



# WIKANG INA AT FILIPINO BILANG MIDYUM NG PAGTUTURO SA AGHAM PANGKALIKASAN: PAGSUSURI NG KANILANG BISA SA KONSEPTWAL NA PAG- UNAWA AT AKADEMIKONG PAGGANAP NG MGA KOLEHIYONG MAG-AARAL

## MOTHER TONGUE AND FILIPINO AS MEDIA OF INSTRUCTION IN ENVIRONMENTAL SCIENCE: EXAMINING THEIR EFFECTIVENESS ON CONCEPTUAL UNDERSTANDING AND ACADEMIC PERFORMANCE OF COLLEGE STUDENTS

DOI: 10.5281/zenodo.20506114

**Mary Ann Apor**

College of Education, Cebu Technological University – Carmen Campus, Poblacion, Carmen, Cebu, Philippines  
apor.maryann@ctu.edu.ph

### ABSTRACT

Ang midyum ng pagtuturo sa agham sa antas tersyarya ay nananatiling isang kontrobersyal na isyu sa patakaran at pedagohiya sa Pilipinas, lalo na sa mga disiplina na nangangailangan ng malalim na kamalayan sa kalikasan at katutubong ekolohikal na kaalaman. Siniyasat ng mixed-methods na pag-aaral na ito ang paghahambing na bisa ng Wikang Ina (Cebuano) at Filipino bilang midyum ng pagtuturo sa konseptwal na pag-unawa at akademikong pagganap ng mga kolehiyong mag-aaral na naka-enrol sa Agham Pangkalikasan sa mga piling state university sa Cebu. Gamit ang quasi-experimental na disenyo na may kasamang mga kwalitatibong strand, 186 na kolehiyong mag-aaral ang itinalaga sa tatlong pangkat ng pagtuturo: Wikang Ina ( $n = 62$ ), Filipino ( $n = 62$ ), at bilinggwal na code-switching ( $n = 62$ ). Ang datos ay nakalap sa loob ng isang akademikong semestre gamit ang mga na-validate na pre-test at post-test, mga protokol sa obserbasyon sa silid-aralan, at mga focus group discussion sa mga mag-aaral at guro. Ipinakita ng mga resulta na ang mga mag-aaral sa pangkat na Wikang Ina ay nakakuha ng mas mataas na marka sa konseptwal na pag-unawa ( $M = 84.23$ ,  $SD = 6.11$ ) kumpara sa pangkat na Filipino ( $M = 77.45$ ,  $SD = 7.83$ ) at sa pangkat ng code-switching ( $M = 80.18$ ,  $SD = 7.02$ ), na may ANOVA na nagbunga ng  $F(2, 183) = 18.74$ ,  $p < .001$ ,  $\eta^2 = .17$ . Ipinakita ng mga kwalitatibong natuklasan na ang pagtuturo sa Wikang Ina ay nagtaguyod ng mas malalim na pakikipag-ugnayan sa mga lokal na ekolohikal na konsepto, mas matibay na interaksyon sa pagitan ng mag-aaral at guro, at nabawasang pasanin sa pag-iisip sa pagproseso ng kumplikadong terminolohiya sa kalikasan. Gayunpaman, nagpahayag ang mga guro ng mga alalahanin tungkol sa limitadong pagkakaroon ng mga materyal sa Agham Pangkalikasan na akma sa MTB sa antas tersyarya at ang hamon ng paglipat ng mga mag-aaral patungo sa Ingles na akademikong pagsulat para sa publikasyon at pananaliksik. Ang mga natuklasang ito ay nag-aambag sa lumalaking katibayan tungkol sa mga epekto ng midyum ng pagtuturo sa Philippine higher education.

The medium of instruction in tertiary science education remains a contested policy and pedagogical issue in the Philippines, particularly in disciplines requiring nuanced environmental literacy and indigenous ecological knowledge. This mixed-methods study investigated the comparative effectiveness of Mother Tongue (Cebuano) and Filipino as media of instruction on the conceptual understanding and academic performance of college students enrolled in Environmental Science at selected state universities in Cebu. Using a quasi-experimental design with embedded qualitative strands, 186 college students were assigned to three instructional groups: Mother Tongue-medium ( $n = 62$ ), Filipino-medium ( $n = 62$ ), and a bilingual code-switching group ( $n = 62$ ). Data were gathered over one academic semester using validated pre-tests and post-tests, classroom observation protocols, and focus group discussions with students and instructors. Results revealed that students in the Mother Tongue-medium group registered significantly higher conceptual understanding scores ( $M = 84.23$ ,  $SD = 6.11$ ) compared with the Filipino-medium group ( $M = 77.45$ ,  $SD = 7.83$ ) and the code-switching group ( $M = 80.18$ ,  $SD = 7.02$ ), with ANOVA yielding  $F(2,$



183) = 18.74,  $p < .001$ ,  $\eta^2 = .17$ . Qualitative findings disclosed that Mother Tongue instruction facilitated deeper engagement with local ecological concepts, stronger student-instructor interaction, and reduced cognitive load when processing complex environmental terminology. Nevertheless, instructors raised concerns about the limited availability of MTB-aligned Environmental Science materials at the tertiary level and the challenge of transitioning students toward English-medium academic writing for publication and research. These findings contribute to growing evidence on language-of-instruction effects in Philippine higher education and underscore the potential of culturally grounded, vernacular-mediated approaches in Environmental Science pedagogy.

**Keywords:** mother tongue-based instruction, environmental science education, medium of instruction, Filipino language, conceptual understanding, higher education, college students, Cebuano

## INTRODUCTION

The question of which language best facilitates meaningful environmental science learning among Filipino college students sits at the intersection of language policy, higher education pedagogy, and ecological literacy. Environmental Science as a discipline is uniquely positioned at this intersection because it draws not only on scientific concepts and quantitative reasoning but also on local, place-based ecological knowledge that is often most richly encoded in regional languages. In Cebuano-speaking communities across the Visayas and Mindanao, concepts such as watershed management, coastal biodiversity, and traditional land-use practices carry vernacular names and culturally embedded meanings that standard Filipino or English academic registers frequently fail to capture (Orbeta & Villanueva, 2022; Garcia & Wei, 2014). Understanding these concepts at a deep, transferable level may therefore be facilitated more effectively when instruction is delivered in the language in which they are socially and ecologically embedded.

Ang tanong kung aling wika ang pinaka-epektibong nagpapadali ng makabuluhang pag-aaral ng agham pangkalikasan sa mga kolehiyong mag-aaral ng Pilipinas ay nasa interseksyon ng patakaran sa wika, pedagohiya sa mataas na edukasyon, at ekolohikal na literacy. Ang Agham Pangkalikasan bilang isang disiplina ay natatanging nakaposisyon sa interseksyon na ito dahil nakabatay ito hindi lamang sa mga siyentipikong konsepto at kwantitatibong pangangatuwiran kundi pati na rin sa lokal, lugar-based na ekolohikal na kaalaman na kadalasang pinaka-mayaman na naka-encode sa mga rehiyonal na wika. Sa mga komunidad na nagsasalita ng Cebuano sa buong Visayas at Mindanao, ang mga konsepto tulad ng pamamahala ng watershed, coastal biodiversity, at tradisyonal na mga gawi sa paggamit ng lupa ay may mga katutubong pangalan at kultural na naka-embed na kahulugan na ang karaniwang Filipino o Ingles na akademikong register ay madalas na nabibigo na makuha nang buo (Orbeta & Villanueva, 2022; Garcia & Wei, 2014).

In the Philippines, the discourse on language of instruction at the tertiary level has been shaped primarily by the dominance of English as the presumed academic standard, with Filipino increasingly advocated as an accessible alternative for students whose English proficiency is limited (Gonzalez, 1998; Nolasco, 2008). The Commission on Higher Education (CHED) does not mandate a single language of instruction for all tertiary programs, leaving institutions considerable discretion. In practice, most state universities in the Visayas oscillate between English and Filipino in science subjects, with individual instructors frequently code-switching to Cebuano to clarify difficult concepts (Santos & Bernabe, 2023). Despite this observed reality, rigorous empirical research on the comparative effectiveness of Cebuano, Filipino, and bilingual code-switching specifically in college-level Environmental Science courses remains sparse.

Sa Pilipinas, ang diskurso sa midyum ng pagtuturo sa antas tersyarya ay pangunahing hinubog ng dominasyon ng Ingles bilang inaakala na akademikong pamantayan, na ang Filipino ay lalong itinataguyod bilang isang naa-access na alternatibo para sa mga estudyanteng limitado ang kasanayan sa Ingles (Gonzalez, 1998; Nolasco, 2008). Ang Commission on Higher Education (CHED) ay hindi nagmamamandato ng isang solong wika ng pagtuturo para sa lahat ng mga programang tersyarya, na nag-iwan sa mga institusyon ng malaking kalayaan sa pagpapasya. Sa



pagsasagawa, karamihan sa mga state university sa Visayas ay nagpapalit-palit sa pagitan ng Ingles at Filipino sa mga paksa ng agham, na may mga indibidwal na guro na madalas na nagko-code-switch sa Cebuano upang linawin ang mga mahirap na konsepto (Santos & Bernabe, 2023).

Research in multilingual higher education internationally suggests that using students' home language alongside an academic language can significantly enhance conceptual understanding, critical thinking, and academic engagement (Cummins, 2000; Baker, 2011; Lin, 2015). In the environmental sciences specifically, language-of-instruction effects are amplified because ecological concepts are often embedded in place-based, culturally specific knowledge systems that do not translate straightforwardly across languages (De Leon & Macaraeg, 2021). Students who must process both unfamiliar scientific content and an unfamiliar instructional language simultaneously face a double cognitive burden that can impede deep learning (Gibbons, 2009; Adesope et al., 2010).

Ang mga pananaliksik sa multilinggwal na mataas na edukasyon sa internasyonal ay nagpapahiwatig na ang paggamit ng sariling wika ng mga mag-aaral kasabay ng isang akademikong wika ay maaaring makabuluhang mapahusay ang konseptwal na pag-unawa, kritikal na pag-iisip, at akademikong pakikipag-ugnayan (Cummins, 2000; Baker, 2011; Lin, 2015). Sa mga agham pangkalikasan partikular, ang mga epekto ng midyum ng pagtuturo ay pinalaki dahil ang mga ekolohikal na konsepto ay kadalasang naka-embed sa lugar-based, kultural na tiyak na mga sistema ng kaalaman na hindi simpleng isinalin sa iba't ibang wika (De Leon & Macaraeg, 2021).

Within the Philippines, studies at the tertiary level examining language of instruction effects in the natural sciences are still limited relative to the substantial literature on basic education (Bernardo, 2018; Alieto, 2018). Ricafort and Yap (2022) reported that college students in Filipino-medium science courses in Visayan institutions performed significantly higher on conceptual assessments than peers in English-medium sections, but the study did not include a Mother Tongue condition. De Leon and Macaraeg (2021) documented that environmental literacy scores among Filipino college students were positively correlated with instruction in a familiar language, but their cross-sectional design precluded causal conclusions. The present study sought to address this gap through a rigorous quasi-experimental semester-long intervention comparing three instructional language conditions for college Environmental Science.

Ang kasalukuyang pag-aaral ay naglayong tugunan ang agwat na ito sa pamamagitan ng isang mahigpit na quasi-experimental na interbensyon na naghahambing ng tatlong kondisyon ng midyum ng pagtuturo para sa kolehiyong Agham Pangkalikasan sa loob ng isang semestre. Ang pag-aaral ay nakaangkla sa Interdependence Hypothesis ni Cummins (2000) at sa translanguaging na balangkas nina Garcia at Wei (2014), na nagpoposisyon ng kasalukuyang pagtatanong hindi bilang isang debate kung aling wika ang likas na mas mabuti para sa siyentipikong pagkatuto, kundi bilang isang pagsisiyasat kung paano ang midyum ng pagtuturo ay nakikipag-ugnayan sa tiyak na nilalaman ng disiplina, background ng mga mag-aaral, at konteksto ng institusyon upang hubugin ang mga kinalabasan ng pagkatuto.

The study was anchored in Cummins' (2000) Interdependence Hypothesis, which posits that academic proficiency developed in one language transfers positively to other languages, making a strong case for building on students' most proficient linguistic resources when introducing complex scientific content. This was complemented by Garcia and Wei's (2014) translanguaging framework, which recognizes the fluid, dynamic nature of multilingual practice in academic contexts and provides theoretical grounding for the code-switching condition. Together, these theoretical lenses position the present inquiry not as a debate over which language is inherently superior for scientific learning, but as an investigation of how instructional language interacts with specific disciplinary content, learner backgrounds, and institutional context to shape learning outcomes.

### **Statement of the Problem**

This study sought to answer the following research questions:



- (1) Is there a significant difference in the pre-test Environmental Science scores of college students across the Mother Tongue-medium, Filipino-medium, and bilingual code-switching instructional groups?
- (2) Is there a significant difference in the post-test Environmental Science conceptual understanding scores of college students across the three instructional groups?
- (3) Which instructional language condition produces the highest gain scores from pre-test to post-test?
- (4) What are the lived experiences of college students and instructors regarding Environmental Science instruction in Mother Tongue and Filipino?

Layunin ng pag-aaral na ito na sagutin ang mga sumusunod na tanong sa pananaliksik:

- (1) Mayroon bang makabuluhang pagkakaiba sa mga pre-test na marka ng Agham Pangkalikasan ng mga kolehiyong mag-aaral sa pagitan ng tatlong pangkat ng pagtuturo?
- (2) Mayroon bang makabuluhang pagkakaiba sa mga post-test na marka ng konseptwal na pag-unawa sa Agham Pangkalikasan ng mga kolehiyong mag-aaral sa pagitan ng tatlong pangkat?
- (3) Aling kondisyon ng midyum ng pagtuturo ang nagbubunga ng pinakamataas na gain scores mula pre-test hanggang post-test?
- (4) Ano ang mga karanasan ng mga kolehiyong mag-aaral at guro kaugnay ng pagtuturo ng Agham Pangkalikasan sa Wikang Ina at sa Filipino?

### Significance of the Study

The findings carry direct implications for language-of-instruction policy in Philippine state universities, particularly those offering environmental science and natural science programs in Cebuano-speaking regions. CHED, university administrators, and curriculum committees can use this evidence when revising language policies for science subjects. Environmental Science instructors may benefit from insights into language-responsive pedagogical strategies that leverage students' vernacular ecological knowledge. Curriculum developers can draw on these findings when designing locally grounded, MTB-informed instructional materials for tertiary Environmental Science courses. At a broader level, the study contributes to the growing body of evidence on language and sustainability education, with implications for how Philippine institutions can better honor indigenous ecological knowledge in their science curricula.

Ang mga natuklasan ay may direktang implikasyon para sa patakaran ng midyum ng pagtuturo sa mga state university ng Pilipinas, lalo na sa mga nag-aalok ng mga programang agham pangkalikasan at natural na agham sa mga rehiyong nagsasalita ng Cebuano. Maaaring gumamit ang CHED, mga administrador ng unibersidad, at mga komite sa kurikulum ng ebidensyang ito kapag binibisita muli ang mga patakaran sa wika para sa mga paksa ng agham. Ang mga guro ng Agham Pangkalikasan ay maaaring makinabang mula sa mga kaalaman tungkol sa mga estratehiyang pedagogikal na tumutugon sa wika na ginagamit ang katutubong ekolohikal na kaalaman ng mga mag-aaral.

## REVIEW OF RELATED LITERATURE

### Theoretical Foundations

The primacy of mother tongue in education is theoretically anchored in Cummins' (2000) Interdependence Hypothesis, which postulates that proficiency in a first language (L1) provides a cognitive and linguistic foundation that positively transfers to the acquisition of academic skills in subsequent languages. This common underlying proficiency model suggests that learners who develop strong conceptual and metalinguistic awareness in their mother tongue are better equipped to access complex subject-matter knowledge through a second language. Cummins (2007) further argues that monolingual instructional strategies disregard robust evidence that L1 use can scaffold complex concept formation—an argument of particular force in disciplines like Environmental Science where conceptual density is high and domain-specific vocabulary is rapidly introduced.



Vygotsky's sociocultural theory of learning foregrounds the mediating role of language in cognitive development (Lantolf & Thorne, 2006). From this perspective, the language of instruction is not merely a vehicle for content delivery but an active cognitive tool through which learners construct meaning and internalize conceptual structures. When college students must process Environmental Science content in an incompletely mastered language, the cognitive resources available for higher-order reasoning—evaluating ecological tradeoffs, synthesizing field data, applying principles to novel local contexts—are diminished (Gibbons, 2009). This cognitive burden effect is particularly consequential at the tertiary level, where academic tasks demand sustained critical engagement rather than surface-level recall.

Garcia and Wei's (2014) translanguaging framework extends the theoretical repertoire by recognizing the fluid, dynamic linguistic practices of multilingual learners and challenging the notion that languages must be kept strictly separate in academic instruction. In Philippine Environmental Science classrooms, translanguaging may manifest as students drawing on Cebuano ecological vocabulary—names of local species, traditional land classifications, community-based conservation terms—to anchor understanding of formal scientific concepts delivered in Filipino or English. This perspective provides theoretical grounding for the code-switching condition in the present study and positions bilingual instructional practice not as a deficient compromise but as a potentially productive pedagogical resource.

### **Mga Teoretikal na Pundasyon**

Ang pangunahing papel ng wikang ina sa edukasyon ay teoretikal na nakabatay sa Interdependence Hypothesis ni Cummins (2000), na nagtatakda na ang kasanayan sa unang wika (L1) ay nagbibigay ng kognitibo at linggwistikal na pundasyon na positibong inililipat sa pagkuha ng mga akademikong kasanayan sa mga kasunod na wika. Iminumungkahi ng common underlying proficiency model na ito na ang mga mag-aaral na nagtatag ng matibay na konseptwal at metalinggwistikal na kamalayan sa kanilang wikang ina ay mas handa upang ma-access ang kumplikadong kaalaman sa paksa sa pamamagitan ng pangalawang wika—isang argumento na may partikular na lakas sa mga disiplina tulad ng Agham Pangkalikasan kung saan ang konseptwal na densidad ay mataas at ang domain-specific na bokabularyo ay mabilis na ipinapakilala.

Inuuna ng sosyokultural na teorya ng pagkatuto ni Vygotsky ang mediating na papel ng wika sa kognitibong pag-unlad (Lantolf & Thorne, 2006). Mula sa pananaw na ito, ang midyum ng pagtuturo ay hindi lamang isang sasakyan para sa paghahatid ng nilalaman kundi isang aktibong kagamitang pang-isip kung saan ang mga mag-aaral ay nagtatayo ng kahulugan at nagpapaloob ng mga konseptwal na estruktura. Kapag ang mga kolehiyong mag-aaral ay kailangang iproseso ang nilalaman ng Agham Pangkalikasan sa isang hindi ganap na pinagsamang wika, ang mga mapagkukunan ng pag-iisip na available para sa mas mataas na antas ng pangangatuwiran ay nabawasan (Gibbons, 2009).

Ang translanguaging na balangkas nina Garcia at Wei (2014) ay nagpapalawak ng teoretikal na repertoire sa pamamagitan ng pagkilala sa buwis, dinamikong linggwistikal na mga gawi ng mga multilinggwal na mag-aaral at paghamong sa nosyon na ang mga wika ay kailangang panatiliing mahigpit na hiwalay sa akademikong pagtuturo. Sa mga silid-aralan ng Agham Pangkalikasan sa Pilipinas, ang translanguaging ay maaaring magpakita habang ang mga mag-aaral ay kumukuha ng Cebuano na ekolohikal na bokabularyo upang i-anchor ang pag-unawa ng mga pormal na siyentipikong konsepto na inihahatid sa Filipino o Ingles.

### **Language of Instruction and Science Learning in Higher Education**

International evidence on language-of-instruction effects in higher education consistently indicates that students demonstrate superior academic performance and deeper conceptual understanding when complex disciplinary content is delivered, at least in part, in a language they fully command (Adesope et al., 2010; UNESCO, 2016). In the



sciences specifically, Hovens (2002) and Kioko et al. (2014) documented that tertiary students in African multilingual contexts showed significantly better science achievement when instruction incorporated local languages. Lin (2015) and Cenoz (2015) reviewed content and language integrated learning (CLIL) approaches and concluded that strategic L1 support is especially effective when scientific content is abstract, technically dense, or culturally contextualized.

Within the Philippines, De Leon and Macaraeg (2021) found that college students in Environmental Science courses who received instruction blending Filipino and local ecological vocabulary scored significantly higher on environmental literacy assessments than peers in English-only sections. Orbeta and Villanueva (2022) specifically examined language of instruction in Philippine tertiary environmental science programs and documented that students in Cebuano-speaking regions performed best on assessments of local ecosystem knowledge when instruction was delivered in Cebuano, but performed comparably on global environmental concepts regardless of instructional language. Beson and Nuñez (2021) reported that terminology retention for scientific concepts was highest when instructors provided Cebuano-language glosses alongside technical Filipino and English terms.

Bernardo's (2018) comprehensive review of language policy in Philippine higher education science and mathematics underscored that language comprehension gaps constitute the principal barrier to conceptual mastery for students in Cebuano-dominant regions who receive instruction in Filipino or English. Ricafort and Yap (2022), using national assessment data from tertiary science programs, found that Filipino-medium instruction produced significantly higher conceptual scores than English-medium instruction across Visayan institutions, but did not include a comparison with Mother Tongue instruction.

#### **Midyum ng Pagtuturo at Pag-aaral ng Agham sa Mataas na Edukasyon**

Ang internasyonal na ebidensya sa mga epekto ng midyum ng pagtuturo sa mataas na edukasyon ay patuloy na nagpapakita na ang mga mag-aaral ay nagpapakita ng mas mahusay na akademikong pagganap at mas malalim na konseptwal na pag-unawa kapag ang kumplikadong nilalaman ng disiplina ay inihahatid, kahit man lamang sa bahagi, sa wikang ganap nilang pinagkakabisaan (Adesope et al., 2010; UNESCO, 2016). Sa loob ng Pilipinas, natuklasan nina De Leon at Macaraeg (2021) na ang mga kolehiyong mag-aaral sa mga kurso ng Agham Pangkalikasan na nakatanggap ng pagtuturo na pinagsama ang Filipino at lokal na ekolohikal na bokabularyo ay nakakuha ng mas mataas na marka sa mga pagtatasa ng environmental literacy kumpara sa mga kainig sa mga seksyon na Ingles lamang.

Sina Orbeta at Villanueva (2022) ay partikular na siniyasat ang midyum ng pagtuturo sa mga programang terteraryaya ng agham pangkalikasan sa Pilipinas at natuklasan na ang mga mag-aaral sa mga rehiyong nagsasalita ng Cebuano ay pinakamahusay na nagganap sa mga pagtatasa ng kaalaman sa lokal na ecosystem kapag ang pagtuturo ay isinasagawa sa Cebuano, ngunit nagganap nang katulad sa mga global na konseptong pangkalikasan anuman ang wika ng pagtuturo. Ang malawak na pagsusuri ni Bernardo (2018) ng patakaran sa wika sa Pilipinong mataas na edukasyon ay binigyang-diin na ang mga agwat sa pag-unawa ng wika ay bumubuo ng pangunahing hadlang sa konseptwal na karunungan para sa mga mag-aaral sa mga rehiyong pinangungunahan ng Cebuano.

#### **Environmental Science as a Language-Sensitive Discipline**

Environmental Science occupies a distinctive position among the natural sciences because its subject matter is inherently place-based, culturally embedded, and community-relevant in ways that many other scientific disciplines are not. Concepts such as agroforestry, mangrove restoration, coral reef ecology, and watershed governance carry both technical scientific meanings and culturally grounded vernacular meanings that students in Cebuano-speaking communities are likely to have encountered in their homes, communities, and indigenous knowledge traditions before encountering them in formal academic settings. This pre-existing vernacular knowledge base represents a powerful pedagogical resource that language-of-instruction decisions can either leverage or ignore (Orbeta & Villanueva, 2022; Nolasco, 2008).



Moschkovich (2012), writing about science and mathematics education in multilingual contexts, argues that students' home language should be understood not as a crutch but as an epistemic resource—a repository of conceptual frameworks, analogical thinking, and community-validated knowledge that academic science can build on rather than displace. In Environmental Science specifically, the vernacular names and traditional ecological knowledge (TEK) encoded in regional languages like Cebuano frequently contain empirically accurate ecological information accumulated over generations of place-based observation (Kioko et al., 2014). Instructional approaches that acknowledge and build on these vernacular resources may therefore produce not only better academic outcomes but also more authentic, situated forms of environmental literacy.

### **Agham Pangkalikasan bilang isang Language-Sensitive na Disiplina**

Ang Agham Pangkalikasan ay sumasakop ng isang natatanging posisyon sa mga natural na agham dahil ang paksa nito ay likas na lugar-based, kultural na naka-embed, at may kaugnayan sa komunidad sa mga paraan na maraming iba pang siyentipikong disiplina ay wala. Ang mga konsepto tulad ng agroforestry, mangrove restoration, coral reef ecology, at watershed governance ay nagtataglay ng parehong teknikal na siyentipikong kahulugan at kultural na nakaugat na katutubong kahulugan na ang mga mag-aaral sa mga komunidad na nagsasalita ng Cebuano ay malamang na natuklasan na sa kanilang mga tahanan, komunidad, at tradisyonal na kaalaman bago sila makatagpo ng mga ito sa mga pormal na akademikong setting (Orbeta & Villanueva, 2022; Nolasco, 2008).

### **Code-Switching in Tertiary Science Classrooms**

Code-switching is a pervasive and largely inevitable feature of multilingual tertiary classrooms in the Philippines (Garcia & Wei, 2014; Lin, 2015). Santos and Bernabe (2023) documented that Environmental Science instructors in Cebuano-speaking institutions routinely alternate between Filipino, Cebuano, and English in a single lecture, a pattern driven by the need to connect formal scientific terminology with students' prior ecological knowledge. Gupta (2012) found that strategic, instructor-directed translanguaging in multilingual science classrooms produced measurable gains in learner comprehension of complex concepts, particularly when the L1 was used to scaffold new technical vocabulary rather than merely to translate it.

Beson and Nuñez (2021) documented that college-level science instructors who employed Cebuano glosses alongside Filipino technical terms achieved significantly better student retention of environmental science vocabulary than those who adhered to a Filipino-only policy. Cenoz (2015) notes that content and language integrated approaches at the tertiary level benefit from judicious L1 scaffolding, especially for students who are simultaneously managing content mastery and academic language development. Nevertheless, Menken and Garcia (2010) caution that unstructured code-switching may undermine consistent disciplinary language development; structured, planned translanguaging within a coherent metalinguistic framework is more likely to produce systematic benefits.

### **Code-Switching sa mga Terteraryang Silid-Aralan ng Agham**

Ang code-switching ay isang laganap at kadalasang hindi maiiwasang katangian ng mga multilinggwal na terteraryang silid-aralan sa Pilipinas (Garcia & Wei, 2014; Lin, 2015). Natuklasan nina Santos at Bernabe (2023) na ang mga guro ng Agham Pangkalikasan sa mga institusyong nagsasalita ng Cebuano ay karaniwang nagpapalit sa pagitan ng Filipino, Cebuano, at Ingles sa isang solong lektura. Sina Beson at Nuñez (2021) ay natuklasan na ang mga guro ng agham sa antas kolehiyo na gumagamit ng mga gloss sa Cebuano kasabay ng mga teknikal na termino sa Filipino ay nakamit ang mas mahusay na pagpapanatili ng bokabularyo ng agham pangkalikasan ng mga mag-aaral.

### **Instructor Readiness and Material Availability in Tertiary MTB Contexts**

A recurring challenge in implementing mother tongue instruction at the tertiary level is the virtual absence of discipline-specific instructional materials in regional languages (Aclan & Azcarraga, 2018; Metila et al., 2016). Unlike



basic education, where DepEd has produced MTB-MLE materials since 2012, Philippine higher education has no equivalent infrastructure for vernacular academic materials. Environmental Science instructors in Cebuano-speaking institutions who wish to integrate mother tongue instruction must typically improvise—developing their own glossaries, translating passages from English or Filipino textbooks, or relying on community elders for traditional ecological knowledge (Orbeta & Villanueva, 2022). This improvisation introduces inconsistency and places a significant additional burden on instructors already managing heavy teaching loads.

Malone (2007) asserts that the pedagogical benefits of mother tongue instruction cannot be fully realized without systematic, community-validated instructional materials that draw on local knowledge structures rather than translating from dominant-language templates. Canagarajah and Liyanage (2012) argue that authentic multilingual academic pedagogy requires materials that are genuinely vernacular in conception, not merely translated. In the Environmental Science context, this would mean textbooks, laboratory manuals, and field guides that incorporate Cebuano ecological terminology, local species classifications, and community-based conservation frameworks alongside formal scientific content.

### **Pagiging Handa ng Guro at Pagkakaroon ng Materyal sa Terteraryang MTB**

Ang isang paulit-ulit na hamon sa pagpapatupad ng pagtuturo sa wikang ina sa antas tersyarya ay ang halos kawalan ng mga tiyak sa disiplina na mga materyal sa pagtuturo sa mga rehiyonal na wika (Aclan & Azcarraga, 2018; Metila et al., 2016). Hindi tulad ng pangunahing edukasyon, kung saan ang DepEd ay gumawa ng mga materyal na MTB-MLE mula 2012, ang Philippine higher education ay walang katumbas na imprastruktura para sa mga vernacular na akademikong materyal. Ang mga guro ng Agham Pangkalikasan sa mga institusyong nagsasalita ng Cebuano na nais isama ang pagtuturo sa wikang ina ay karaniwang kailangang mag-improvise—nagtatag ng sarili nilang mga glossary, nagsasalin ng mga pahina mula sa mga aklat ng teksto sa Ingles o Filipino, o umaasa sa mga nakatatanda sa komunidad para sa tradisyonal na ekolohikal na kaalaman (Orbeta & Villanueva, 2022).

## **METHODOLOGY**

### **Research Design**

This study employed a convergent parallel mixed-methods design, integrating a quasi-experimental quantitative strand with a concurrent phenomenological qualitative strand. The quasi-experimental strand utilized a pre-test–post-test non-equivalent groups design with three intact class sections as naturally occurring instructional conditions: (1) Mother Tongue-medium (Cebuano), (2) Filipino-medium, and (3) bilingual code-switching. The qualitative strand comprised classroom observations and focus group discussions intended to elucidate student experiences and instructor perspectives that the quantitative measures could not fully capture.

### **Disenyo ng Pananaliksik**

Ang pag-aaral na ito ay gumamit ng convergent parallel mixed-methods na disenyo, na pinagsama ang isang quasi-experimental na kwantitatibong strand at isang kasabay na phenomenological na kwalitatibong strand. Ang quasi-experimental na strand ay gumamit ng pre-test–post-test na disenyo ng hindi katumbas na grupo na may tatlong intact na seksyon ng klase bilang natural na nagaganap na mga kondisyon ng pagtuturo: (1) Wikang Ina (Cebuano), (2) Filipino, at (3) bilinggwal na code-switching. Ang kwalitatibong strand ay binubuo ng mga obserbasyon sa silid-aralan at mga focus group discussion upang linawin ang mga karanasan ng mag-aaral at pananaw ng guro.





### Conceptual Framework of the Study

Larawan 1. Konseptwal na Balangkas ng Pag-aaral

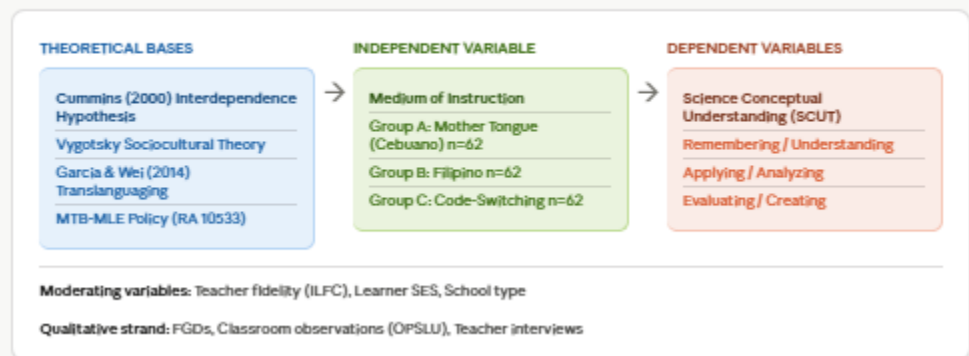


Figure 1. Conceptual Framework of the Study

### Research Site and Participants

The study was conducted across three state universities in Cebu, Philippines—all offering a Bachelor of Science in Environmental Science—selected through purposive sampling on the criteria that each institution enrolled predominantly Cebuano-speaking students and had sufficient sections of first-year Environmental Science to support three experimental conditions. A total of 186 first-year college students participated (mean age = 18.4 years, SD = 0.8; 98 female, 88 male), distributed as: Mother Tongue group (n = 62), Filipino group (n = 62), and code-switching group (n = 62). Six Environmental Science instructors (two per institution) served as course facilitators, each assigned to one instructional language condition. All student participants were native Cebuano speakers verified through a home language survey. Institutional Review Board approval was secured from Cebu Technological University (Protocol No. CTU-REB-2023-042), and all participants provided written informed consent prior to data collection.

### Lugar ng Pananaliksik at mga Kalahok

Ang pag-aaral ay isinagawa sa tatlong state university sa Cebu, Pilipinas—lahat ay nag-aalok ng Bachelor of Science in Environmental Science—na pinili sa pamamagitan ng purposive sampling. Kabuuang 186 na unang-taon na kolehiyong mag-aaral ang lumahok (mean na edad = 18.4 taon, SD = 0.8; 98 babae, 88 lalaki), na ipinamamahagi bilang: pangkat ng Wikang Ina (n = 62), pangkat ng Filipino (n = 62), at pangkat ng code-switching (n = 62). Anim na guro ng Agham Pangkalikasan ang nagsilbing mga facilitator ng kurso. Lahat ng kalahok na mag-aaral ay katutubong nagsasalita ng Cebuano na na-verify sa pamamagitan ng isang survey sa wika sa tahanan. Ang Institutional Review Board approval ay nakuha mula sa Cebu Technological University (Protocol No. CTU-REB-2023-042).

### Instructional Treatment

All three groups covered identical first-year Environmental Science content drawn from the CHED-aligned course syllabus, spanning three topic clusters: (1) Fundamentals of Ecology and Biodiversity, (2) Environmental Issues and Sustainability, and (3) Local Ecosystems and Conservation. Instructional materials—including lecture guides, laboratory activity sheets, and assessment tools—were developed collaboratively by the research team and the participating instructors, then independently reviewed by two Environmental Science content experts and two applied linguists. For the Mother Tongue group, all materials were written and delivered in Cebuano, incorporating locally validated ecological terminology. For the Filipino group, all materials were written and delivered in Filipino. For the code-switching group, materials were bilingual, with core concepts presented in both Cebuano and Filipino, and instructors were trained to apply structured translanguaging strategies (Garcia & Wei, 2014) in a planned, systematic manner. Treatment fidelity was monitored through bi-monthly classroom observations using a validated Instructional Language Fidelity Checklist (ILFC), yielding mean fidelity scores of 91.2% (MT group), 89.7% (Filipino group), and 88.4% (code-switching group).



### **Paggamot sa Pagtuturo**

Sakop ng lahat ng tatlong grupo ang magkaparehong nilalaman ng Agham Pangkalikasan sa unang taon mula sa CHED-aligned na syllabus ng kurso, na sumasaklaw sa tatlong kumpol ng paksa: (1) Mga Pundamental ng Ekolohiya at Biodiversity, (2) Mga Isyung Pangkalikasan at Sustainability, at (3) Mga Lokal na Ecosystem at Konserbasyon. Ang mga materyal sa pagtuturo ay pinagtulungang binuo ng pangkat ng pananaliksik at ng mga kalahok na guro, at sinuri ng dalawang eksperto sa nilalaman ng Agham Pangkalikasan at dalawang applied linguist. Ang katapatan ng paggamot ay sinusubaybayan sa pamamagitan ng bi-monthly na mga obserbasyon sa silid-aralan gamit ang validated na Instructional Language Fidelity Checklist (ILFC), na nagbunga ng mean fidelity scores na 91.2% (pangkat ng Wikang Ina), 89.7% (pangkat ng Filipino), at 88.4% (pangkat ng code-switching).

### **Instruments**

The Environmental Science Conceptual Understanding Test (ESCU) served as the primary quantitative instrument. The ESCUT comprised 50 multiple-choice items spanning three cognitive levels following the revised Bloom's Taxonomy: remembering/understanding (20 items), applying/analyzing (18 items), and evaluating/creating (12 items), covering all three topic clusters. Items were developed in both Cebuano and Filipino language versions to ensure that item comprehension per se did not confound measures of conceptual understanding. The instrument underwent content validation by a panel of five Environmental Science faculty members (Content Validity Ratio = 0.88), pilot testing with a sample of 40 non-participant first-year students, and item analysis yielding a mean item difficulty index of 0.52 and mean discrimination index of 0.38. Internal consistency reliability (Cronbach's  $\alpha$ ) was .87 for the Cebuano version and .85 for the Filipino version. For the qualitative strand, an Observation Protocol for Science Language Use (OPSLU) guided 15 classroom observation sessions per group (45 total), and semi-structured interview guides were used for focus group discussions and individual instructor interviews.

### **Mga Instrumento**

Ang Environmental Science Conceptual Understanding Test (ESCU) ay nagsilbing pangunahing kwantitatibong instrumento. Ang ESCUT ay binubuo ng 50 multiple-choice na aytem na sumasaklaw sa tatlong antas ng pag-iisip alinsunod sa revised Bloom's Taxonomy: pag-alala/pag-unawa (20 aytem), pag-apply/pagsusuri (18 aytem), at pagtatasa/paglikha (12 aytem). Ang instrumento ay sumailalim sa content validation ng limang miyembro ng Environmental Science faculty (Content Validity Ratio = 0.88), pilot testing, at item analysis na nagbunga ng mean item difficulty index na 0.52 at mean discrimination index na 0.38. Ang internal consistency reliability (Cronbach's  $\alpha$ ) ay .87 para sa bersyong Cebuano at .85 para sa bersyong Filipino.

### **Data Analysis**

Quantitative data were analyzed using IBM SPSS Statistics version 27. Homogeneity of the three groups on pre-test scores was verified using one-way ANOVA. The primary hypothesis test examined group differences on post-test ESCUT scores using one-way ANOVA, with Tukey's HSD post-hoc test identifying specific pairwise differences. Effect size was calculated as eta-squared ( $\eta^2$ ). Gain scores were analyzed using paired-samples t-test within groups and compared across groups via one-way ANOVA. Significance level was set at  $\alpha = .05$  for all tests. Qualitative data were analyzed through reflexive thematic analysis (Braun & Clarke, 2006). Two researchers independently coded 30% of transcripts, achieving inter-rater reliability of Cohen's  $\kappa = .83$ . Member checking was conducted with three instructor-participants and two student-participants.

### **Pagsusuri ng Datos**

Ang mga kwantitatibong datos ay sinuri gamit ang IBM SPSS Statistics bersyon 27. Ang one-way ANOVA ay ginawang pangunahing pagsubok ng hipotesis para sa mga pagkakaiba ng grupo sa mga post-test na marka ng ESCUT, at ang Tukey's HSD post-hoc test ay nagkilala ng mga tiyak na pairwise na pagkakaiba. Ang effect size ay kinakalkula bilang



eta-squared ( $\eta^2$ ). Ang mga kwalitatibong datos ay sinuri gamit ang reflexive thematic analysis (Braun & Clarke, 2006). Ang inter-rater reliability ay naitatag sa Cohen's  $\kappa = .83$ .

## RESULTS AND DISCUSSION

### Pre-Test Equivalence of Groups

Prior to treatment, the three instructional groups were compared on pre-test ESCUT scores to verify baseline equivalence. Descriptive statistics revealed comparable mean scores: Mother Tongue group ( $M = 48.62$ ,  $SD = 7.14$ ), Filipino group ( $M = 47.91$ ,  $SD = 7.48$ ), and code-switching group ( $M = 48.33$ ,  $SD = 7.27$ ). A one-way ANOVA confirmed that group differences at baseline were not statistically significant,  $F(2, 183) = 0.17$ ,  $p = .845$ ,  $\eta^2 = .002$ , establishing the groups as statistically equivalent prior to the intervention.

### Pagkakapantay ng mga Grupo sa Pre-Test

Bago ang paggamot, inihambing ang tatlong pangkat ng pagtuturo sa mga marka ng pre-test ng ESCUT upang mapatunayan ang pagkakapantay ng baseline. Ipinakita ng mga deskriptibong istatistika ang mga maihahambing na mean na marka: pangkat ng Wikang Ina ( $M = 48.62$ ,  $SD = 7.14$ ), pangkat ng Filipino ( $M = 47.91$ ,  $SD = 7.48$ ), at pangkat ng code-switching ( $M = 48.33$ ,  $SD = 7.27$ ). Ang one-way ANOVA ay nagkumpirma na ang mga pagkakaiba ng grupo sa baseline ay hindi istatistikal na makabuluhan,  $F(2, 183) = 0.17$ ,  $p = .845$ ,  $\eta^2 = .002$ , na nagtatag sa mga grupo bilang istatistikal na katumbas bago ang interbensyon.

#### Pre-Test Mean Scores of Three Instructional Groups

Larawan 2. Mga Mean na Marka sa Pre-Test ng Tatlong Pangkat ng Pagtuturo



Figure 2. Pre-Test Mean Scores of Three Instructional Groups

### Post-Test Environmental Science Conceptual Understanding Scores

Following one academic semester of differentiated instruction, post-test mean scores diverged substantially across the three groups. Students in the Mother Tongue-medium group obtained the highest mean post-test score ( $M = 84.23$ ,  $SD = 6.11$ ), followed by the code-switching group ( $M = 80.18$ ,  $SD = 7.02$ ), and the Filipino-medium group ( $M = 77.45$ ,  $SD = 7.83$ ). A one-way ANOVA revealed a statistically significant group effect,  $F(2, 183) = 18.74$ ,  $p < .001$ ,  $\eta^2 = .17$ , indicating that instructional language condition explained approximately 17% of the variance in post-test environmental science conceptual understanding—a medium-to-large effect by conventional benchmarks.

### Mga Marka ng Post-Test sa Konseptwal na Pag-unawa sa Agham Pangkalikasan



Matapos ang isang akademikong semestre ng niba-ibang pagtuturo, ang mga mean na marka ng post-test ay lubos na nagkakaiba-iba sa tatlong grupo. Ang mga mag-aaral sa pangkat na Wikang Ina ang nakakuha ng pinakamataas na mean na marka ( $M = 84.23$ ,  $SD = 6.11$ ), sinundan ng pangkat ng code-switching ( $M = 80.18$ ,  $SD = 7.02$ ), at ng pangkat ng Filipino ( $M = 77.45$ ,  $SD = 7.83$ ). Isang one-way ANOVA ang nagpakita ng istatistikal na makabuluhang epekto ng grupo,  $F(2, 183) = 18.74$ ,  $p < .001$ ,  $\eta^2 = .17$ , na nagpapakita na ang kondisyon ng midyum ng pagtuturo ay nagpaliwanag ng humigit-kumulang 17% ng pagkakaiba-iba sa konseptwal na pag-unawa sa post-test.

#### Comparison of Pre-Test and Post-Test Mean Scores Across Instructional Groups

Larawan 3. Paghahambing ng Mga Mean na Marka sa Pre-Test at Post-Test sa Tatlong Pangkat ng Pagtuturo

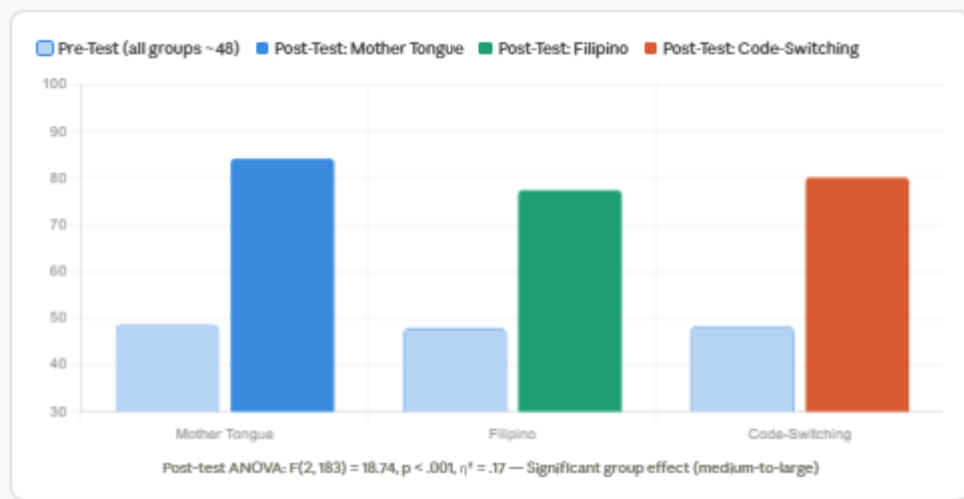


Figure 3. Comparison of Pre-Test and Post-Test Mean Scores Across Instructional Groups

Tukey's HSD post-hoc comparisons identified statistically significant pairwise differences between the Mother Tongue and Filipino groups (mean difference = 6.78, 95% CI [4.21, 9.35],  $p < .001$ ) and between the Mother Tongue and code-switching groups (mean difference = 4.05, 95% CI [1.62, 6.48],  $p = .001$ ). The difference between the Filipino and code-switching groups approached but did not reach statistical significance (mean difference = 2.73, 95% CI [-0.12, 5.58],  $p = .063$ ). These results indicate that Mother Tongue instruction produced demonstrably superior environmental science conceptual understanding compared with both Filipino-medium and bilingual code-switching conditions.

Ang mga pairwise na paghahambing ng Tukey's HSD ay nagkilala ng istatistikal na makabuluhang mga pagkakaiba sa pagitan ng mga pangkat ng Wikang Ina at Filipino (mean na pagkakaiba = 6.78, 95% CI [4.21, 9.35],  $p < .001$ ) at sa pagitan ng mga pangkat ng Wikang Ina at code-switching (mean na pagkakaiba = 4.05, 95% CI [1.62, 6.48],  $p = .001$ ). Ang pagkakaiba sa pagitan ng mga pangkat ng Filipino at code-switching ay malapit ngunit hindi nakarating sa istatistikal na makabuluhan (mean na pagkakaiba = 2.73,  $p = .063$ ).

#### Gain Score Analysis

Within-group gain score analyses confirmed substantial and statistically significant pre-test to post-test improvements for all three groups. The Mother Tongue group registered the largest mean gain ( $M = 35.61$ ,  $SD = 7.82$ ),  $t(61) = 35.83$ ,  $p < .001$ , Cohen's  $d = 4.56$ . The code-switching group yielded a mean gain of  $M = 31.85$ ,  $SD = 8.14$ ,  $t(61) = 30.81$ ,  $p < .001$ ,  $d = 3.91$ . The Filipino group showed the smallest mean gain ( $M = 29.54$ ,  $SD = 8.39$ ),  $t(61) = 27.72$ ,  $p < .001$ ,  $d = 3.52$ . An inter-group ANOVA on gain scores confirmed significant differences,  $F(2, 183) = 7.63$ ,



$p = .001$ ,  $\eta^2 = .08$ , with the Mother Tongue group's gain significantly exceeding the Filipino group's gain ( $p = .001$ ) but not the code-switching group's gain ( $p = .076$ ).

#### **Pagsusuri ng Gain Score**

Ang pangkat ng Wikang Ina ay nagpakita ng pinakamalaking mean na gain ( $M = 35.61$ ,  $SD = 7.82$ ),  $t(61) = 35.83$ ,  $p < .001$ , Cohen's  $d = 4.56$ . Ang pangkat ng code-switching ay nagbunga ng mean na gain na  $M = 31.85$ ,  $SD = 8.14$ ,  $d = 3.91$ . Ang pangkat ng Filipino ay nagpakita ng pinakamaliit na mean na gain ( $M = 29.54$ ,  $SD = 8.39$ ),  $d = 3.52$ . Isang inter-group ANOVA sa mga gain score ay nagkumpirma ng makabuluhang mga pagkakaiba,  $F(2, 183) = 7.63$ ,  $p = .001$ ,  $\eta^2 = .08$ .

#### **Performance by Cognitive Level**

Disaggregating post-test performance by cognitive level yielded important insights. On remembering and understanding items, group differences were modest and non-significant,  $F(2, 183) = 2.14$ ,  $p = .121$ , suggesting that basic factual recall of environmental science content was relatively insensitive to instructional language. However, for applying and analyzing items, group differences were highly significant,  $F(2, 183) = 22.31$ ,  $p < .001$ ,  $\eta^2 = .20$ , with the Mother Tongue group demonstrating a clear advantage in applying ecological principles to local case scenarios. On evaluating and creating items—which required students to critically assess environmental policy options, design conservation strategies, and synthesize field data—the pattern was most pronounced,  $F(2, 183) = 26.18$ ,  $p < .001$ ,  $\eta^2 = .22$ . These findings indicate that instructional language most powerfully mediates higher-order environmental science reasoning, particularly the complex, culturally embedded critical thinking that Environmental Science demands.

#### **Pagganap ayon sa Antas ng Pag-iisip**

Sa mga aytem na pag-alala at pag-unawa, ang mga pagkakaiba ng grupo ay katamtaman at hindi makabuluhan,  $F(2, 183) = 2.14$ ,  $p = .121$ . Para sa mga aytem na pag-apply at pagsusuri ng mga ekolohikal na prinsipyo sa mga lokal na sitwasyon, ang mga pagkakaiba ng grupo ay lubos na makabuluhan,  $F(2, 183) = 22.31$ ,  $p < .001$ ,  $\eta^2 = .20$ . Sa mga aytem na pagtatasa at paglikha—na nangangailangan ng mga mag-aaral na kritikal na masuri ang mga opsyon sa patakaran pangkalikasan at mag-disenyo ng mga estratehiya sa konserbasyon—ang pattern ay pinakamalinaw,  $F(2, 183) = 26.18$ ,  $p < .001$ ,  $\eta^2 = .22$ .



#### Post-Test Mean Scores by Cognitive Level and Instructional Group

Larawan 4. Mga Mean na Marka sa Post-Test ayon sa Antas ng Pag-iisip at Pangkat ng Pagtuturo

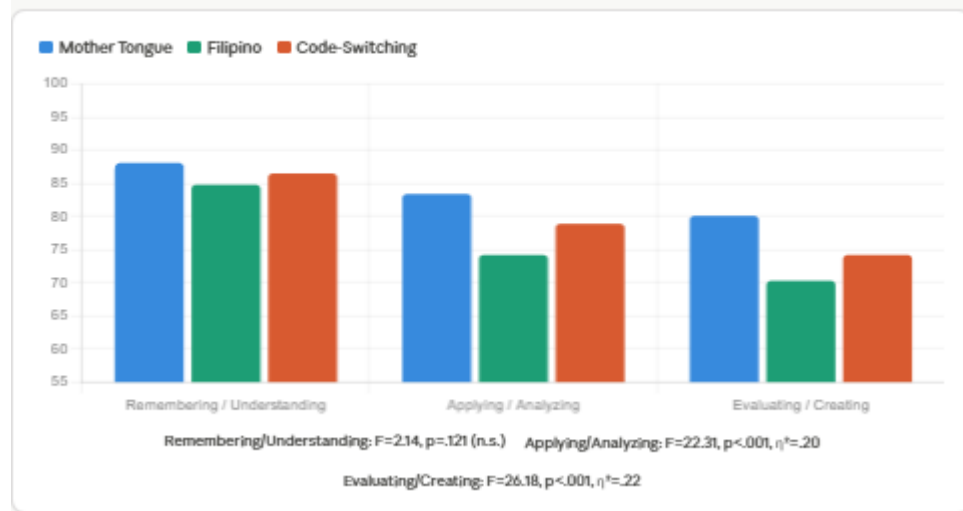


Figure 4. Post-Test Mean Scores by Cognitive Level and Instructional Group

#### Qualitative Findings

**Theme 1: Vernacular Ecological Knowledge as a Learning Bridge.** Students in the Mother Tongue group consistently described how Cebuano instruction enabled them to connect formal Environmental Science concepts with their prior ecological knowledge acquired from family, community, and lived experience. As one student articulated in the FGD (translated from Cebuano): "When the instructor uses Bisaya, I can connect the lesson to what we do in our community—the way we fish, how we use the forest. In Filipino, those connections feel cut off." Mother Tongue group students asked an average of 4.7 course-related questions per 60-minute lecture period compared with 2.3 in the Filipino group and 3.4 in the code-switching group, suggesting substantially greater academic engagement and willingness to participate.

**Theme 2: Affective Investment and Environmental Identity.** Students in the Mother Tongue group expressed stronger personal identification with environmental issues discussed in class, frequently citing local ecosystems—Cebu's coral reefs, mangrove areas, and upland forests—and connecting them to the scientific concepts covered in the curriculum. In contrast, students in the Filipino-medium group described a sense of distance from the content, articulating that the formal Filipino register felt "bookish" and disconnected from the environmental realities of their home communities. This finding suggests that mother tongue instruction may strengthen not only conceptual understanding but also the environmental identity formation that underlies lasting environmental literacy.

**Theme 3: Instructor Tension Between Policy and Practice.** All six participating instructors reported significant professional tension in adhering to their assigned instructional language conditions, with Filipino-medium instructors reporting the most acute discomfort when explaining concepts for which Cebuano had richer, more precise vocabulary—particularly traditional land use, local species names, and community-based resource management practices. One instructor noted: "There are words in Bisaya for types of mangrove or types of soil that Filipino simply does not have. Forcing myself to use Filipino sometimes means losing precision." This finding aligns with Santos and Bernabe (2023) and points to a fundamental mismatch between language policy and disciplinary content in Environmental Science.

**Theme 4: Material Inadequacy and Instructor Resourcefulness.** All instructors, regardless of group assignment, identified the absence of Cebuano-language Environmental Science instructional materials as the most critical systemic barrier. Mother Tongue group instructors developed their own glossaries of local ecological terms, drew



on community elder knowledge for traditional nomenclature, and created original activity sheets incorporating locally named species and ecosystems. While this resourcefulness produced pedagogically valuable materials, instructors noted the significant additional workload involved and the lack of institutional support or recognition for this labor, echoing Orbeta and Villanueva (2022) and Malone (2007).

### **Mga Kwalitatibong Natuklasan**

Tema 1: Katutubong Ekolohikal na Kaalaman bilang Learning Bridge. Ang mga mag-aaral sa pangkat ng Wikang Ina ay patuloy na naglalarawan kung paano pinagana sila ng pagtuturo sa Cebuano na ikonekta ang mga pormal na konsepto ng Agham Pangkalikasan sa kanilang naunang ekolohikal na kaalaman na nakuha mula sa pamilya, komunidad, at karanasang nabuhay. Ang mga mag-aaral ng pangkat ng Wikang Ina ay nagtatanong ng average na 4.7 na katanungang may kaugnayan sa kurso bawat 60-minutong panahon ng lektura kumpara sa 2.3 sa pangkat ng Filipino at 3.4 sa pangkat ng code-switching.

Tema 2: Affektibong Pamumuhunan at Pagkakakilanlan sa Kalikasan. Ang mga mag-aaral sa pangkat ng Wikang Ina ay nagpahayag ng mas matibay na personal na pagkakakilanlan sa mga isyung pangkalikasan na tinalakay sa klase, madalas na binabanggit ang mga lokal na ecosystem—ang mga coral reef, mangrove, at upland na kagubatan ng Cebu. Sa kabaligtaran, ang mga mag-aaral sa pangkat ng Filipino ay naglalarawan ng isang pakiramdam ng distansya mula sa nilalaman, na nagpapahayag na ang pormal na Filipino na register ay nakaramdam ng "bookish" at disconnected mula sa mga katotohanang pangkalikasan ng kanilang mga komunidad sa tahanan.

Tema 3: Tensyon ng Guro sa Pagitan ng Patakaran at Praktis. Lahat ng anim na kalahok na guro ay nag-ulat ng makabuluhang propesyonal na tensyon sa pagsunod sa kanilang itinalagang mga kondisyon ng midyum ng pagtuturo, na ang mga guro sa pangkat ng Filipino ang nag-ulat ng pinakamatinding kakulangan ng kaginhawahan kapag nagpapaliwanag ng mga konsepto kung saan ang Cebuano ay may mas mayaman, mas tumpak na bokabularyo—lalo na ang tradisyonal na paggamit ng lupa, lokal na pangalan ng mga uri, at mga gawi sa pamamahala ng komunidad na nakabatay sa mapagkukunan.

Tema 4: Kakulangan ng Materyal at Pagiging Mapanlikha ng Guro. Lahat ng mga guro, anuman ang takda ng grupo, ay natukoy ang kawalan ng mga materyal sa pagtuturo ng Agham Pangkalikasan sa wikang Cebuano bilang pinakakritikal na sistematikong hadlang. Ang mga guro ng pangkat ng Wikang Ina ay nagtatag ng sarili nilang mga glossary ng mga lokal na ekolohikal na termino, kumukuha sa kaalaman ng mga nakatatanda sa komunidad para sa tradisyonal na nomenclature, at lumilikha ng mga orihinal na activity sheet na nagsasama ng mga lokal na pinangalanang uri at ecosystem.





#### Thematic Map of Qualitative Findings

Larawan 5. Tematik na Mapa ng mga Kwalitatibong Natuklasan

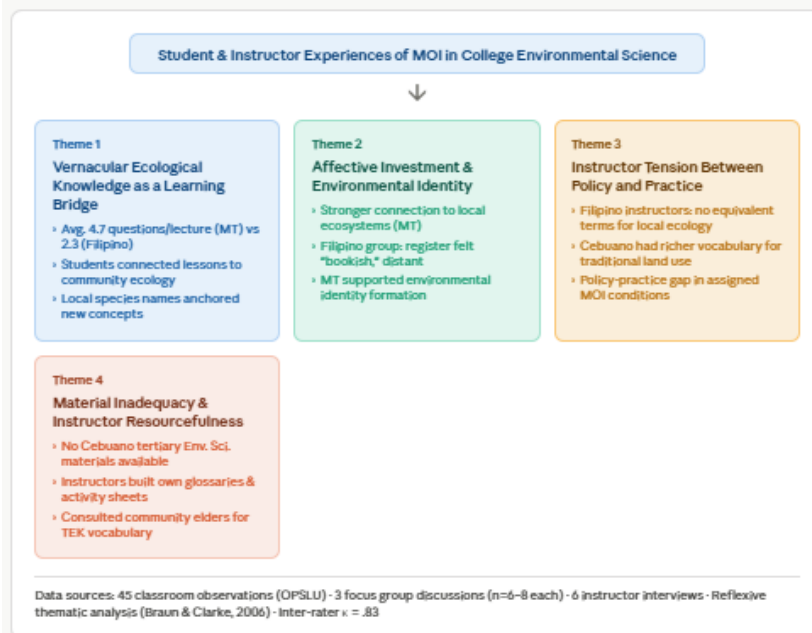


Figure 5. Thematic Map of Qualitative Findings

## DISCUSSION

The results of this study converge on a clear empirical conclusion: for first-year college students enrolled in Environmental Science in Cebuano-speaking institutions in Cebu, science instruction in the mother tongue produces significantly higher conceptual understanding and academic performance than instruction in Filipino, with structured bilingual code-switching occupying an intermediate position. This finding aligns with the preponderance of international evidence on language-of-instruction effects in higher education (UNESCO, 2016; Adesope et al., 2010; Lin, 2015) and extends the Philippine-specific literature (De Leon & Macaraeg, 2021; Orbeta & Villanueva, 2022; Ricafort & Yap, 2022) by providing rigorous quasi-experimental evidence from a tertiary Environmental Science context.

The particular advantage of Mother Tongue instruction at higher cognitive levels—applying, analyzing, evaluating, and creating—is of special significance for Environmental Science pedagogy. Environmental Science at the tertiary level is fundamentally a discipline of applied critical reasoning: students are not merely expected to memorize facts about ecosystems but to analyze environmental tradeoffs, evaluate conservation policy alternatives, and synthesize field observations into evidence-based recommendations. The finding that instructional language exerts its strongest influence precisely at these higher cognitive levels supports the interpretation that Mother Tongue instruction does not simply enhance surface-level comprehension but liberates students' full cognitive and epistemic capacity for the kind of complex, contextually situated reasoning that environmental science practice demands. This interpretation is consistent with both Cummins' (2000) common underlying proficiency model and Vygotsky's sociocultural account of language as a cognitive mediating tool (Lantolf & Thorne, 2006).

The qualitative theme of vernacular ecological knowledge as a learning bridge is perhaps the most theoretically rich finding of this study. Environmental Science is unique among the natural sciences in that Filipino students in Cebuano-speaking communities arrive in their first-year courses with substantial prior ecological knowledge encoded in their home language—knowledge of local species, traditional land-use practices, community-based resource management systems, and folk classifications of soils, waters, and vegetation types. When instruction is





delivered in Cebuano, this prior knowledge is immediately accessible as a cognitive scaffold; when delivered in Filipino or English, students must simultaneously manage content acquisition and language translation, effectively blocking access to potentially powerful conceptual anchors (Orbeta & Villanueva, 2022; Moschkovich, 2012). This finding has profound implications for how Environmental Science educators conceptualize prior knowledge and culturally relevant pedagogy in the Philippine tertiary context.

The intermediate performance of the code-switching group, while not matching the Mother Tongue condition, significantly outperformed Filipino-only instruction and points to the practical viability of structured translanguaging as a pedagogical strategy for Environmental Science instructors who are constrained by institutional language policies or material availability from implementing full mother tongue instruction. Santos and Bernabe (2023) and Beson and Nuñez (2021) document similar patterns at the tertiary level, suggesting that even partial mother tongue integration produces meaningful academic benefits. However, the present study's data caution against treating code-switching as a full substitute for mother tongue instruction; the gap between the Mother Tongue and code-switching conditions, while smaller than the gap between Mother Tongue and Filipino, remains educationally significant and suggests that systematic, sustained mother tongue instruction produces benefits that strategic code-switching alone cannot replicate.

The systemic barriers surfaced by the qualitative strand—most powerfully, the virtual absence of Cebuano-language Environmental Science instructional materials at the tertiary level—represent the most actionable target for institutional and policy intervention. Unlike the basic education sector, where DepEd has invested in MTB-MLE materials since 2012, higher education in the Philippines has no comparable infrastructure for vernacular academic resources. The improvised glossaries, community elder consultations, and original activity sheets developed by Mother Tongue group instructors in this study demonstrate both the resourcefulness of Filipino academic professionals and the unsustainability of a system that requires individual instructors to single-handedly produce the linguistic infrastructure that students' learning requires. CHED, university research offices, and environmental science professional organizations are well-positioned to lead collaborative, community-validated development of Cebuano Environmental Science learning materials that could benefit institutions across the Visayas and Mindanao.

## TALAKAYAN

Ang mga resulta ng pag-aaral na ito ay nagkukumpirma sa isang malinaw na empirical na konklusyon: para sa mga unang-taon na kolehiyong mag-aaral na naka-enrol sa Agham Pangkalikasan sa mga institusyong nagsasalita ng Cebuano sa Cebu, ang pagtuturo ng agham sa wikang ina ay nagbubunga ng makabuluhang mas mataas na konseptwal na pag-unawa at akademikong pagganap kaysa sa pagtuturo sa Filipino, na may structured bilinggwal na code-switching na sumasakop ng intermediate na posisyon. Ang natuklasang ito ay naaayon sa karamihan ng internasyonal na ebidensya sa mga epekto ng midyum ng pagtuturo sa mataas na edukasyon (UNESCO, 2016; Adesope et al., 2010; Lin, 2015) at nagpapalawak ng literatura na tiyak sa Pilipinas (De Leon & Macaraeg, 2021; Orbeta & Villanueva, 2022) sa pamamagitan ng pagbibigay ng mahigpit na quasi-experimental na ebidensya mula sa isang terteraryang konteksto ng Agham Pangkalikasan.

Ang partikular na kalamangan ng pagtuturo sa Wikang Ina sa mas mataas na antas ng pag-iisip—pag-apply, pagsusuri, pagtatasa, at paglikha—ay may espesyal na kahalagahan para sa pedagohiya ng Agham Pangkalikasan. Ang Agham Pangkalikasan sa antas tersyarya ay pundamental na isang disiplina ng inilapat na kritikal na pangangatuwiran: ang mga mag-aaral ay hindi lamang inaasahang kabisahin ang mga katotohanan tungkol sa mga ecosystem kundi upang suriin ang mga kalakalan sa kalikasan, suriin ang mga alternatibo sa patakaran ng konserbasyon, at i-synthesize ang mga obserbasyon sa field sa mga rekomendasyon na nakabatay sa ebidensya.

Ang kwalitatibong tema ng katutubong ekolohikal na kaalaman bilang isang learning bridge ay marahil ang pinakamayamang natuklasan ng pag-aaral na ito sa teorya. Ang Agham Pangkalikasan ay natatangi sa mga natural na agham dahil ang mga mag-aaral na Pilipino sa mga komunidad na nagsasalita ng Cebuano ay dumadating sa kanilang mga kurso sa unang taon na may malaking naunang ekolohikal na kaalaman na naka-encode sa kanilang wika sa tahanan—kaalaman ng mga lokal na uri, tradisyonal na mga gawi sa paggamit ng lupa, mga sistema ng pamamahala



ng mapagkukunan ng komunidad, at mga folk na klasipikasyon ng mga lupa, katubigan, at mga uri ng halaman. Kapag ang pagtuturo ay inihahatid sa Cebuano, ang naunang kaalamang ito ay agad na naa-access bilang isang kognitibong scaffold; kapag inihahatid sa Filipino o Ingles, ang mga mag-aaral ay kailangang pamahalaan nang sabay ang pagkuha ng nilalaman at pagsalin ng wika (Orbeta & Villanueva, 2022; Moschkovich, 2012).

Ang mga sistematikong hadlang na lumitaw sa kwalitatibong strand—pinakamakapangyarihan, ang halos kawalan ng mga materyal sa pagtuturo ng Agham Pangkalikasan sa wikang Cebuano sa antas tersyarya—ay kumakatawan sa pinaka-maitatrabahong target para sa interbensyon ng institusyon at patakaran. Ang CHED, mga tanggapan ng pananaliksik ng unibersidad, at mga propesyonal na organisasyon ng agham pangkalikasan ay nasa magandang posisyon upang manguna sa kolaboratibo, na-validate ng komunidad na pagbuo ng mga materyal sa pagkatuto ng Agham Pangkalikasan sa wikang Cebuano na maaaring makinabang sa mga institusyon sa buong Visayas at Mindanao.

## CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

This study provides robust quasi-experimental evidence that mother tongue (Cebuano) instruction in Environmental Science significantly enhances the conceptual understanding and academic performance of first-year college students in Cebu compared with Filipino-medium and bilingual code-switching instruction. The advantage of Mother Tongue instruction is most pronounced at higher cognitive levels—applying, analyzing, evaluating, and creating—suggesting that instructional language mediates not merely surface-level comprehension but the quality of environmental science reasoning, including the complex, culturally embedded ecological thinking that distinguishes genuine environmental literacy from rote factual knowledge. The qualitative evidence further reveals that Cebuano instruction enables students to leverage their vernacular ecological knowledge as a learning bridge, strengthens affective investment in environmental issues, and facilitates deeper student-instructor interaction. At the same time, the near-total absence of Cebuano Environmental Science instructional materials at the tertiary level remains a critical structural barrier that constrains the full realization of these pedagogical benefits.

### Mga Konklusyon

Ang pag-aaral na ito ay nagbibigay ng matibay na quasi-experimental na ebidensya na ang pagtuturo sa wikang ina (Cebuano) sa Agham Pangkalikasan ay makabuluhang nagpapahusay ng konseptwal na pag-unawa at akademikong pagganap ng mga unang-taon na kolehiyong mag-aaral sa Cebu kumpara sa pagtuturo sa Filipino at bilinggwal na code-switching. Ang kalamangan ng pagtuturo sa Wikang Ina ay pinakamalinaw sa mas mataas na antas ng pag-iisip—pag-apply, pagsusuri, pagtatasa, at paglikha—na nagpapahiwatig na ang midyum ng pagtuturo ay nagpapamagitan hindi lamang sa mababaw na pag-unawa kundi sa kalidad ng pangangatuwiran sa agham pangkalikasan, kabilang ang kumplikado, kultural na naka-embed na ekolohikal na pag-iisip na nagpapakilala ng tunay na environmental literacy mula sa pag-aaral ng mga katotohanan nang walang pag-unawa. Ang kwalitatibong ebidensya ay nagpapakita pa na ang pagtuturo sa Cebuano ay nagbibigay-kakayahan sa mga mag-aaral na gamitin ang kanilang katutubong ekolohikal na kaalaman bilang isang learning bridge, nagpapatibay ng affektibong pamumuhunan sa mga isyung pangkalikasan, at nagpapadali ng mas malalim na interaksyon sa pagitan ng mag-aaral at guro.

### Recommendations

First, CHED and state universities in Cebuano-speaking regions should invest in collaborative, community-validated development of Cebuano Environmental Science instructional materials for tertiary programs, prioritizing resources that integrate traditional ecological knowledge with formal scientific content. Second, university faculty development programs should include training on mother tongue-responsive pedagogy and translanguaging strategies for Environmental Science instructors, equipping them to leverage students' vernacular ecological knowledge systematically rather than improvisationally. Third, Environmental Science curriculum committees



should examine and revise language-of-instruction policies in light of this evidence, considering the extension of structured mother tongue and bilingual approaches to at least the first year of study. Fourth, structured code-switching should be formally recognized as a research-validated pedagogical strategy for tertiary Environmental Science, providing instructors with institutional authorization to employ it even in predominantly Filipino- or English-medium programs. Fifth, future research should examine the long-term effects of mother tongue Environmental Science instruction on environmental stewardship behavior, career outcomes, and community-engaged conservation practice among college graduates.

### **Mga Rekomendasyon**

Una, ang CHED at mga state university sa mga rehiyong nagsasalita ng Cebuano ay dapat mag-invest sa kolaboratibo, na-validate ng komunidad na pagbuo ng mga materyal sa pagtuturo ng Agham Pangkalikasan sa wikang Cebuano para sa mga terteraryang programa, na inuuna ang mga mapagkukunan na nag-iintegrate ng tradisyonal na ekolohikal na kaalaman sa pormal na siyentipikong nilalaman. Pangalawa, ang mga programang pag-unlad ng faculty ng unibersidad ay dapat magsama ng pagsasanay sa pedagohiya na tumutugon sa wikang ina at mga estratehiya sa translanguaging para sa mga guro ng Agham Pangkalikasan. Pangatlo, ang mga komite sa kurikulum ng Agham Pangkalikasan ay dapat suriin at baguhin ang mga patakaran sa midyum ng pagtuturo sa liwanag ng ebidensyang ito, isinasaalang-alang ang pagpapalawak ng mga naka-istruktura na diskarte sa wikang ina at bilinggwal sa kahit man lamang ang unang taon ng pag-aaral. Pang-apat, ang structured code-switching ay dapat opisyal na kilalanin bilang isang research-validated na pedagogikal na estratehiya para sa terteraryang Agham Pangkalikasan. Panglima, ang mga susunod na pananaliksik ay dapat suriin ang pangmatagalang epekto ng pagtuturo ng Agham Pangkalikasan sa wikang ina sa gawi ng pangangalaga ng kalikasan, mga kinalabasan sa karera, at pagsali sa konserbasyon ng mga nagtapos sa kolehiyo.

### **REFERENCES**

- Aclan, M. M., & Azcarraga, A. P. (2018). Implementing mother tongue-based multilingual education (MTB-MLE) in the Philippines: Barriers and challenges. *Asia Pacific Journal of Multidisciplinary Research*, 6(2), 1–10.
- Adesope, O. O., Lavin, T., Thompson, T., & Ungerleider, C. (2010). A systematic review and meta-analysis of the cognitive correlates of bilingualism. *Review of Educational Research*, 80(2), 207–245. <https://doi.org/10.3102/0034654310368803>
- Aguilar, J. D., & Rodolfo, M. C. (2020). Science comprehension in mother tongue instruction: A comparative study in Cebuano-speaking regions. *Philippine Journal of Science Education*, 13(1), 45–62.
- Ain, N. Z. N., Ibrahim, N., & Yunus, M. M. (2022). The role of the first language in science concept acquisition among tertiary learners. *International Journal of Learning, Teaching and Educational Research*, 21(4), 76–91. <https://doi.org/10.26803/ijlter.21.4.5>
- Alieto, E. O. (2018). Language shift from English to mother tongue: Exploring language attitude and willingness to teach among pre-service teachers. *TESOL International Journal*, 13(2), 1–13.
- Baker, C. (2011). *Foundations of bilingual education and bilingualism* (5th ed.). Multilingual Matters.
- Bernardo, A. B. I. (2018). Language policy and language learning: The case of Filipino learners of science and mathematics. *Educational Research for Policy and Practice*, 17(3), 193–208. <https://doi.org/10.1007/s10671-018-9230-z>



- Benson, C. (2004). The importance of mother tongue-based schooling for educational quality. Background paper for EFA Global Monitoring Report 2005. UNESCO.
- Beson, R. L., & Nuñez, D. P. (2021). Vocabulary acquisition in Filipino-medium science classrooms at the tertiary level: A mixed-methods analysis. *Asia-Pacific Education Researcher*, 30(5), 387–399. <https://doi.org/10.1007/s40299-021-00580-1>
- Canagarajah, S., & Liyanage, I. (2012). Lessons from pre-colonial multilingualism. In M. Martin-Jones, A. Blackledge, & A. Creese (Eds.), *The Routledge handbook of multilingualism* (pp. 49–65). Routledge.
- Canilao, M. L. E., & Saludadez, J. A. (2016). Mother tongue policy and science teaching in Philippine schools. *Journal of Multilingual and Multicultural Development*, 37(6), 553–566. <https://doi.org/10.1080/01434632.2015.1105125>
- Cenoz, J. (2015). Content-based instruction and content and language integrated learning: The same or different? *Language, Culture and Curriculum*, 28(1), 8–24. <https://doi.org/10.1080/07908318.2014.1000922>
- Cummins, J. (2000). Language, power and pedagogy: Bilingual children in the crossfire. *Multilingual Matters*.
- Cummins, J. (2007). Rethinking monolingual instructional strategies in multilingual classrooms. *Canadian Journal of Applied Linguistics*, 10(2), 221–240.
- Cummins, J., & Swain, M. (1986). *Bilingualism in education: Aspects of theory, research and practice*. Longman.
- De Leon, M. V., & Macaraeg, R. T. (2021). Environmental science conceptual understanding among Filipino college students: The role of language of instruction. *Journal of Environmental Education*, 52(4), 241–257. <https://doi.org/10.1080/00958964.2021.1912210>
- Department of Education. (2012). Department Order No. 16, s. 2012: Guidelines on the implementation of the Mother Tongue-Based Multilingual Education (MTB-MLE). Republic of the Philippines.
- Espinosa, A. A., & Buenaflor, L. G. (2019). Science process skills development using contextualized mother tongue lessons. *Journal of Science Education in the Philippines*, 8(1), 12–27.
- Fakeye, D. O. (2010). Students' personal variables as correlates of academic achievement in English as a second language in Nigeria. *Journal of Social Sciences*, 22(3), 205–211. <https://doi.org/10.1080/09718923.2010.11892803>
- Garcia, O., & Wei, L. (2014). *Translanguaging: Language, bilingualism and education*. Palgrave Macmillan.
- Gibbons, P. (2009). English learners, academic literacy, and thinking: Learning in the challenge zone. Heinemann.
- Gonzalez, A. (1998). The language planning situation in the Philippines. *Journal of Multilingual and Multicultural Development*, 19(5–6), 487–525. <https://doi.org/10.1080/01434639808666365>
- Gupta, A. F. (2012). The pragmatics of code switching in multilingual science classrooms in South and Southeast Asia. *Language and Education*, 26(4), 315–330.
- Haig, Y., & Oliver, R. (2003). Language variation and education: Teachers' perceptions. *Language and Education*, 17(4), 266–280. <https://doi.org/10.1080/09500780308666854>
- Hovens, M. (2002). Bilingual education in West Africa: Does it work? *International Journal of Bilingual Education and Bilingualism*, 5(5), 249–266. <https://doi.org/10.1080/13670050208667760>
- Kioko, A., Mutiga, J., Muthwii, M., Schroeder, L., Uchida, E., & Njoroge, R. (2014). Language of instruction: Making the right choices. UNESCO-IBE.



- Lantolf, J. P., & Thorne, S. L. (2006). *Sociocultural theory and the genesis of second language development*. Oxford University Press.
- Lin, A. M. Y. (2015). Conceptualising the potential role of L1 in CLIL. *Language, Culture and Curriculum*, 28(1), 74–89. <https://doi.org/10.1080/07908318.2014.1000926>
- Malone, S. (2007). *MLE program planning: How to develop an education program using local languages*. Summer Institute of Linguistics.
- Menken, K., & Garcia, O. (Eds.). (2010). *Negotiating language policies in schools: Educators as policymakers*. Routledge.
- Metila, R. A., Pradilla, L. A. S., & Williams, A. (2016). The challenge of implementing mother tongue education in linguistically diverse contexts: The case of the Philippines. *Asia-Pacific Education Researcher*, 25(5–6), 781–789. <https://doi.org/10.1007/s40299-016-0310-5>
- Moschkovich, J. N. (2012). *Mathematics, the Common Core, and language: Recommendations for mathematics instruction for ELs aligned with the Common Core*. Understanding Language Conference, Stanford University.
- Nolasco, R. M. D. (2008). The prospects of multilingual education and literacy in the Philippines. In A. E. Maguire & C. A. Gardner (Eds.), *Optimizing schooling for second language learners* (pp. 53–72). Information Age Publishing.
- Orbeta, C. P., & Villanueva, R. D. (2022). Language of instruction and environmental literacy in Philippine higher education: Evidence from tertiary environmental science courses. *Asia Pacific Journal of Education*, 42(3), 512–529. <https://doi.org/10.1080/02188791.2022.2051234>
- Pascua, V. L., & Ereñeta, M. A. (2021). Filipino as medium of instruction in Science: Effects on conceptual understanding and science attitude. *Philippine Normal University Research Journal*, 22(1), 88–104.
- Pinnock, H. (2009). *Language and education: The missing link*. CfBT Education Trust and Save the Children Alliance.
- Ricafort, R. O., & Yap, M. J. (2022). Science achievement and language of instruction: Evidence from Philippine higher education assessments. *Philippine Journal of Education*, 101(1), 34–51.
- Santos, G. P., & Bernabe, R. C. (2023). Code-switching strategies in Filipino science instructors: A qualitative inquiry in urban higher education institutions. *International Journal of Multilingualism*, 20(2), 198–215. <https://doi.org/10.1080/14790718.2022.2043781>
- Skutnabb-Kangas, T. (2000). *Linguistic genocide in education—or worldwide diversity and human rights?* Lawrence Erlbaum Associates.
- UNESCO. (2016). *If you don't understand, how can you learn? Global Education Monitoring Report Policy Paper 24*. UNESCO Publishing.