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| RESEARCH ARTICLE

The Role of Artificial Intelligence Translation Tools in Academic Translation: Faculties of Pure Sciences as a Case Study

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| ABSTRACT
Considering the influence of globalization and the dominance of English as the de facto language of scientific research, doctoral students in North Africa generally and in Morocco specifically face a certain linguistic discrimination hindering the visibility of their academic contributions. Therefore, they resort to translation from French into English as a survival strategy. Several studies have demonstrated that the advent of Artificial Intelligence-powered translation tools has proven effective in improving the quality of students' writing performance. The present study seeks to investigate the role of AI-powered translation tools in facilitating the composition of research articles, specifically within the pure sciences disciplines of physics, biology, chemistry, geology, and mathematics. Moreover, this paper aims to identify the AI tools preferred by doctoral students for translating and post-editing their articles. Besides, it sheds light on the perceptions of doctoral students and PhD holders regarding the utility of AI-powered language tools in enhancing the linguistic quality of research articles. The present research is quantitative. It takes the form of an online survey comprising 17 items. Moroccan doctoral students frequently use AI tools to translate from French to English and to enhance the quality of their English to meet academic writing standards. By exploring the effectiveness of AI-powered translation tools in overcoming linguistic barriers, this paper contributes to enhancing the visibility of Moroccan doctoral students' publications in the global scientific community. Finally, the findings can inform English language materials designers in Moroccan higher education to deeply understand the linguistic challenges encountered by doctoral students.

| KEYWORDS

Artificial Intelligence-powered translation tools, scientific and technical translation, academic writing, scientific discourse, postediting

| ARTICLE INFORMATION

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1. Introduction

It is common knowledge that Moroccan Universities strive to secure a place in global rankings. Cadi Ayyad University, for instance, is ranked first in Morocco and 1101st in the world. Among the factors behind this substandard performance is the inconsistency between the language of instruction and the language of conducting research. While English is the lingua franca of scientific communication, the linguistic background of Moroccan researchers is bilingual (Arabic and French) with a limited proficiency in English. Thus, to publish in English or perish in French has become the new pressing requirement for Moroccan researchers.

Being caught in the dilemma of publishing in distinguished scientific journals and lacking sufficient English academic writing skills, Moroccan doctoral students resort to translation as a survival strategy to bridge this gap. Often, doctoral students seek alternative methods other than professional translation services due to their high costs.

Indeed, several studies have demonstrated that the advent of Artificial Intelligence-powered language tools has proven effective in improving the quality of students' translation performance (Tran, Thi(2024), Chen, W., & Wei, H (2021), Kornfeld, L., & Roy, D (2021), Adams, D., & Chuah (2022), Song C and Song Y (2023). The present study aims to investigate how AI-powered translation tools contribute to the process of composing research articles. This will involve assessing doctoral students' perceptions of the effectiveness of AI translation and post-editing tools. Additionally, the study aims to identify the specific translation and post-editing software currently utilized by doctoral students. The disciplines covered are physics, biology, chemistry, geology, mathematics, and computer sciences.

As far as the research questions are concerned, this study seeks to answer the following questions:

- Which AI translation tools are predominantly utilized by doctoral students?
- Which AI post-editing tools are most employed by doctoral students?
- How do Moroccan doctoral students perceive the effectiveness of these tools in enhancing the quality of English-published manuscripts?

2. Literature Review

2.1. Linguistic Landscape in Moroccan Higher Education

For a detailed description of the linguistic challenges that Moroccan doctoral students have been facing, it is worth providing a thumbnail sketch of Moroccan language policy in educational settings. Morocco, being a multilingual country, offers its citizens exposure to a diverse array of languages, including Moroccan vernacular, standard Arabic, and Amazigh, as well as foreign languages such as French and Spanish. According to Belhiah (2020), "Morocco can be considered a diglossia community, in which Modern Standard Arabic is the high variety as it is often used in formal domains, such as religion, education, and administration, whereas Moroccan Arabic is the low variety due to its use mainly as a spoken medium and its lack of a standardized variety"(p.37). The Amazigh language and culture have deep historical origins in Morocco, and they constitute a crucial part of the nation's identity. Both Arabic and Amazigh are decreed by the constitution of 2011 as the official languages of Morocco.

French, Spanish, and English are the prominent foreign languages in Morocco. French is taught in primary, middle, and high schools as a foreign language, and it constitutes the medium of instruction in scientific and technical fields in higher education. Beyond its function as a communication tool, French enjoys a special status in Moroccan society. Loutfi and Noamane (2020) argue that "the country's elite consider French a privilege that they are not willing to give up on easily. Speaking French sets them and their children apart from the rest" (p.2). However, Boukous (2009) claims that English will become more prevalent than French as Morocco's primary foreign language. This shift is attributed to the skepticism towards the French colonial legacy and ideals by traditionalist, Islamist, and nationalist factions. This was confirmed by Errihani (2017) who believes that English is gaining traction in the Moroccan linguistic landscape and "all indications at this time point to a strong shift in Morocco's language education policy from a focus on Arabic and French as the traditional mediums of education to English" (p. 130). English is the third foreign language after French and Spanish. Moroccan students start their first English language course at K9 which corresponds to the third year of middle school in the Moroccan educational system. Furthermore, there has been a turnaround in students' perceptions and attitudes toward English as a medium of instruction, several Moroccan studies document the positive attitudes of students towards English given its dominance in scientific research, and the opportunities it offers in terms of job opportunities and professional promotion (Belhiah(2016), Kirat and Laaraj (2017), Errihani(2017), Bouziane (2020), Belhiah (2020), Et-Tahiri (2019).

The language of teaching scientific and technical subjects in the Moroccan educational system is indeed controversial. Post-independence (1956) linguistic policies prioritized the Arabization of all scientific and technical subjects at primary, secondary, and tertiary levels to fortify national identity and decrease the dominance of French in the country. However, in scientific fields, French has continued as a dominant medium of instruction, (Rabia, 1998, p.199). Languages such as English, Spanish, and German were taught as foreign languages at private and public schools. Almost 30 years after Morocco adopted the Arabic language for teaching scientific subjects from primary school up to the baccalaureate, French is back in middle and high schools as the medium of instruction for scientific and technical subjects.

2.2 L2 – L3 Translation: The Moroccan Context

Just as Greek, Latin, Arabic, French, and German have held the status of lingua franca of science over the centuries, much international exchange of scientific knowledge today happens through English (Montgomery, 2009). Numerous international science journals are dedicated to publishing papers solely in English. Thus, non-native English scientists worldwide find themselves obliged to submit their research in English to gain influence and recognition in prestigious journals. It is worth noting that the profile of scientific and technical translators is different; they can be either linguists or professional translators who received formal training in linguistics or translation studies with ancillary knowledge in a specific field or they can be bilingual scientists demonstrating a high linguistic competence that enables them to translate texts in their fields of specialization.

Moroccan doctoral students are no exception; they must publish two research articles in indexed journals as part of defending their Ph.D. dissertations. Consequently, doctoral candidates often engage in translation, either as a writing tactic to publish their research articles in English or as a means to provide Arabic and English versions of their thesis abstracts. To my knowledge, there is a dearth of empirical research describing the role of translation in writing research articles in scientific and technical fields and the strategies Moroccan doctoral students employ to produce the English version of their research articles.

Having studied scientific subjects in Arabic in secondary school and then in French at graduate levels, Moroccan researchers are consequently obliged to master English or resort to translation as a quick fix. Indeed, Bachiri and Tribak (2020) found that 76.2% of Moroccan doctoral students (a case study of Euromed University of Fez) use translation in writing their papers. Unfortunately, the authors claim that "in scientific writing, students oftentimes adopt word-for-word translation to convert their text into English" (p.16). Therefore, doctoral students make considerable efforts to build a translation competence that enables them to produce texts that align with the strict standards of English academic writing.

Translation from L1 to L2 or from L2 to L1 is the evident directionality addressed in the literature. In the Moroccan context, students translate from French as a foreign language into English as a foreign language too, a fact that leads to questioning their level in both languages and thus the quality of the source and target texts. The practice of translation for publishing purposes is frequently not recognized in the literature. Translators are seldom acknowledged in journals (Aixela, 2004, p.30). Hence, the translation of the article enjoys the status of an academic paper written originally in English and this is what House (2014) refers to as covert translation. For instance, Montgomery (2009, pp. 9–10) points out the diverse range of translation practices within academic settings. These encompass translation of entire texts, translating excerpts of academic texts for individual use, self-translation either in full or part for publication purposes, and various forms of partial translation or mediation aiding the dissemination of knowledge across different languages.

2.3. The Role of AI-Powered Machine Translation and Post-Editing Tools In Composing Research Articles

Before submitting manuscripts for publication, doctoral students go through a long editing process. They carefully scrutinize their papers for any linguistic issues; the authors double-check mistakes related to spelling, grammar, style, or tone. Traditionally, students tend to resort to English teachers, professional translation services, or simply their English-speaking colleagues to proofread their papers. The high cost of professional translators and the lack of expertise and knowledge among English editors make the situation more challenging. However, the emergence of Artificial Intelligence has reshaped this tradition. For instance, AI-powered writing tools such as Chatgpt, DeepL, Quilbot, and Grammarly. have garnered significant interest thanks to their efficiency and preciseness that imitate human language.

Brown, T. B. et al. (2020) define ChatGPT as an AI language model developed by OpenAI, utilizing the GPT (Generative Pre-trained Transformer) architecture. It is designed to generate human-like text based on the input it receives, capable of engaging in conversations, answering questions, and assisting with various language tasks. Several studies focus on the use of AI tools in academic writing and scientific communication. For instance, Barrot JS (2023), Dergaa I, Chamari K, Zmijewski P, Ben Saad H (2023), Huang J, Tan M (2023), Ray, P.P. (2023) investigate the role of Chatgpt in writing academic texts. They highlight the potential advantages of Chatgpt in academic writing as well as the concerns relating to academic integrity and authenticity of the generated text.

In the same vein, Translation tools powered by Artificial Intelligence such as DeepL, Google Translate, Reverso, and Chatgpt have demonstrated high accuracy and efficiency compared to traditional machine translation. They employ deep learning techniques and natural language processing to identify nuances of meaning and contextual particularities that have a direct influence on the naturalness of the translation. The utility of machine translation in multiple settings has stimulated interest among many academics. However, limited research has explored the utilization of machine translation and post-editing for academic purposes. For instance, Sebo P., and de Lucia S (2024) compare the performance of three machine translation tools (DeepL, Google Translate, and CUBBITT) in translating medical research abstracts from French to English. The researchers addressed the challenges faced by non-English speaking medical researchers when writing academic articles in English. The findings suggest that French-speaking researchers could benefit from using DeepL, Google Translate, or CUBBITT when translating articles from French to English. The study acknowledges the potential limitations, such as the influence of French source texts on the translation process. Besides, it highlights the need for further research to evaluate the performance of machine translation tools with full articles and languages other than French.

It is worth mentioning that the quality of the output of machine translation varies following the language pair in question. Balk et al. (2013) conducted a study comparing the accuracy of Google Translate in translating non-English language studies for systematic reviews across five languages. They observed variations in translation accuracy. Spanish translations had the highest rate of correct extraction, with 93% of items being accurately extracted more than half the time. This was followed by German and Japanese at

89%, French at 85%, and Chinese at 78%. Within the same field of inquiry, Groves and Mundt (2014) conducted a study on assessing the grammatical accuracy of the Google Translate engine in translating language for academic purposes. The authors requested students to submit an essay in their native language, which was subsequently translated into English using Google Translate. The English text produced was then examined for grammatical errors. The findings indicated that the translation engine did not consistently generate error-free texts. Nevertheless, when assessed against international testing standards, the accuracy level approached the minimum requirement for university admission at numerous institutions.

In conclusion, AI-powered tools have demonstrated their utility in facilitating the writing and translation processes, leading to time savings and enhanced productivity. Despite these advantages, concerns regarding the authenticity and quality of the generated work persist as areas that require further efforts and scrutiny in future versions. While numerous studies have explored machine translation and compared outputs from various translation engines to professional human translations, there is a noticeable gap in the literature concerning the process describing the interaction between humans and AI translation tools. Specifically, research focusing on the post-editing efforts made by users, particularly in the academic genre, remains sparse. Post-editing in the professional translation industry has garnered considerable attention; however, employing translation as a method to generate academic text has received comparatively less attention.

The uniqueness of this research lies in the profile of the translators who are initially doctoral students majoring in scientific and technical disciplines without formal training in linguistics or translation studies. This presents an intriguing angle, as it enables a deeper understanding of the role of AI translation and editing tools in refining academic writing in scientific and technical fields. Consequently, this experiment promises to offer valuable insights into the nuances of human-AI interaction in the context of academic text translation.

3. Methodology

The present study adopts a quantitative research approach. It takes the form of a questionnaire aiming at eliciting quantitative data regarding the perceptions of doctoral students on the use and utility of AI translation and editing tools in translating research articles from French into English in five disciplines: physics, chemistry, biology geology, mathematics, and computer sciences. These fields constitute the departments of the faculties of sciences in Moroccan universities. The questionnaire is designed to answer the previously mentioned research questions.

3.1. Data collection

The questionnaire consists of 17 items divided into three parts. The first part describes the demographic information of the participants. The second part seeks to identify the translation tools used by doctoral students and the reasons behind their choice. The last part delves into their perceptions regarding the use of AI-powered tools in the translation and post-editing of their texts in English with a focus on identifying the tools they use most. The language of the questionnaire is French because it is the medium of instruction in the faculties. The questionnaire was distributed through Google Forms.

To avoid research bias, the development of surveys requires establishing validity and reliability to optimize the quality of measuring research constructs. Mellinger& Hanson (2017) clarify that "face validity can be strengthened by conducting a thorough literature review on the topic and seeking feedback from experts in the field while developing the survey" (p.31). The questionnaire was presented to three professors with long experience in teaching English as a foreign language in Moroccan departments of English studies. They reviewed the questionnaire and suggested some alterations in the phrasing of the questions.

A pilot study was conducted with 10 participants to measure the time to fill it out, check its clarity, and receive feedback regarding the phrasing and order of items. Participants in the pilot study provided feedback on the wording of the items, noting ambiguity in certain terms associated with linguistics and translation theory. Consequently, the adoption of simplification and plain language, supplemented by illustrative examples, served to clarify these ambiguities.

3.2. Participants

The sample randomly incorporated a cohort of 98 doctoral students who were enrolled in the disciplines at the following Universities during the second semester of the academic year 2023-2024.

Table 1: Demographic information of Study Participants

	Percentage of doctoral students in the sample						Total
Gender	Female			Male			
	66.7%			33.3%			98
Academic year	1	2	3	4	5	6	Doctor
	12.6%	13.7%	23.2%	17.9%	10.5%	10.5%	11.6%
Discipline	Physics	Chemistry	Biology	Geology	Mathematics and Computer Science		
	32.6%	9.5%	31.6%	8.4%	17.5%		
University	Hassan II University	Abdelmalek Essaadi University	Chouaib Doukkali University	Mohammed V University			
	63.5%	12.5%	17.5%	3.1%			

4. Results and Discussion

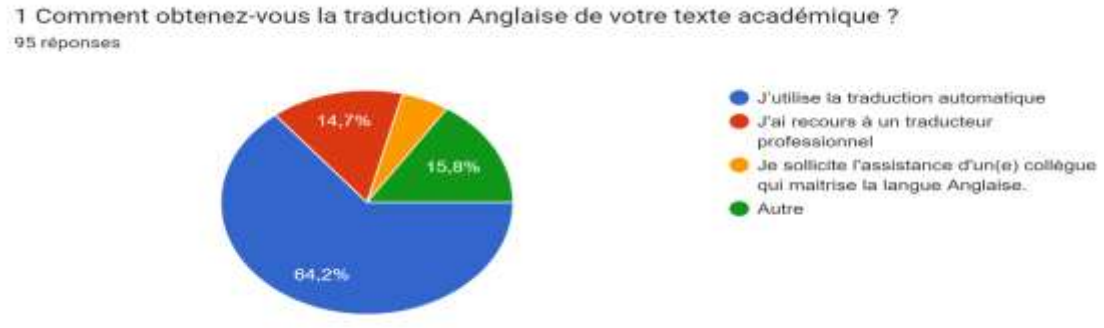
4.1. Results

4.1.1. Utilizing AI Translation Tools for Composing Research Articles

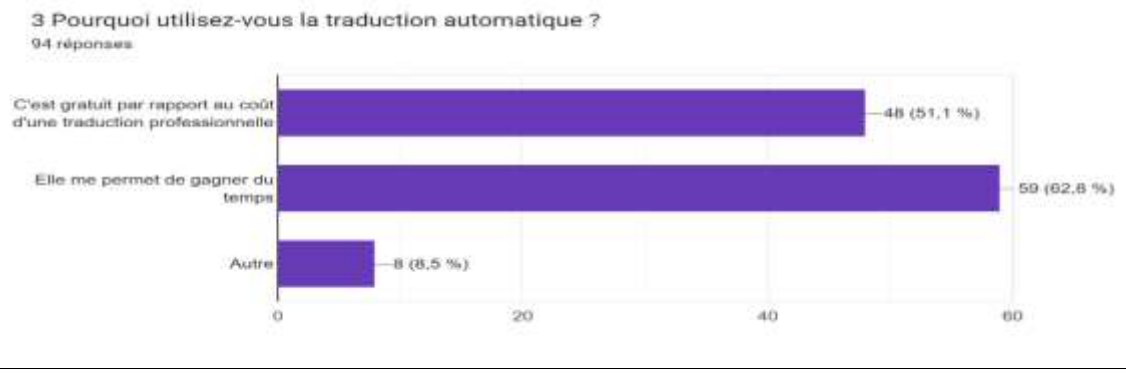
The first question aims to understand the methods used by researchers to translate their academic texts into English. The figure shows that 64.2% of participants use automated translation to translate their articles from French into English. 14.7% of responses use professional translation services while 15.8% use other methods. The second question seeks to identify the reasons behind the use of automated translation tools. 51.1% of respondents claim that automated translation is free of charge compared to professional translation. Besides, 62.8% claim that enables them to save time since manual translation is time-consuming. The third question focuses on the specific software preferred by researchers for translation purposes, and the results revealed that a significant number of doctoral students use DeepL (51.6%) followed by Google Translate (15.8%) and ChatGpt (20%).

Table 2: Utilizing AI Translation Tools for Composing Research Articles.

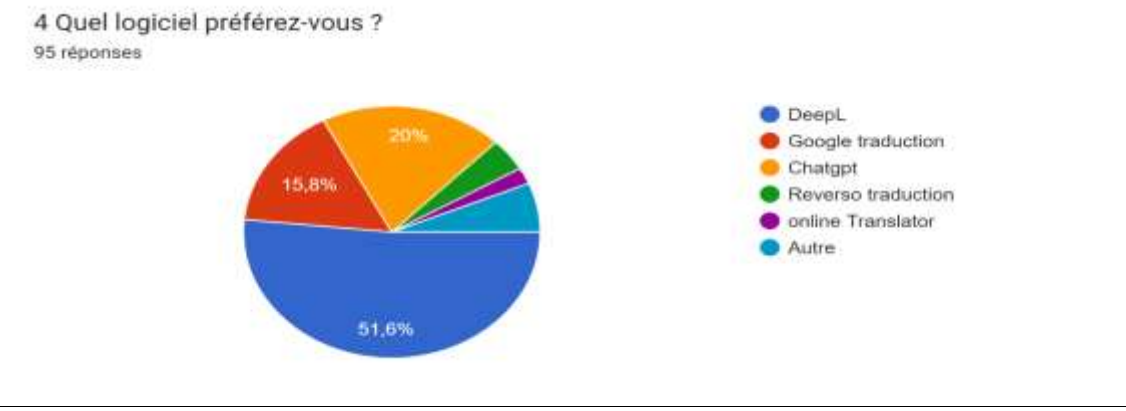
Question 1: How do you obtain the English translation of your academic text?



Question 2: Why do you use automated translation?

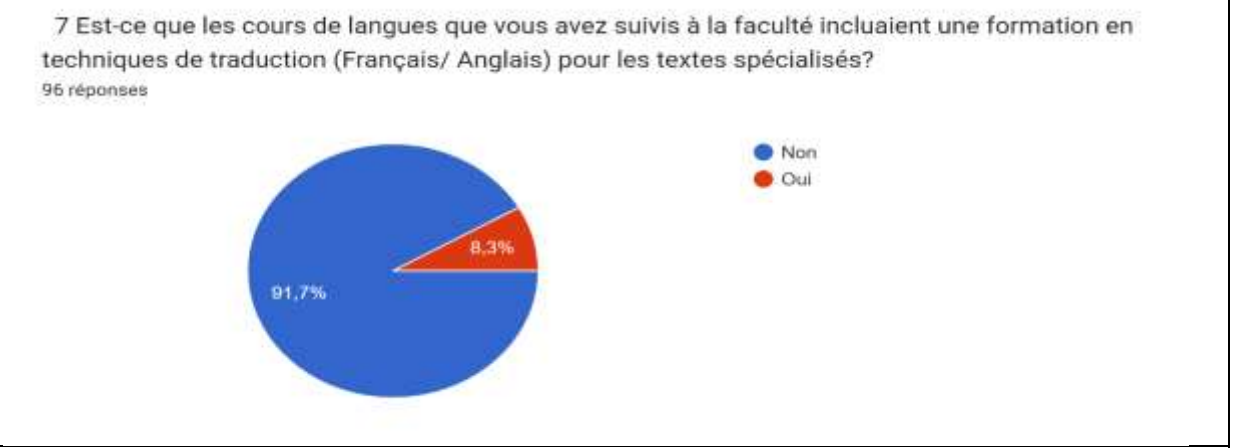


Question 3: What software do you prefer?

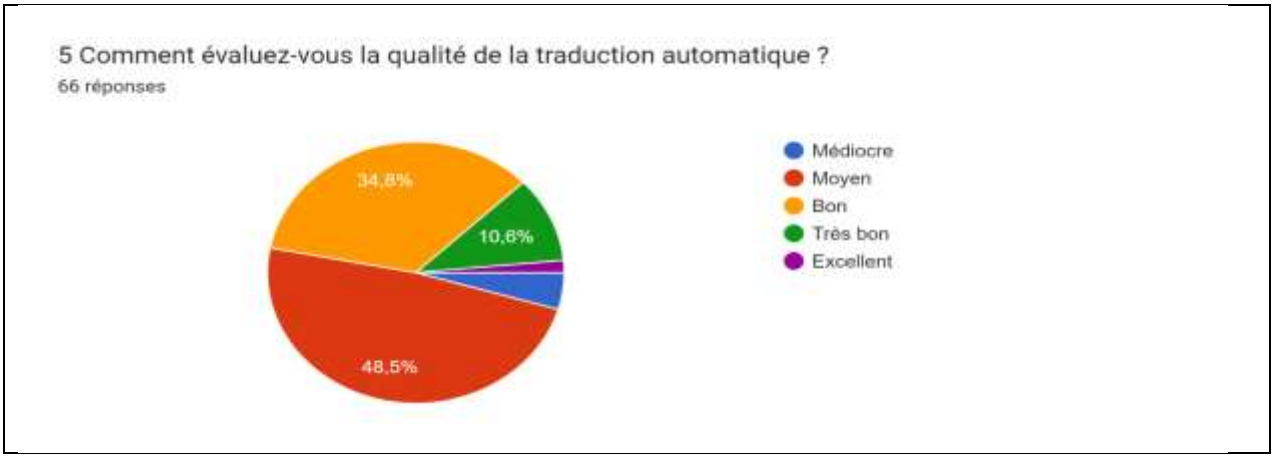


The fourth question aims to understand the educational background of researchers in terms of formal training in translation techniques. 91.7% report that they have not received any instructions on how to translate from French into English, a fact that substantiates their choice of automated translation. The following question evaluates the perceived quality of automated translation tools; 48.5% of respondents report that the quality is medium necessitating subsequent revision and postediting; however, 34.8% believe that the output of machine translation is good.

Question 4: Did the language courses you took at university include training in translation techniques (French/English) for specialized texts?

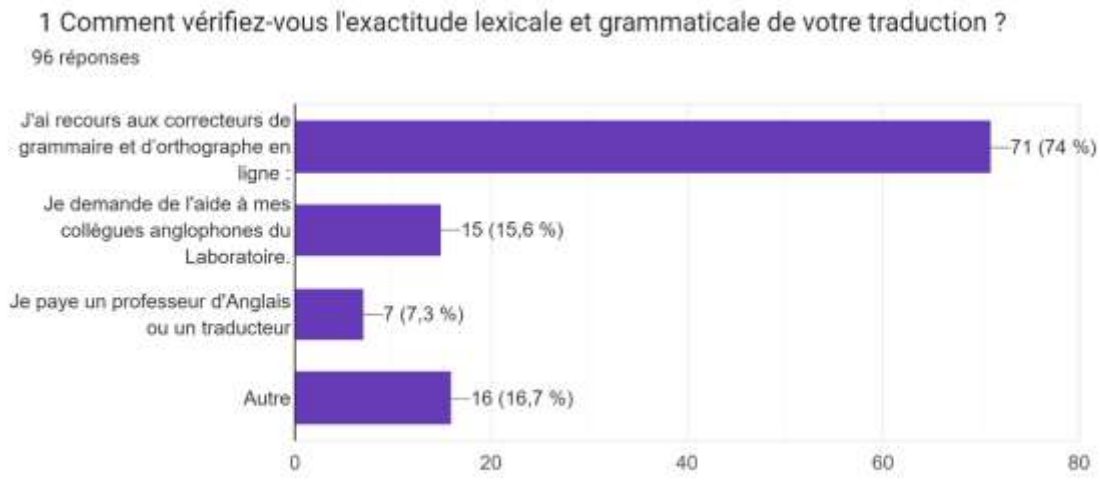


Question 5: How do you rate the quality of automated translation?

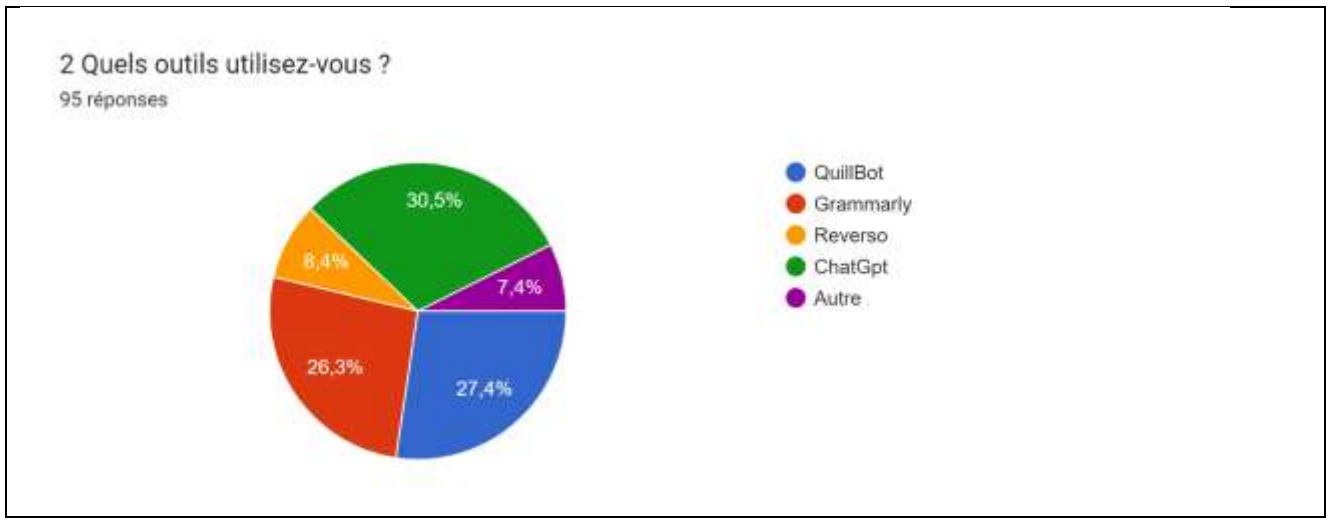


After retrieving the translation from the software, students are required to check the correctness and readability of the text. Hence, the sixth question investigates the methods used by researchers to ensure the accuracy of translations. 74% of responses use online grammar and spelling checkers while 15.6% resort to their English-speaking colleagues in the laboratory to assist them in correcting and revising their papers. 7.3% pay a teacher of English to perform this task. It is worth noting that there are plenty of language checkers available online, each offering a variety of features tailored to different user needs. Regarding the most used AI tools used to refine their English texts, responses to question 7 show that ChatGpt comes the first place with 30.5%, and 27.4% of respondents chose Quilbot which is an AI-driven paraphrasing tool that aids students and professionals in revising, modifying, and adjusting the tone of their text to enhance clarity. Grammarly is also used by 26.3% of participants.

Question 6: How do you check the lexical and grammatical accuracy of your translation?



Question 7: What tools do you use?



4.1.2 Perceptions of doctoral students regarding the use of AI-empowered tools in enhancing the quality of scientific and technical texts

The third section of the questionnaire consists of four statements. The first statement sheds light on the role of AI-empowered editing tools in reducing the number of language errors in students' research articles. The following statement discusses the role of AI-powered tools in improving the clarity and coherence of academic texts. The third statement focuses on the time aspect entailing that the use of artificial intelligence editing tools helps save time while editing manuscripts. The fourth statement discusses how AI-powered editing tools aid students in adhering to the linguistic standards required by scientific journals.

Statement	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
1- Artificial intelligence tools such as Grammarly have enabled me to reduce errors in my articles.	22.1%	61.1%	10.5%	3.2%	3.2%
2- Artificial intelligence tools have improved the clarity and coherence of my research articles, using Grammarly for example	20.8%	59.6%	13.5%	4.2%	2.1%
3- The use of artificial intelligence tools has saved me time when editing my articles.	28.1%	57.3%	10.4%	3.1%	1%
4- Artificial intelligence tools have enabled me to better meet the linguistic requirements of scientific journals.	20.8%	52.1%	18.8%	5.2%	3.1%

The fifth statement posits that Artificial intelligence tools should be incorporated into English courses to help refine students' style and correct their grammatical errors. The last statement suggests including translation practices in English courses will simplify the production of research articles.

Statement	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
5- Artificial intelligence tools need to be incorporated into English courses.	39.6%	44.8%	8.3%	5.2%	2.1%
6- Integrating translation practices into English courses will make it easier to produce research articles.	43.2%	43.2%	10.5%	2.1	1.1%

The survey results reveal a strong positive perception of artificial intelligence tools such as Grammarly among academic writers. A significant majority (83.2%) agree that these tools help reduce errors in their articles, while 80.4% believe they improve the clarity and coherence of their writing. Additionally, 85.4% of respondents find that AI tools save them time during the editing process. While 72.9% agree that AI tools help meet the linguistic requirements of scientific journals, a substantial 84.4% support incorporating these tools into English courses. Furthermore, an overwhelming 86.4% agree that integrating translation practices into English courses will facilitate the production of research articles. These findings underscore the educational value and practical utility of AI tools in enhancing academic writing skills.

4.2 Discussion

Translation tools powered by artificial intelligence (AI) have revolutionized automated translation generating adequate and accurate translations. Therefore, researchers opt for this type of translation to help them in the writing process of their papers. Although the choice of a professional translator seems wise, doctoral students choose automated translation. The rationale for this decision lies in the time-saving aspect and the cost-effectiveness of machine translation as opposed to the expenses associated with professional translation services. As far as the tools that participants prefer the most, A substantial proportion of doctoral students utilize DeepL, ChatGPT, and Google Translate (15.8%) being the next most popular tools.

Indeed, Moroccan doctoral students are no exception. In a paper investigating the impact of the dominance of English in science on Colombian researchers, Valeria Ramı´rez-Castañeda (2020) finds that " the need for editing or translation of scientific texts is widespread among Colombian doctoral students……93.9% have asked for favors to edit their English and 32.7% have asked for translation favors" (p.5). Translation is considered a quick fix that compensates for their insufficient mastery of English. Therefore, formulating ideas in French first mitigates the burden of writing in English. This was confirmed by the study of Marii Abdeljaouad and Tahar Labassi (2020) on the prevalence of English as a lingua franca in publishing among scholars in Tunisia, a country with practically the same linguistic landscape as Morocco. They claim that "most participants underscored the automaticity of generating ideas in French. It seems that they cannot think in English and whenever they have an idea to write about, it just comes out in French" (p.11).

It is evident that translation is a common practice among Moroccan doctoral candidates. 91.7% have not received any formal training in translation, this implies that doctoral students are not familiar with the adequate translation techniques specific to scientific and technical translation as well as the conventions framing the academic genre. In fact, the output of automated translations requires a knowledge of the conventions of research articles to post-edit and rectify terminological, grammatical, and textual disparities between the translated text and the source text before they can be deemed suitable for use. While online grammar and spelling checkers can enhance the linguistic quality of research articles, doctoral students should not overly depend on these tools as they primarily address surface-level errors. For example, online language checkers might not identify differences in writing conventions between French and English, such as those related to tenses, sentence structure, and logical connectors.

The third section of the questionnaire consists of investigating the perceptions of Moroccan doctoral students regarding the use of AI language tools in refining the language of research articles. Moroccan doctoral students make basic errors related to the aforementioned aspects due to a lack of training in English academic writing in their respective institutions. In reality, a study conducted by Belhiah (2016) confirms this reality as 75% of the participants claim that their institution does not (or did not) provide English courses.

AI editing tools detect mistakes in spelling, grammar, syntax, and style, thereby improving the clarity and cohesion of academic writing. The results of the survey align with a study conducted in Vietnam on the use of AI Tools in teaching and learning English academic writing skills. Tran Thi Thu Hien (2024) claims that the utilization of AI-driven writing tools significantly benefits students by enhancing cohesion and coherence, expanding lexical resources, broadening grammatical range, and improving accuracy. Such tools may play a transformative role in empowering non-native speakers of English to refine their language by restructuring sentences, improving grammar, and optimizing the structure of the text to fulfill the conventions of the native scholarly community. Thorough editing of the paper enhances its likelihood of swift acceptance for publication. In non-English speaking countries, researchers and doctoral students must exert additional efforts to disseminate their contributions compared to their native colleagues. Consequently, they face linguistic barriers that prevent them from using their mother tongues or, at least, their second language in which they received their training, such as French in the case of Morocco. Interestingly, studies have shown that science journal editors frequently prefer manuscripts authored by native English speakers (Strauss, 2019), and reviewers tend to judge papers written by non-native English speakers more critically, independently of their content (Lillis and Curry, 2015).

In light of the results of the survey, it is high time to democratize the utilization of AI writing and editing tools in language classrooms, considering the diverse array of benefits they offer. While concerns about the integrity and authenticity of the work may arise in this discourse, it is crucial to acknowledge that their application is restricted to enhancing the original composition of

the manuscript, which remains the responsibility of the researcher. Additionally, a significant portion of respondents appears to strongly support the belief that incorporating translation practices into English courses would indeed ease the process of writing research articles. Formal guidelines on how to translate are vitally important. Emphasis should be placed on raising students' awareness of the fact that translation requires linguistic proficiency, cultural sensitivity, and expertise. While students may not face significant challenges in terms of subject matter expertise, mastering both language nuances and the cultural disparities inherent in academic genres across languages is paramount. Students in scientific and technical fields may indeed find translation theory a bore, but it constitutes a crucial part of the writing process for sure. Scientific concepts are encapsulated in language and cannot be fully articulated through symbols.

5. Conclusion

This study aims to identify the prevalent AI translation and post-editing tools used by doctoral students. Additionally, it seeks to assess Moroccan doctoral students' perceptions of how effectively these tools enhance the quality of English-published manuscripts in five disciplines: physics, biology, geology chemistry, mathematics, and computer science. It shows that Moroccan doctoral students are familiar with AI translation and post-editing tools to improve the quality of the language of their publications. Most participants cite timesaving and cost-effectiveness as the primary factors influencing their selection of AI-driven software. Tools such as DeepL, Google Translate, Grammarly, and Quilbot are widely used by doctoral students in scientific and technical fields. They strongly believe that these tools help them reduce the number of errors they make along with harnessing the clarity and coherence of the papers. As a result, this simplifies adherence to the linguistic standards of scientific journals, leading to fewer comments and rejections from reviewers stemming from language errors. The recommendations provided below were derived solely from the thorough investigation conducted during the present research project.

- Integrate instruction on translation techniques into language courses to enhance doctoral students' proficiency in academic writing across disciplines.
- Offer specialized courses in academic writing tailored to the needs of doctoral students in physics, biology, geology, chemistry, mathematics, and computer science.
- Develop language courses focusing on scientific and technological terminology to equip doctoral students with the language skills necessary for their respective fields.
- Collaborate with the Centre of Doctoral Studies (Cedoc) to provide subscriptions to language centers, facilitating access to resources for language enhancement.
- Establish Editing Committees comprising language professionals to provide comprehensive feedback on language usage and ensure the quality of manuscripts.
- Incorporate AI tools into language courses to streamline the writing process and optimize time and energy expenditure.
- Introduce scientific writing courses within master's and Ph.D. programs at faculties of sciences to cultivate effective communication skills among doctoral students.
- Raise awareness of genre-specific differences between French academic writing and English academic writing through targeted workshops and seminars.
- Encourage doctoral students to engage in daily reading and practice of English to reinforce language proficiency and familiarity with academic writing conventions.

5.1 Study Limitations and Future Research

While this study provides valuable insights into the use of AI translation and post-editing tools among Moroccan doctoral students, several limitations should be acknowledged. The study was conducted with a relatively small sample size, which may not fully represent the diverse population of doctoral students enrolled Moroccan universities. Future research should include a larger and more diverse sample to enhance the generalizability of the findings. The reliance on self-reported data from participants introduces potential biases, such as social desirability bias and recall bias. Participants might have over- or under-reported their use of AI tools and their perceptions of their effectiveness. The study focused on five disciplines: physics, biology, geology, chemistry, mathematics, and computer science. This limitation may not capture the experiences and perceptions of doctoral students in other fields, such as humanities and social sciences. Including a broader range of disciplines in future studies would provide a more comprehensive understanding of the use of AI tools in producing academic papers.

By acknowledging these limitations, we aim to provide a transparent account of our study and encourage further research to address these constraints and build upon our findings.

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