A Call to Diversify the Lingua Franca of Academic STEM Communities

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Executive Summary: The current bias in the STEM academy favors English-language research publications, creating a barrier between English-speaking and non-English speaking researchers that is detrimental to the continuity and evolution of STEM research. In this paper, we lay out policy measures that employ U.S. government resources to create infrastructure that standardizes and facilitates the language translation process and hosting of multilingual publications. This proposal aims to increase linguistic diversity in academic STEM publications for the ultimate goal of improving global scientific communication and ameliorating the existing disparity between English and non-English STEM literature.

I. Homogeneity of language in the STEM academy: A "poisoned apple" to global research

When English was recognized as the international language of science in 1967, after shifts in global power from both world wars, the academic community defined the ability to speak fluent English as a criterion for professionalism in STEM (Garfield 1977; Gordin 2015). While publishing research only in English seems efficient, it creates an inequitable global academic environment. **Even now, researchers who are multilingual or do not speak English as a first language must make extra efforts for their work to be considered ground-breaking or even relevant**. Considering that 97% of papers in *Web of Science's* Science Citation Index Expanded and 80% of journals in *Elsevier's* Scopus are only published in English, it is customary for researchers to publish in English-language journals over their native-language journals (van Weijen 2012; Liu 2016). This English-centric publishing approach in the STEM academy dismisses the cultures and perspectives of non-English-speaking communities (Gibbs 1995; Canagarajah 1996; Kacchru 1997; Alves and Pozzebon 2013). In contrast, arts and humanities disciplines have long recognized the importance of non-English work. Their first citation database, created in 1975, included academic articles published in all languages (Liu 2017). A linguistic and cultural bias in STEM academia has developed over time and is glaringly apparent today.

Concretely, **global advances in combating climate change have been delayed** in part due to the lack of knowledge English speakers have of the biodiversity of indigenous South American land and crops (Amano 2016; Balmford 2012). **We believe that cross-cultural solutions are necessary to prevent critical information from being missed by English-speaking researchers.** A prime example of successful environmental conservation efforts incorporating indigenous knowledge is the partnership between the U.S. Forest Service and the indigenous tribes of the

Karuk, Yurok, and Hoopa to improve wildfire management in Northern California (Sommer 2020; Buono 2020). Using burning practices that are part of indigenous cultures, stem production and density of shrubs and trees has increased thirteen-fold while also providing a sustainable livelihood for tribe members (Marks-Block 2021).

Alternatively, if a researcher publishes in their native, non-English language, it is likely that their work will not be cited by researchers in the United States (Fung 2008). Shockingly, some journals do not allow researchers to cite non-English articles at all (Fung 2008; Lazarev 2018; Neff 2018)! In fact, many COVID-19 articles published in Chinese journals **were not cited even once by English journal articles**, although they focused on critical aspects of the disease (Xiang 2020). This missing information results in lost time during the global pandemic, when U.S. academics may have performed research to determine the same results that **had already been published** (Xiang 2020). The COVID-19 pandemic was not the first time this language barrier has hindered global health research. Tu Youyou **won the Nobel prize** for her discovery of artemisinin, a treatment for malaria, but because her work was published in a Chinese journal, she was cited *only once* outside of China while a *review of her paper* in an English journal *has been cited over 800 times* (Tao 2018; Fung 2008; Liu 2008). We cannot continue risking chance summaries and serendipitous descriptions of non-English papers to fill in the gaps of global scientific communication.

We have witnessed as a society what happens when the ugly tradition of cultural neglect comes to a head. White supremacy, racism, and prejudice range from blatant violence to prolonged, deleterious effects of gatekeeping and exclusion in the workplace. Last summer, the Black Lives Matter protests sought to alter the way U.S. society values Black lives, an affirmation against institutional racism that historically pushes the interests of the nonwhite populace aside (Black Lives Matter n.d.). The emotionally heavy truth that follows is that one *cannot* separate large-scale societal issues from academia. From Google searches of "unprofessional hairstyles'' that feature Black, female engineers, to associating African American Vernacular English (AAVE) with

"limited education or sophistication" instead of a legitimate language within academia, the exclusion of Black culture from a white-defined concept of STEM professionalism is sprinkled about the Ivory Tower of academia (Alexander 2016; Tahmincioglu n.d.; Rickford n.d.). Although STEM has been, and continues to be, white- and male-dominated, successful initiatives have been taken to improve this disparity, such as the adoption of "double-anonymous" reviewing, which reduces bias against female authors and levels the (binary) gender gap in grant approvals (NSB 2020; Roberts 2016; Strolger 2019). In academia, other diversity and cultural issues have been intentionally addressed, but **global linguistic diversity desperately needs to be modernized.**

To tackle this problem, **we propose that federal agencies lead massive infrastructural changes to fund translations of STEM research using private translation services that are already partnered with large journals.** The major benefits to government and industry would include: U.S. federal agencies funding efficacious research that is more extensively disseminated throughout the international STEM community, private language-translation companies financially profiting from these large-scale translation efforts, and increased readership for academic journals that offer multilingual hosting sites. Within academia, this proposal would **improve research outcomes** and **redefine the association of English with professionalism in STEM disciplines** (Liu 2008).

In Section II, we first detail obstacles and preliminary solutions to linguistic diversity, namely the absence of field-specific linguistic demographics, financial inaccessibility to translation services, and lack of infrastructure for hosting multilingual academic papers. In Sections III and IV, we then offer more detailed solutions to these obstacles. This includes the creation of an inter-agency working group that would organize and collaborate with academia and private industry to build the requisite infrastructure for funding and hosting of research article translations, while taking into account the linguistic demography of specific STEM sub-fields. We propose to implement the latter point through government contracts with private translation

services and subsidies to journal companies in order to create the infrastructure that hosts these multilingual papers.

II. Halt! Obstructions to linguistic diversity

i. Absence of field-specific linguistic demography
As there is no official count of sub-field-specific languages spoken by STEM researchers, we are lacking critical information regarding which languages would be most beneficial for translation from English. We propose that initial decisions be made from language surveys for broad STEM demographics, such as the "hard sciences" (van Weijen 2012), which would be refined by our proposed linguistic demography surveys of U.S. grant recipients (see **Section III**).

ii. Selecting non-English languages for translations
Author Michael Gordin says it best: "There are around 6,000 languages in the world today. If science were being conducted in all of them, a lot of knowledge would be lost" (Woolston 2019). While ideally research could be published in any language and shared by all, this would be an inefficient way to disseminate research. To address the lack of linguistic diversity in STEM, **we propose for researchers to publish in English as well as *one of three* non-English languages**, **selected from a list of those most spoken in their academic field *and* in the U.S.** Although this list would not account for international STEM researchers, it is more feasible for the U.S. government to execute a smaller-scale language census of U.S.-funded research. Importantly, this combination of choices would encompass linguistic diversity in U.S. society and academia. For example, Spanish is overwhelmingly ranked the first most spoken language in the U.S. after English (U.S. Census Bureau 2013), however it is ranked eighth in academia (van Weijen 2012). More nuanced issues persist, such as **framing translation within cultural context**. For instance, in 2015, a South African college published English lecture notes in isiXhosa, another local language. However, they found the students who spoke isiXhosa did not prefer these notes, because they were written in an overly formal dialect not accessible to vernacular speakers (Daley 2015). To avoid a similar situation, the culture of the intended audience must be considered.

iii. Infrastructure for multilingual publications
Unfortunately, researchers **have little choice in platform** to host their translated work. Most academic journals, including those published by prominent companies such as *Springer* and *IOP Science*, do not provide hosting platforms amenable to multilingual publications. However, increasing linguistic diversity would **expand their readership,** ultimately increasing the financial gain from a single article. This greater accessibility would **increase the number of citations** (the currency of academia) per paper and, in turn, **incentivize researchers to prefer publishing in those journals**. Non-English languages, such as Chinese, already comprise over 70% of physical science publications between the years 1996-2011, exemplifying the potential impact on readership (van Weijen 2012). Moreover, academics in the U.S. who speak English as a second language may have an easier time digesting and internalizing papers published in their native language. This strategy would allow **faster and more inclusive research to be conducted**. Providing researchers with the ability to publish their work in their heritage language precludes the need for a third-party translation service to be heavily involved in translating these publications and provides an **increased sense of inclusion** for international and multilingual researchers in the U.S.

Currently, if English-speaking academics are individually inspired to take up the task of translating their work *from* English, they face a **hefty financial barrier**. Some trusted publishing companies charge up to $10,000 to translate a 3,500-10,000-word manuscript (Björk 2009; Wiley Editing Services n.d.). As federal funding agencies tightly monitor their purchases, academics cannot adjust their own research budget to foot this tremendous bill. If our translation subsidy was a preallocated part of academics' grant budgets, then **paying for translation services would become streamlined and straightforward**.

We offer two solutions for publishing these translations. First, researchers could publish in an English-speaking journal that also hosts the translated piece. Federal funding would be provided for publishing companies to establish infrastructure to host non-English papers and for researchers to purchase translation services.

Multilingual publishing sites already exist, as preprint hosting sites such as *Arxiv* allow researchers to upload their translated work, only requiring an English abstract for simpler, searchable keywords (arXiv 2019; arXiv 2019). However, preprints do not follow the high-quality peer-review process, diminishing incentives for researchers to use this platform for final publications. Alternatively, authors could choose to have their paper translated for publication in a non-English speaking journal or a journal that provides international editions, such as the *British Medical Journal* or *Angewandte Chemie* (Fung 2008). In both solutions, researchers would be awarded their usual government-funded grants, but with an added stipend for translation services and additional publication charges.

III. On the international stage: Increasing accessibility of English-language research

Current infrastructure for academic translations is insufficient to accomplish the goal of increased language accessibility for U.S. government-funded research. We suggest **an ambitious construction** of governmental policies that would spearhead the initiative to address this issue, kickstarting momentum otherwise difficult to generate in the private sector. Federal agencies coordinating translation services, including the National Virtual Translation Center and the Interagency Language Roundtable, do not include stipulations for federal funding of translation projects. Additionally, translation of technical scientific papers requires rarified knowledge as academic language is nuanced, with distinct associations that could change meanings entirely if improperly translated. Illustratively, the English verb "test" could be translated to Spanish as the verb "probar," to try or taste, or as "examinar," to take an exam. Fortunately, several companies capable of producing academic-level translations already exist. *Academic Language Experts* advertise translation services with field-specific translators, while high-impact journals, such as *Nature*, and reputable groups, such as the *Royal Society*, recommend and offer discounts for translation services. **However, the large expense of translations, combined with low incentives for individual research groups to employ these services, provides a large obstacle that currently has not been mitigated by coordinated government action.**

We propose the **formation of a federal interagency working group** focused on decreasing costs and increasing incentives for English-speaking researchers conducting government-funded research to publish in additional non-English languages. This working group would be formed by the National Science and Technology Council (NSTC)—a part of the Office of Science and Technology Policy that coordinates science technology policy across federal research and development agencies, including academia. Unfortunately, there is no existing federal group that organizes and funds academic-level translation services. Our proposed working group would consist of members from the most relevant of the fourteen major government agencies funding STEM research, including, but not limited to, the National Science Foundation, the Department of Health and Human Services, the Department of Energy, and the Department of Defense. **This group would ensure that translation subsidies would be a stipulation in all federally-funded research grants.** Government agencies would be direct beneficiaries from these actions by increasing the visibility of U.S.-funded research in all STEM fields.

Grants awarded from any of the aforementioned governmental agencies would contain an additional stipend that would *only* be used to translate articles into a non-English language upon acceptance of a research article to an academic journal. Three potential non-English languages would be suggested for translation by the interagency working group. These languages would be determined by accounting for linguistic statistics collected from both the U.S. Census and from a yearly survey conducted by the working group that would encompass all federally-funded researchers. This survey would be collected within pre-existing grant reports, thus accounting for linguistic demography changes within STEM academia in the U.S. over time.

IV. From protests to policy: Integrating the global voices of STEM researchers

Beyond translating and disseminating originally *English* works to multiple languages, in order to

level the English-speaking playing field we must consider the bidirectionality of the language barrier. Non-native English speakers experience an inordinately greater demand on their time and budget to communicate their work in publication-ready English. We propose that the U.S. government creates infrastructure to reduce existing barriers for translation of *non-English* articles *to* English. This proposal recognizes the English-centric bias of the U.S. and works to elevate the visibility of non-English researchers and improve communication between English language research and other non-English languages. Government action would be required to implement the required infrastructure, which would incentivize private industry and academia to break the status quo, thereby **increasing the flow of relevant information between countries and elevating the quality of U.S. government-funded research and its competitiveness in a global marketplace.**

Field-specific literature searches that guide future research endeavors are almost exclusively performed in English, resulting in an incomplete overview of already-published work. An important consequence is that papers published in non-English languages are overlooked, such as Tu Youyou's Nobel prize-winning work on artemisinin (Fung 2008; Tao 2018)**.** Thus, the current system pressures translation of research to English. However, the U.S. lacks any relevant infrastructure to address these language barriers. This results in issues with **accessibility** for those who publish in English but have limited written fluency, such as English as a Second Language (ESL) researchers in the U.S. Translations from other languages *to* English are expensive and the process is not standardized, increasing the vulnerability of non-native English speakers. *Before* translating the rest of their work, researchers must begin the process by providing an abstract in English. Then, if researchers opt for the translation services recommended by hosting journals, manuscripts between 3,000-10,000 words have a median cost of $1,200 to translate Chinese, Portuguese, or Spanish papers *to* English (Wiley Editing Services n.d.). However, this price is quoted from *publicly-posted* information provided by journal-recommended translation websites. Unfortunately, the vast majority of reputable translation services **do not**

post their prices, and require ESL researchers to provide their abstract, then **email and barter in a less familiar language.** The author must now trust a stranger's aptitude to assess their needs, gauge their writing, and provide a fair price for their effort, resulting in susceptibility to price gouging. Therefore, government policies must be created to protect ESL researchers, as the current system does not resolve language and financial barriers within STEM.

To address both issues, we first propose to **employ government resources for a two-pronged solution: 1) to standardize translation services from other languages *to* English and 2) to increase the availability of academic research published in non-English journals to English speakers in the U.S.** A larger upfront cost would be required for the government to build this infrastructure, but, once established, costs and time commitment to maintain these efforts would be substantially reduced. Once in place, the government would benefit by not having to fund U.S.-based research already published in a non-English language, such as the infectious disease research discussed in the introduction. Additionally, this would provide government-funded scientists with critical, missing information, such as biodiversity studies from non-English speaking countries. The first goal of this working group would be to **incentivize translation companies to both standardize prices and dramatically reduce the cost of translating from non-English languages to English**, for example, by signing large government contracts securing their services. Next, employing this improved translation service infrastructure, the group would **organize, subsidize, and host a massive translation effort to increase visibility of critical non-English research**. This could be accomplished by creating an additional interagency working group through the NSTC which **facilitates and maintains** a collection of translations from non-English journals. It would be wholly unfeasible to propose that this collection of English translations would include all research articles ever published in perpetuity. Thus, the working group should receive input from international experts in each STEM discipline to decide which articles are most critical to translate, incorporating the impact on the academic

community and U.S. federal interests, such as food security and public health. Expert groups would be selected by prioritizing linguistic and geographic diversity to mitigate potential biases. Finally, the working group would coordinate with private U.S.-based journal companies to host a curated database of all translated articles. This database would be available to all research groups funded by U.S. federal grants, providing a government-coordinated, bidirectional translation effort when combined with our previous proposal.

As a next step, we propose to expand hosting capabilities by involving private publishing companies. The government-organized infrastructure could incentivize academic publishers to take charge of the translation/hosting efforts for financial gain. If there is not enough involvement, the government could introduce additional subsidies for smaller companies. By incentivizing larger journals to compete with smaller journals backed by the government, it is our hope that **all journals will provide translation services themselves,** creating a **standardized, transparent process.** Alternatively, we propose that governments enter into contracts to cover or subsidize either in-house journal translation or translation through private companies. For example, journals such as *The Royal Society* offer discounts through *external* translation services so that the authors can afford to translate their work before submission (The Royal Society n.d.). Demand for this service would also come from academics, who would benefit from wider literature searches and increased citations of their work. **Our suggested amendment to the current U.S. system normalizes multilingual publishing and allows researchers to put more of their funding and effort towards their research.** Altogether, our proposal would not only increase the accessibility of impactful research published in non-English languages, but would also be mutually beneficial for the government-university-industry partnership.

V. The future is NOW: A multilingual STEM academy

We urge against carrying into the future our colonial mentality that considers English as the only professional language of STEM. As a guide, we should look to the arts and humanities, which have recognized the importance of non-English work since 1975 (Liu 2017). In an attempt to decrease the bidirectional language barriers currently existing in the U.S. between English and non-English researchers, we have recommended multiple policy avenues: 1) implementation of a multilingual hosting structure for private journal companies, 2) creation of federally-funded subsidies for translating STEM research, and 3) facilitation of allocating research groups' budgets to cover translation services. This proposal aims to protect and amplify the diverse voices and cultures within STEM. Although these policies focus on translations of government-funded research, we believe that the increased visibility of research published in multiple languages would have a sufficiently beneficial effect on readership to incentivize multilingual publications of *non-government* funded research. Importantly, once the infrastructure has been established, our mission to connect research institutions with publishing and translation companies coordinated by the federal interagency working group would be self-perpetuating. If implemented properly, this has the potential to **meaningfully alter the accessibility of academic research at an international level within a few years**. These outlined policy measures would change the proverbial "English-centric" tide, altering the culture of STEM academia to be less obsessive about maintaining English as the sole language of professional research and become more inclusive of multilingualism. By increasing the interconnectivity and bidirectionality of international STEM research, our proposal facilitates the creation of better STEM-based solutions to respond to complex crises, ranging from climate change to global pandemics.

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