical use of AI tools but also the capacity to interrogate their reliability, biases, and broader implications.

To maximize this potential, translator training must adopt a hybrid pedagogical approach: integrating AI into classroom practice while simultaneously fostering critical engagement, metalinguistic awareness, and cultural competence. Rather than positioning AI as a replacement for human expertise, this approach frames it as a catalyst for deeper linguistic reflection and professional skill development.

In summary, while AI-powered translation systems reproduce human-like CLI and offer valuable material for pedagogical exploration, their limitations demand a critical stance. Addressing issues of reliability, technological dependency, and cultural bias is essential to ensure that AI functions not as a crutch, but as a tool for cultivating the critical awareness and evaluative skills that remain central to the translator's role.

**Table 1.** Examples of negative crosslinguistic influence in ChatGPT-3.5

Type of interference	Portuguese ST Excerpt	AI TT	Issue identified	Suggested TT / comment
Morphological	<i>o Sporting lamentará que Gyokeres seja</i>	Sporting regrets that Gyokeres is	Incorrect mood transfer; English subjunctive required	Sporting may regret that Gyokeres may be / should be
	<i>que é o que dá sentido à vida de milhões de portugueses</i>	which gives meaning to the lives of millions of Portuguese	Portuguese used adjectivally instead of as a plural noun	...to the lives of millions of Portuguese people
Semantic	<i>Previsões astrológicas para 2024</i>	Astrological Predictions for 2024	Overly literal translation lacks satirical tone	Possibly Horoscope for 2024 or Your 2024 forecast
	<i>deputados</i>	deputies	False cognate; deputies not standard in UK/US parliamentary English	Use MPs or members of parliament
	<i>os seus colegas</i>	your colleagues	May imply professional peers, not intended in ST	... peers or associates, depending on context
Syntactic	<i>onde Mercúrio não está retrógrado, mas marca sempre temperaturas muito baixas</i>	where Mercury is not retrograde but marks always very low temperatures	Adverb placement violates English norms	...always marks very low temperatures
	<i>da barriga de Maria Antónia Palla</i>	from the belly of Maria Antónia Palla	Awkward calque; literal word order sounds unnatural in English	Rephrase: born to Maria Antónia Palla
	<i>as novidades urgentes por telefone, com minutos contados</i>	urgent news by phone with counted minutes	Literal translation of idiom; results in lack of clarity	urgent news delivered by phone in a matter of minutes
Cultural	<i>sobretudo na hora de não mandar à fava</i>	especially when it comes to not telling off	Idiomatic loss; <i>mandar à fava</i> not equivalent to telling off	Possibly especially when it comes to keeping quiet or an explanatory note
	<i>Não quero avaliar a laracha</i>	I don't want to evaluate the joke	<i>Laracha</i> has informal/cultural nuance lost in TT	Consider wisecrack or quip; explain if necessary
	<i>filhoses</i>	<i>filhoses</i>	Cultural reference not adapted; readers unfamiliar	Add explanation: <i>filhoses</i> (Portuguese Christmas fritters)
	<i>maçã bravo de Esmolfe; arroz carolino</i>	Bravo de Esmolfe apple; carolino rice	Direct transfer may confuse target readers	Glossary or footnote: a regional apple variety; a type of short-grain rice

**Table 2.** Examples of negative crosslinguistic influence in ChatGPT-4

Type of interference	Portuguese ST excerpt	AI TT	Issue identified	Suggested TT / comment
Morphological	<i>impressionando-me com a densidade emocional</i>	impressing me with the emotional depth	English gerund implies ongoing action; PT refers to a moment	Consider which impressed me with...
	<i>fascinada por cabeças</i>	fascinated by minds	Loss of gendered nuance; <i>fascinada</i> signals female speaker	As a woman, fascinated by minds or retain feminine subject
	<i>devendo gerar condições</i>	creating the necessary conditions	Omission of modal aspect ( <i>devendo</i> implies obligation)	supposed to create conditions
Semantic	<i>dei-lhe umas migalhas e ele atirou-me pão para cima</i>	I fed it crumbs, and it showered me with bread	showered exaggerates effect; adds humour not in ST	Possibly use gave me back bread
	<i>num registo quase onnipresente</i>	an almost omnipresent awareness	<i>registo</i> = tone or communicative mode, not mental state	in a tone that was almost omnipresent
	<i>arrufos de alecrim e manjerona</i>	cryptic gamesmanship	Erases gentle domestic tone; replaces with abstract term	petty squabbles over rosemary and marjoram
	<i>grandes aventuras ou desastres por concretização ao lado do pretendido</i>	unintended disasters	Loses nuance of near-miss or misfire	disasters resulting from near-misses
Syntactic	<i>mas aqui só as minhas mãos escrevem – o resto vem de um ente que nem é gente para ter corpo</i>	but here only my hands type—the rest comes from an entity without a body	TT flattens rhythm and introspective tone	Rephrase to preserve poetic rhythm and ambiguity
	<i>como se não fossem farinha do mesmo saco</i>	as though they weren't cut from the same cloth	English equivalent changes rhythm and metaphor	Footnote or alternative to retain ST metaphor
	<i>não são lineares, não são coerentes e decidem sem explicar</i>	are inconsistent and make unexplained decisions	Simplified list; loses cumulative emphasis	Retain triadic form: not linear, not coherent, and decide...
Cultural	<i>o gajo é uma máquina</i>	that thing is a machine	Loss of compliment and familiarity; thing dehumanises	That guy's a machine (retains tone and context)
	<i>um livro que escrevi para os meus filhos</i>	a book I wrote for my kids	kids is more casual than <i>filhos</i> ; tone shift	Use children to preserve neutral/formal tone
	<i>vale tudo</i>	anything goes	TT lacks chaotic connotation of PT phrase	“a free-for-all” or “no-holds-barred”
	<i>Estado</i>	state operations	Lowercase state misses formal/legal register of capitalised <i>Estado</i>	Use the State to preserve status

## 5. Conclusions and future directions

This exploratory case study examined whether AI-powered translation systems (ChatGPT-3.5 and ChatGPT-4) reproduce patterns of Crosslinguistic Influence (CLI) in Portuguese–English translation and how students’ engagement with these outputs supports translator training. The findings demonstrated consistent instances of morphological, syntactic, semantic, and cultural transfer, confirming that AI systems, much like human learners, are prone to crosslinguistic interference. Importantly, students often failed to identify these errors when translations appeared fluent, highlighting the need to cultivate critical AI literacy as an integral component of translator education.

From a pedagogical perspective, the study contributes by framing AI errors not as simple shortcomings but as learning opportunities. When integrated into teaching, such outputs can enhance students’ diagnostic skills, foster reflective practice, and deepen awareness of linguistic and cultural nuance. In doing so, the study reinforces the importance of embedding machine translation literacy into curricula so that future translators learn to critically evaluate and refine automated outputs rather than relying on them uncritically.

At the same time, several limitations must be acknowledged. The study was limited to a single institution and to students with a relatively homogeneous profile (native Portuguese speakers with C2-level English), which constrains generalisability. It also focused exclusively on Portuguese–English translations, leaving open questions about how CLI manifests in typologically different language pairs. Furthermore, only two versions of a single AI system were examined, and the analysis relied on student-produced corrections, which, despite researcher verification, may still reflect subjectivity in interpretation. These limitations point to several opportunities for future research. Comparative studies involving other AI platforms (e.g., DeepL, Google Translate) and additional language pairs could reveal whether observed CLI patterns are tool-specific or universal.

Longitudinal studies following students over multiple semesters would provide insights into how exposure to AI outputs shapes their translation competence and critical literacy over time. Collaboration with computational linguists could also help illuminate the underlying mechanisms of error generation, bridging applied linguistics with technical AI development. Finally, experimental interventions—such as CLI-focused workshops or hybrid AI-assisted translation modules—could test concrete pedagogical strategies for strengthening students’ evaluative skills.

In conclusion, this study highlights both the potential and the risks of integrating AI into translator training. While AI tools reproduce CLI and carry risks of dependency and cultural bias, they also offer rich opportunities for pedagogical innovation. The challenge for translation studies and education lies not in rejecting these tools but in teaching future professionals to engage with them critically, ethically, and creatively.

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