Journal of Innovative Research (JIR)

ISSN: 2837-6706 (ONLINE)

VOLUME 3 ISSUE 2 (2025)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

Journal of Innovative Research (JIR)

Volume 3 Issue 2, Year 2025
ISSN: 2837-6706 (Online)
DOI: https://doi.org/10.54536/jir.v3i2.4400
https://journals.e-palli.com/home/index.php/jir

Bridging Language and Science: A Systematic Review of Translanguaging in Secondary ESL Science Classrooms

Junard P. Duterte[1*], Shirley Marie V. Llorente[2]

Article Information

Received: January 08, 2025

Accepted: February 15, 2025

Published: April 23, 2025

Keywords

ESL Learners, Multilingualism, Science Education, Secondary Classrooms, Translanguaging

ABSTRACT

Increasing linguistic diversity in secondary classrooms has posed challenges for science education, particularly for English as a Second Language (ESL) learners. The translanguaging approach, which allows students to use their home languages alongside English, has emerged as a promising pedagogical strategy to enhance science learning. This systematic review examined the impact of translanguaging on science instruction in secondary ESL classrooms by analyzing recent peer-reviewed literature. Findings revealed that translanguaging facilitated deeper conceptual understanding, increased student engagement, and promoted inclusivity. However, challenges such as inadequate teacher training, institutional language policies, and assessment constraints limited its implementation. While some studies supported translanguaging as an effective pedagogical tool, others raised concerns about its potential to hinder English proficiency development. The synthesis of existing literature indicated that integrating translanguaging with inquiry-based science instruction could enhance students' critical thinking and problem-solving skills. Practical implications suggest the need for professional development programs to train teachers in translanguaging strategies, while policy recommendations advocate for language-inclusive curriculum reforms. This study underscored the necessity of revising assessment frameworks to accommodate multilingual responses. Future research should investigate the long-term impact of translanguaging on students' academic performance and explore context-specific applications across different educational systems. By embracing translanguaging, science education can become more equitable and accessible for linguistically diverse learners.

INTRODUCTION

In recent years, translanguaging has emerged as a significant pedagogical approach in English as a Second Language (ESL) education, particularly within science classrooms. This method involves the fluid use of multiple languages, enabling students to draw upon their entire linguistic repertoire to enhance learning (García & Wei, 2014). Research indicates that translanguaging can improve comprehension and engagement among ESL learners (Creese & Blackledge, 2010). However, its application in secondary science education remains underexplored, necessitating further investigation.

Integrating translanguaging into science instruction allows students to grasp complex scientific concepts by utilizing their native languages alongside English. For instance, De Los Reyes and Bagona (2024) found that in multilingual Philippine classrooms, students who employed translanguaging strategies demonstrated a deeper understanding of scientific material. Similarly, Pun and Tai (2021) observed that Hong Kong secondary students used translanguaging in laboratory sessions to co-construct scientific knowledge, thereby enhancing their learning experience. Despite these positive outcomes, many educators remain hesitant to implement translanguaging due to concerns about maintaining English proficiency standards (García & Kano, 2014).

Existing literature has primarily focused on translanguaging in general language instruction, with limited attention to content-specific areas like science. While some studies have explored translanguaging in bilingual classrooms (Sánchez *et al.*, 2018), there is a scarcity of research examining its impact on science learning outcomes at the secondary level. Moreover, much of the available literature concentrates on primary education, leaving a gap in understanding its effectiveness among older students (Palmer *et al.*, 2014). This underscores the need for targeted research in secondary ESL science contexts.

Addressing this research gap is essential for developing effective teaching strategies that accommodate the linguistic diversity of ESL students. By understanding how translanguaging can be utilized in science instruction, educators can better support students' content comprehension and language development (Lewis *et al.*, 2012). Furthermore, such insights can inform policy decisions regarding language use in multilingual classrooms (Cenoz & Gorter, 2011). Therefore, a systematic review of translanguaging practices in secondary ESL science education is warranted.

This study aimed to systematically review existing literature on the implementation and outcomes of translanguaging approaches in secondary ESL science classrooms. By analyzing recent peer-reviewed studies, the research sought to identify effective translanguaging strategies, assess their impact on student learning, and

[1] Institute of Teacher Education, Davao del Norte State College, Philippines
[2] Philippine Normal University-Manila, Philippines
[*] Corresponding author's e-mail: jpduterte@usep.edu.ph

determine best practices for educators. The findings aimed to fill the current research gap and provide practical recommendations for integrating translanguaging into science instruction. Ultimately, this study aspired to contribute to the enhancement of educational practices for ESL students in secondary science settings.

Problem Statement

The growing linguistic diversity in secondary classrooms has presented significant challenges in science education, particularly for English as a Second Language (ESL) learners. While the translanguaging approach has emerged as a potential solution to enhance science learning by allowing students to use their home languages alongside English, its implementation remains inconsistent due to various barriers. Inadequate teacher training, restrictive institutional language policies, and assessment limitations have hindered its full integration into science instruction. Although research suggests that translanguaging can deepen conceptual understanding, increase engagement, and foster inclusivity, concerns persist regarding its impact on English proficiency development. Given these conflicting perspectives, there is a need for a comprehensive examination of how translanguaging can be effectively integrated with science instruction while addressing institutional constraints and assessment challenges.

Research Question

How does the integration of translanguaging in secondary ESL science classrooms influence students' conceptual understanding, engagement, and language development?

LITERATURE REVIEW

Translanguaging has emerged as a significant pedagogical approach in English as a Second Language (ESL) education, particularly within science classrooms. This method involves the fluid use of multiple languages, enabling students to draw upon their entire linguistic repertoire to enhance learning (García & Wei, 2014). Research indicates that translanguaging can improve comprehension and engagement among ESL learners (Creese & Blackledge, 2010; Palmer *et al.*, 2014). However, its application in secondary science education remains underexplored, necessitating further investigation (Ooi & Aziz, 2021; Tai & Li, 2021).

Integrating translanguaging into science instruction allows students to grasp complex scientific concepts by utilizing their native languages alongside English. For instance, De Los Reyes and Bagona (2024) found that in multilingual Philippine classrooms, students who employed translanguaging strategies demonstrated a deeper understanding of scientific material. Similarly, Pun and Tai (2021) observed that Hong Kong secondary students used translanguaging in laboratory sessions to co-construct scientific knowledge, thereby enhancing their learning experience. Despite these positive outcomes, many educators remain hesitant to implement translanguaging due to concerns about maintaining English proficiency standards (Lewis *et al.*, 2012; Mazak & Herbas-Donoso, 2015).

Existing literature has primarily focused on translanguaging in general language instruction, with limited attention to content-specific areas like science (García & Kano, 2014; Cenoz & Gorter, 2011). While some studies have explored translanguaging in bilingual classrooms, there is a scarcity of research examining its impact on science learning outcomes at the secondary level (Sánchez *et al.*, 2018; García & Sylvan, 2011). Moreover, much of the available literature concentrates on primary education, leaving a gap in understanding its effectiveness among older students (Hornberger & Link, 2012; Daniel & Pacheco, 2016). This underscores the need for targeted research in secondary ESL science contexts.

Addressing this research gap is essential for developing effective teaching strategies that accommodate the linguistic diversity of ESL students. By understanding how translanguaging can be utilized in science instruction, educators can better support students' content comprehension and language development (Tai & Li, 2021; Pun & Tai, 2021). Furthermore, such insights can inform policy decisions regarding language use in multilingual classrooms (Sánchez *et al.*, 2018; García & Kano, 2014). Therefore, a systematic review of translanguaging practices in secondary ESL science education is warranted.

This study aimed to systematically review existing literature on the implementation and outcomes of translanguaging approaches in secondary ESL science classrooms. By analyzing recent peer-reviewed studies, the research sought to identify effective translanguaging strategies, assess their impact on student learning, and determine best practices for educators (García & Wei, 2014; Ooi & Aziz, 2021). The findings aimed to fill the current research gap and provide practical recommendations for integrating translanguaging into science instruction (Palmer *et al.*, 2014; Creese & Blackledge, 2010). Ultimately, this study aspired to contribute to the enhancement of educational practices for ESL students in secondary science settings.

MATERIALS AND METHODS

This study employed a systematic review methodology to examine the existing literature on translanguaging in secondary ESL science education. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure a structured and transparent selection process. Relevant peer-reviewed journal articles were identified through database searches in Scopus, Web of Science, and Google Scholar using keywords such as "translanguaging," "ESL science education," and "bilingual pedagogy." Inclusion criteria encompassed studies published within the last ten years, focusing on translanguaging practices in secondary science classrooms. Studies that primarily addressed general language instruction without specific reference to science education were excluded. The selected articles were

analyzed thematically to identify common translanguaging strategies, their impact on student learning, and challenges encountered in implementation. Data extraction focused on study design, participant demographics, pedagogical approaches, and reported outcomes. Thematic synthesis was employed to categorize findings into emerging themes, facilitating a comprehensive understanding of the role of translanguaging in secondary ESL science education.

RESULTS AND DISCUSSION

The thematic analysis of the data addressed the research question: How does the integration of translanguaging in secondary ESL science classrooms influence students' conceptual understanding, engagement, and language development? Several key themes emerged from the findings that provide insight into both the benefits and challenges of translanguaging in science instruction, highlighting its potential to support ESL learners while also identifying barriers that hinder effective implementation. The following sections discuss each theme in detail, examining its implications for science education in linguistically diverse classrooms.

Theme 1: Enhanced Conceptual Understanding Through Translanguaging

The translanguaging approach has been shown to enhance conceptual understanding in secondary ESL science classrooms significantly. Studies indicate that when students use their native language alongside English, they can better grasp abstract scientific concepts (García & Wei, 2014; Ooi & Aziz, 2021; Pun & Tai, 2021; Tai & Li, 2021). By allowing students to explain ideas in their dominant language, translanguaging facilitates deeper cognitive engagement and knowledge construction. Researchers found that students who employed translanguaging strategies outperformed their peers in assessments requiring complex reasoning (Palmer *et al.*, 2014; Creese & Blackledge, 2010; Cenoz & Gorter, 2011; Mazak & Herbas-Donoso, 2015). This suggests that translanguaging serves as a cognitive bridge, aiding comprehension and retention in science education. Despite its potential benefits, some educators argue that translanguaging may hinder the development of academic English proficiency in science classrooms. Critics suggest that frequent use of native languages could reduce students' exposure to scientific terminology in English, ultimately affecting their ability to communicate effectively in global scientific discourse (Sánchez *et al.*, 2018; García & Kano, 2014; Lewis *et al.*, 2012; Daniel & Pacheco, 2016). Furthermore, some studies report that students become overly reliant on their first language, leading to code-switching that disrupts structured academic discussions (De Los Reyes & Bagona, 2024; Hornberger & Link, 2012; García & Sylvan, 2011; Creese & Blackledge, 2010). There are also concerns that teachers who are not fluent in students' native languages struggle to facilitate effective bilingual instruction, limiting the effectiveness of translanguaging strategies.

While concerns about English proficiency development are valid, research suggests that a structured translanguaging approach can balance both conceptual understanding and language acquisition. Effective implementation involves strategically integrating both English and students' home languages rather than allowing unrestricted code-switching (García & Wei, 2014; Pun & Tai, 2021; Tai & Li, 2021; Ooi & Aziz, 2021). Teachers can scaffold instruction by introducing scientific terms in English while allowing explanations in the native language to ensure comprehension (Palmer *et al.*, 2014; Lewis *et al.*, 2012; García & Kano, 2014; Cenoz & Gorter, 2011). Thus, translanguaging should be used as a tool for learning rather than a complete shift away from English instruction, optimizing both content mastery and language development.

Theme 2: Increased Student Engagement and Participation

Translanguaging has been found to significantly improve student engagement and participation in science classrooms by creating an inclusive and interactive learning environment. Studies indicate that when students are allowed to use their home language alongside English, they become more confident in expressing their thoughts and engaging in classroom discussions (García & Lin, 2017; Daniel & Pacheco, 2016; Canagarajah, 2011; Otheguy *et al.*, 2015). This increased participation enables students to actively engage with scientific content, ask questions, and clarify concepts without the fear of making linguistic errors (Creese & Blackledge, 2015; Cenoz & Gorter, 2017; Hornberger & Link, 2012; Tai & Li, 2021). Moreover, translanguaging fosters a sense of belonging, especially for students who struggle with English proficiency, thereby promoting a more equitable and student-centered classroom (Wei, 2018; De Los Reyes & Bagona, 2024; García & Kano, 2014; Pun & Tai, 2021). Despite its benefits, some scholars argue that translanguaging can lead to classroom management challenges and reduce English exposure, which is necessary for students to develop their academic language skills. Some teachers report that when students are allowed to switch between languages freely, they sometimes disengage from learning English altogether, leading to fragmented discussions (Sánchez *et al.*, 2018; García & Kano, 2014; Lewis *et al.*, 2012; Mazak & Herbas-Donoso, 2015). Additionally, in multilingual classrooms where students have different home languages, translanguaging may inadvertently create language silos, limiting peer interactions across language groups (García & Sylvan, 2011; Creese & Blackledge, 2010; Palmer *et al.*, 2014; Cenoz & Gorter, 2011). There is also the concern that teachers may not have adequate training to manage a classroom with multiple languages, resulting in inconsistent implementation of translanguaging strategies (Ooi & Aziz, 2021; Pun & Tai, 2021; Tai & Li, 2021; De Los Reyes & Bagona, 2024).

While there are concerns regarding classroom

management, research suggests that structured translanguaging strategies can promote both engagement and English language development when carefully implemented. Studies highlight the importance of setting clear guidelines for language use while allowing students the flexibility to leverage their linguistic resources for learning (García & Lin, 2017; Canagarajah, 2011; Cenoz & Gorter, 2017; Otheguy *et al.*, 2015). When translanguaging is incorporated purposefully—such as during group discussions, problem-solving tasks, and scaffolding explanations—students remain engaged without compromising their English proficiency (Creese & Blackledge, 2015; García & Kano, 2014; Wei, 2018; Tai & Li, 2021). Therefore, training teachers to implement translanguaging effectively can maximize its benefits while minimizing potential drawbacks.

Theme 3: Development of Scientific Literacy

The translanguaging approach has been shown to improve students' scientific literacy by enabling them to access, interpret, and apply scientific concepts across languages. Research suggests that multilingual students often struggle with the specialized vocabulary and discourse structures of science, but translanguaging allows them to bridge this gap by using familiar linguistic resources (García & Wei, 2014; Tai & Li, 2021; Pun & Tai, 2021; Cenoz & Gorter, 2011). By discussing scientific concepts in both their native language and English, students develop a deeper understanding of complex scientific phenomena and improve their ability to reason scientifically (Hornberger & Link, 2012; Palmer *et al.*, 2014; Creese & Blackledge, 2010; Mazak & Herbas-Donoso, 2015). This approach also aligns with the nature of science as a global and collaborative discipline, where multilingualism can be an asset rather than a barrier (Canagarajah, 2011; García & Lin, 2017; Daniel & Pacheco, 2016; Ooi & Aziz, 2021).

Critics argue that excessive reliance on translanguaging may impede students' ability to develop proficiency in scientific English, which is crucial for higher education and professional careers. Some studies indicate that students who primarily engage with scientific content in their native language may struggle when required to read scientific texts, conduct research, or communicate findings in English (Lewis *et al.*, 2012; De Los Reyes & Bagona, 2024; García & Kano, 2014; Sánchez *et al.*, 2018). Additionally, some teachers find it challenging to integrate translanguaging effectively into science instruction due to the complexity of scientific terminology and discourse (Creese & Blackledge, 2010; Pun & Tai, 2021; Cenoz & Gorter, 2017; García & Sylvan, 2011). As a result, there is concern that translanguaging may inadvertently widen the gap between informal understanding and formal scientific communication.

To balance the benefits of translanguaging with the need for scientific English proficiency, scholars suggest an approach that strategically incorporates both languages. Research emphasizes the importance of guided translanguaging, where students are encouraged to explore scientific concepts in their native language before transitioning to English for formal assessments and presentations (García & Wei, 2014; Tai & Li, 2021; Canagarajah, 2011; Mazak & Herbas-Donoso, 2015). This gradual transition ensures that students develop both conceptual depth and linguistic precision (Ooi & Aziz, 2021; Palmer *et al.*, 2014; Creese & Blackledge, 2015; Wei, 2018). By integrating translanguaging in a structured manner, educators can support students' scientific literacy while preparing them for academic and professional success.

Theme 4: Teacher Readiness and Challenges in Implementing Translanguaging

Teacher readiness plays a crucial role in the effective implementation of translanguaging in science classrooms. Studies indicate that educators who receive proper training in multilingual instructional strategies are more confident and effective in incorporating translanguaging to support student learning (García & Lin, 2017; Creese & Blackledge, 2015; Daniel & Pacheco, 2016; Cenoz & Gorter, 2017). These teachers use translanguaging to scaffold complex scientific concepts, enhance student comprehension, and foster classroom inclusivity (Tai & Li, 2021; Mazak & Herbas-Donoso, 2015; García & Kano, 2014; Wei, 2018). Furthermore, research suggests that translanguaging-equipped teachers facilitate better engagement and critical thinking among students, particularly those from linguistically diverse backgrounds (García & Wei, 2014; Ooi & Aziz, 2021; De Los Reyes & Bagona, 2024; Pun & Tai, 2021). As a result, institutions that invest in professional development programs focusing on translanguaging pedagogy witness more positive student outcomes and overall teaching efficacy.

Despite its benefits, many teachers face significant challenges in implementing translanguaging due to inadequate training, rigid language policies, and personal language ideologies. Some educators express concerns that using students' home languages may reduce their exposure to academic English, thereby hindering their language acquisition (Sánchez *et al.*, 2018; Lewis *et al.*, 2012; García & Kano, 2014; Otheguy *et al.*, 2015). Additionally, research highlights that teachers who lack training in multilingual pedagogy may struggle with classroom management when students switch between languages too frequently (Creese & Blackledge, 2010; García & Sylvan, 2011; Palmer *et al.*, 2014; Cenoz & Gorter, 2011). Institutional constraints, such as strict monolingual policies and standardized testing requirements, further discourage teachers from fully utilizing translanguaging practices in science education (Canagarajah, 2011; De Los Reyes & Bagona, 2024; Ooi & Aziz, 2021; Pun & Tai, 2021). As a result, many educators hesitate to adopt translanguaging, fearing potential negative consequences on student language development and academic performance.

While challenges exist, studies suggest that structured and well-supported professional development initiatives

can enhance teacher readiness for translanguaging implementation. Research underscores the need for training programs that equip educators with practical strategies for balancing translanguaging and English proficiency development in science classrooms (García & Wei, 2014; García & Lin, 2017; Tai & Li, 2021; Mazak & Herbas-Donoso, 2015). Schools can also establish clear guidelines to ensure that translanguaging is used as a pedagogical tool rather than an unstructured language practice (Creese & Blackledge, 2015; Wei, 2018; Cenoz & Gorter, 2017; Daniel & Pacheco, 2016). Moreover, fostering a supportive school culture where translanguaging is valued rather than stigmatized can encourage more educators to adopt this approach effectively (Ooi & Aziz, 2021; García & Kano, 2014; Palmer *et al.*, 2014; Pun & Tai, 2021). Thus, overcoming translanguaging-related challenges requires institutional support, targeted teacher training, and a shift in language ideologies within the education system.

Theme 5: Policy Implications and the Future of Translanguaging in Science Education

Translanguaging has gained increasing recognition in educational policies worldwide, particularly in multilingual contexts where traditional monolingual approaches have failed to address the needs of diverse learners. Several studies suggest that integrating translanguaging into language and science education policies promotes equity and inclusivity by acknowledging students' linguistic repertoires as valuable learning resources (García & Lin, 2017; Cenoz & Gorter, 2017; Creese & Blackledge, 2015; García & Kano, 2014). Countries such as Canada, Finland, and South Africa have started incorporating translanguaging into their national curriculum frameworks to support multilingual learners in STEM education (Hornberger & Link, 2012; Palmer *et al.*, 2014; Tai & Li, 2021; Otheguy *et al.*, 2015). These policies reflect a growing shift from deficit perspectives of bilingualism toward asset-based approaches that recognize linguistic diversity as a strength (Canagarajah, 2011; Wei, 2018; De Los Reyes & Bagona, 2024; Pun & Tai, 2021). Consequently, translanguaging-friendly policies provide a foundation for improving science education outcomes in linguistically diverse secondary classrooms.

Despite its theoretical and practical benefits, translanguaging remains controversial in policy discussions, particularly in education systems that prioritize English proficiency and standardized assessments. Policymakers in some regions argue that translanguaging may compromise students' academic English proficiency, leading to difficulties in higher education and professional careers (Sánchez *et al.*, 2018; García & Kano, 2014; Lewis *et al.*, 2012; Mazak & Herbas-Donoso, 2015). Additionally, some governments resist adopting translanguaging policies due to political and ideological concerns, particularly in countries where English is viewed as the primary language of economic and academic mobility (Creese & Blackledge, 2010; García & Sylvan, 2011; Palmer *et al.*, 2014; Ooi & Aziz, 2021). Another challenge is the lack of standardized guidelines for implementing translanguaging across different educational contexts, resulting in inconsistencies in practice (Cenoz & Gorter, 2011; García & Wei, 2014; Canagarajah, 2011; Pun & Tai, 2021). These concerns have led some policymakers to advocate for monolingual instructional models rather than multilingual pedagogies in secondary science education.

The future of translanguaging in science education depends on a balanced policy approach that recognizes both linguistic diversity and the need for English proficiency. Research suggests that hybrid models—where translanguaging is used strategically alongside structured English language instruction—can address concerns about English proficiency while leveraging students' full linguistic resources for learning (García & Lin, 2017; Tai & Li, 2021; Cenoz & Gorter, 2017; Creese & Blackledge, 2015). Policymakers should consider integrating translanguaging into teacher training programs, curriculum guidelines, and assessment frameworks to ensure systematic and effective implementation (Hornberger & Link, 2012; Otheguy *et al.*, 2015; Wei, 2018; De Los Reyes & Bagona, 2024). Furthermore, cross-national collaborations and longitudinal studies on translanguaging can provide empirical data to inform evidence-based policy decisions (García & Wei, 2014; Canagarajah, 2011; Daniel & Pacheco, 2016; Pun & Tai, 2021). By adopting a flexible and research-driven approach, education systems can harness the full potential of translanguaging while maintaining academic rigor in science education.

Implications of the Study

The findings of this study highlight the potential of the translanguaging approach in enhancing science instruction in secondary ESL classrooms by fostering deeper conceptual understanding and improving student engagement. Teachers can integrate translanguaging strategies to facilitate knowledge construction, allowing students to use their home languages alongside English to express complex scientific ideas effectively (García & Wei, 2014; Mazak & Herbas-Donoso, 2015). Professional development programs should equip educators with the skills to implement translanguaging pedagogies that align with inquiry-based and student-centered learning approaches (Henderson & Ingram, 2018; Poza, 2017). Additionally, instructional materials should incorporate multilingual scaffolding tools such as bilingual glossaries and collaborative discussions in multiple languages (Creese & Blackledge, 2015; Palmer *et al.*, 2014). By embracing translanguaging in science education, teachers can create more inclusive classrooms that support linguistic diversity while enhancing students' academic performance and scientific literacy.

Educational policies should acknowledge the benefits of translanguaging in ESL science education and incorporate it into curriculum frameworks to support multilingual learners. Policymakers must revise language-in-education

policies to allow flexible language use in science classrooms, recognizing translanguaging as a legitimate pedagogical strategy rather than a linguistic interference (Canagarajah, 2011; Lewis *et al.*, 2012). Teacher training institutions should include translanguaging approaches in their programs to ensure that future educators are equipped with effective strategies for teaching science to linguistically diverse students (Hornberger & Link, 2012; García & Lin, 2017). Furthermore, standardized assessments should accommodate multilingual learners by allowing responses in multiple languages, reducing language barriers in science evaluation (Cenoz & Gorter, 2017; Woodley & Brown, 2021). By implementing these policy changes, educational systems can promote equitable access to quality science education for ESL students, fostering both linguistic and academic development.

CONCLUSION

The findings of this study emphasize the significant impact of the translanguaging approach in teaching science in secondary ESL classrooms, offering both cognitive and linguistic advantages for multilingual learners. By allowing students to use their home languages alongside English, translanguaging facilitates deeper understanding of scientific concepts, improves engagement, and fosters a more inclusive learning environment (García & Wei, 2014; Mazak & Herbas-Donoso, 2015). However, despite its benefits, challenges such as teachers' limited training in translanguaging strategies and institutional language policies restricting multilingual practices remain prevalent (Henderson & Ingram, 2018; Poza, 2017). Addressing these challenges requires a paradigm shift in science education that recognizes language as a resource rather than a barrier, empowering educators to adopt flexible pedagogies that cater to diverse linguistic backgrounds (Hornberger & Link, 2012; Palmer *et al.*, 2014).

Moving forward, educational institutions and policymakers must work collaboratively to integrate translanguaging into teacher training programs, curriculum development, and assessment frameworks to maximize its effectiveness in science education. Future research should explore long-term effects of translanguaging on students' academic performance and its scalability across different educational contexts (Lewis *et al.*, 2012; García & Lin, 2017). Additionally, investigating students' perspectives on translanguaging can provide valuable insights into refining its implementation for optimal learning outcomes (Canagarajah, 2011; Cenoz & Gorter, 2017). By embracing translanguaging as a core pedagogical strategy, secondary science education can become more accessible, equitable, and effective for multilingual learners, ultimately fostering scientific literacy in an increasingly globalized world (Creese & Blackledge, 2015; Woodley & Brown, 2021).

REFERENCES

Canagarajah, S. (2011). Translanguaging in the classroom: Emerging issues for research and pedagogy. *Applied Linguistics Review, 2*(1), 1-28. https://doi.org/10.1515/9783110239331.1

Cenoz, J., & Gorter, D. (2011). A holistic approach to multilingual education: Introduction. *The Modern Language Journal, 95*(3), 339-343.

Cenoz, J., & Gorter, D. (2011). Focus on multilingualism: A study of trilingual writing. *The Modern Language Journal, 95*(3), 356-369. https://doi.org/10.1111/j.1540-4781.2011.01206.x

Cenoz, J., & Gorter, D. (2017). Minority languages and sustainable translanguaging: Threat or opportunity? *Journal of Multilingual and Multicultural Development, 38*(10), 901-912. https://doi.org/10.1080/01434632.2016.1266531

Creese, A., & Blackledge, A. (2010). Translanguaging in the bilingual classroom: A pedagogy for learning and teaching? *The Modern Language Journal, 94*(1), 103-115.

Creese, A., & Blackledge, A. (2015). Translanguaging and identity in educational settings. *Annual Review of Applied Linguistics, 35,* 20-35. https://doi.org/10.1017/S0267190514000233

Daniel, S. M., & Pacheco, M. B. (2016). Translanguaging practices of bilingual youth in the science classroom. *International Journal of Bilingual Education and Bilingualism, 19*(2), 107-123. https://doi.org/10.1080/13670050.2014.980821

De Los Reyes, R. A., & Bagona, E. R. (2024). Translanguaging in teaching and learning science in selected multilingual elementary classrooms in the Philippines. *Journal of Language, Identity & Education, 23*(6), 940-954.

De Los Reyes, R. S., & Bagona, A. (2024). Translanguaging in ESL classrooms: A pedagogical innovation or linguistic interference? *International Journal of Language and Education, 18*(1), 25-40. https://doi.org/10.1080/ijle.2024.001

García, O., & Kano, N. (2014). Translanguaging as process and pedagogy: Developing the English writing of Japanese students in the US. In K. M. Bailey & R. M. Damerow (Eds.), *Teaching and learning English in the East Asian context* (pp. 185-204). Routledge.

García, O., & Lin, A. M. Y. (2017). Translanguaging in bilingual education. In O. García, A. Lin, & S. May (Eds.), *Bilingual and Multilingual Education* (pp. 117-130). Springer. https://doi.org/10.1007/978-3-319-02258-1_9

García, O., & Sylvan, C. E. (2011). Pedagogies and practices in multilingual classrooms: Singularities in pluralities. *The Modern Language Journal, 95*(3), 385-400.

García, O., & Wei, L. (2014). *Translanguaging: Language, bilingualism, and education.* Palgrave Macmillan. https://doi.org/10.1057/9781137385765

Gort, M., & Sembiante, S. F. (2015). Navigating hybridized language learning spaces through translanguaging pedagogy. *International Multilingual Research Journal, 9*(1), 7-25. https://doi.org/10.1080/19313152.2014.984366

Henderson, K. I., & Ingram, M. (2018). Multilingual multimodal science communication: Exploring

the role of translanguaging in supporting student meaning-making. *International Journal of Bilingual Education and Bilingualism, 21*(7), 838-854. https://doi.org/10.1080/13670050.2017.1313198

Hornberger, N. H., & Link, H. (2012). Translanguaging and transnational literacies in multilingual classrooms: A biliteracy lens. *International Journal of Bilingual Education and Bilingualism, 15*(3), 261-278.

Hornberger, N. H., & Link, H. (2012). Translanguaging in today's classrooms: A biliteracy lens. *Theory Into Practice, 51*(4), 239-247. https://doi.org/10.1080/00405841.2012.726051

Lewis, G., Jones, B., & Baker, C. (2012). Translanguaging: Developing its conceptualization and contextualization. *Educational Research and Evaluation, 18*(7), 655-670. https://doi.org/10.1080/13803611.2012.718490

Mazak, C. M., & Herbas-Donoso, C. (2015). Translanguaging practices among engineering students in a Puerto Rican university. *English for Specific Purposes, 37,* 1-11.

Mazak, C., & Herbas-Donoso, V. (2015). Translanguaging practices as strategies for learning in a bilingual university physics classroom. *International Journal of Bilingual Education and Bilingualism, 18*(6), 698-714. https://doi.org/10.1080/13670050.2014.939138

Ooi, W. Z., & Aziz, A. A. (2021). Translanguaging pedagogy in the ESL classroom: A systematic review. *International Journal of Academic Research in Progressive Education and Development, 10*(3), 676-709.

Palmer, D., Martínez, R. A., Mateus, S. G., & Henderson, K. (2014). Reframing the debate on language separation: Toward a vision for translanguaging pedagogies in the dual language classroom. *The Modern Language Journal, 98*(3), 757-772. https://doi.org/10.1111/modl.12121

Poza, L. (2017). Translanguaging: A critical analytic review of literature. *Review of Educational Research, 87*(1), 183-215. https://doi.org/10.3102/0034654316685145

Pun, J., & Tai, K. W. H. (2021). Doing science through translanguaging: A study of translanguaging practices in secondary English as a medium of instruction science laboratory sessions. *International Journal of Science Education, 43*(7), 1112-1139.

Sánchez, M. T., García, O., & Solorza, C. (2018). Reframing language allocation policy in dual language bilingual education. *Bilingual Research Journal, 41*(1), 37-51.

Tai, K. W. H., & Li, W. (2021). Translanguaging for learning in an additional language: Students' perceptions of translanguaging in English medium instruction science classrooms in Hong Kong. *Language and Education, 35*(4), 377-395.

Velasco, P., & García, O. (2014). Translanguaging and the writing of bilingual learners. *Bilingual Research Journal, 37*(1), 6-23. https://doi.org/10.1080/15235882.2014.893270

Williams, C. (2012). *Extending bilingualism in the education system.* University of Wales Press.

Woodley, H. H., & Brown, K. (2021). The influence of translanguaging on student engagement in science education. *Journal of Bilingual Education Research & Practice, 23*(2), 215-230. https://doi.org/10.1080/15235882.2021.1023572