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Teaching Beyond Disciplines and Borders: A Medicine-Engineering COIL Project between Mexico and Colombia Advancing SDG 3 through Technological and Cultural Innovation

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ABSTRACT: *This study presents a longitudinal exploration of a Collaborative Online International Learning (COIL) initiative between Tecnológico de Monterrey (Medicine, Mexico) and Universidad Católica de Colombia (Engineering, Colombia). Across three semesters (2022–2023), 213 students and three faculty members cocreated mobile health applications addressing chronic kidney disease awareness, with each edition presenting distinct challenges: foundational collaboration (n=43), large-scale rotating cohort coordination (n=100), and metaverse-enhanced learning (n=77). The collaboration produced eleven Android applications on the Google Play Store, contributing to Sustainable Development Goal 3. Graduate surveys revealed high competency development perceptions ($M = 4.75/5.0$) in intercultural communication, interdisciplinary collaboration, and professional preparation. Qualitative analysis revealed themes such as communication adaptation, medical domain understanding, and cross-cultural collaboration capabilities. Implementation challenges included asymmetric participation ratios and faculty workload sustainability. This study addresses a literature gap that intersects COIL methodology, software development education, and health-focused interdisciplinary collaboration, demonstrating that medical-engineering COIL can produce deployable solutions while developing intercultural competencies—contingent upon faculty commitment and structural equity.*

Keywords: Android Development, COIL, Chronic Kidney Disease, Global Citizenship, Intercultural Competence, Interdisciplinary Collaboration,

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INTRODUCTION

The integration of medical and engineering disciplines has emerged as a critical paradigm for addressing contemporary health challenges, particularly in developing countries where resource constraints demand innovative technological solutions (Varpio & Macleod, 2020). This interdisciplinary convergence becomes particularly relevant when addressing chronic diseases that require both medical expertise and technological accessibility for effective public health education (Hosseini et al., 2024). Chronic kidney disease (CKD), which affects approximately 850 million people globally, with prevalence rates reaching 14% in low- and middle-income countries compared with 10% in high-income nations (Infante et al., 2023), exemplifies a condition in which mobile health (mHealth) interventions could significantly increase awareness and early detection, particularly in underserved populations in which traditional healthcare infrastructure remains limited.

Parallel to these healthcare challenges, higher education institutions have increasingly embraced internationalization strategies that prepare students for an interconnected global workforce. Collaborative Online International Learning (COIL), initially developed by the State University of New York and subsequently refined by scholars globally, has emerged as a transformative pedagogical approach that enables meaningful cross-cultural collaboration without physical mobility (Hong et al., 2025). Recent systematic reviews demonstrate COIL's effectiveness in developing intercultural competencies, with Hackett et al. (2023) documenting significant improvements in students' global awareness and collaborative problem-solving abilities, while (Appiah-Kubi & Annan, 2020) emphasize how virtual exchange models, including COIL, have become essential alternatives for developing intercultural competencies post pandemic. This aligns with what Mareye (2025) describes as “international mindedness”—a critical attribute for professionals navigating multicultural environments.

Furthermore, the intersection of interdisciplinary collaboration between medicine and engineering within COIL frameworks presents unique pedagogical challenges that remain underexplored in the literature (Dekkers et al., 2022). While previous studies have examined COIL implementation in singular

disciplines, the specific dynamics of medicine-engineering collaboration through international online learning represent a significant gap (Munoz-Escalona et al., 2022). This gap becomes particularly pronounced when the development of soft skills alongside technical competencies is considered, as the contemporary international education landscape requires not only disciplinary knowledge but also the cultivation of empathy, cultural sensitivity, and collaborative capabilities that transcend traditional academic boundaries (De Regil Sanchez et al., 2024). The present study explores the longitudinal implementation of a COIL initiative between Tecnológico de Monterrey's School of Medicine (Mexico) and Universidad Católica de Colombia's Computing and Systems Engineering program, which was conducted across three consecutive semesters from 2022 to 2023. A total of 213 students and three faculty members participated: two from medicine and one from engineering. Each edition posed distinct pedagogical challenges: 43 students in the first edition engaged in foundational cross-disciplinary collaboration; 100 in the second edition addressed large-scale coordination with rotating medical cohorts; and 77 in the third edition explored immersive learning through metaverse technologies. The collaboration resulted in eleven Android applications published on the Google Play Store, addressing CKD awareness and prevention.

This exploratory case study examines the following questions: How do engineering graduates perceive the impact of interdisciplinary international collaboration on their professional development? What implementation challenges emerge across multiple program iterations with varying scale and technological complexity? What technological outcomes result from sustained medicine-engineering collaboration? This approach aligns with recent calls for nuanced understanding of international student experiences, documenting how students from two distinct professional cultures—the patient-centered approach of medicine and the solution-oriented methodology of engineering—negotiate meaning and create shared understanding while developing practical mHealth solutions (Cuevas Álvarez et al., 2025).

The significance of this work extends beyond the immediate educational context. From a practical perspective, the eleven Android applications developed and published on the Google Play Store demonstrate how student collaboration can produce tangible contributions to public health education, directly supporting Sustainable Development Goal 3 (Good Health and Well-being). These applications, focused on CKD awareness and prevention, represent authentic learning artifacts that bridge academic exercises with real-world impact. Furthermore, the study provides insights for institutions seeking sustainable internationalization strategies that minimize environmental impact while maximizing intercultural learning opportunities (Stange & Stange, 2020).

By documenting the evolution of this collaboration across three distinct iterations—each with unique challenges related to scale, technology integration, and pedagogical approach—this study offers practical guidance for educators attempting similar interdisciplinary international partnerships. The findings emphasize particularly how soft skills development, often overlooked in technical

disciplines, becomes central to project success and student satisfaction in cross-cultural collaborative environments.

LITERATURE REVIEW

Bibliometric analysis of collaborative international learning and mobile development literature reveals five distinct thematic clusters with limited connectivity between mobile software development and health-focused interdisciplinary education (**Error! Reference source not found.**). Using VOSviewer software, this analysis examined 26 studies published between 2020 and 2025 and revealed the following clusters: (1) COIL methodology and virtual exchange practices, (2) software engineering education and agile methodologies, (3) intercultural competency development, (4) mobile application development technologies, and (5) health technology and SDG-focused education. Visualization reveals that while these domains are individually well established, their integration remains underexplored (Bahroun et al., 2023). Notably, medical collaboration appears in the peripheral position within the broader development methodology cluster, highlighting significant gaps at the intersection of engineering education, international collaboration, and healthcare applications. This peripheral positioning reflects the limited research connecting interdisciplinary medical-engineering work with COIL frameworks—precisely the gap this study addresses (Dekkers et al., 2022).

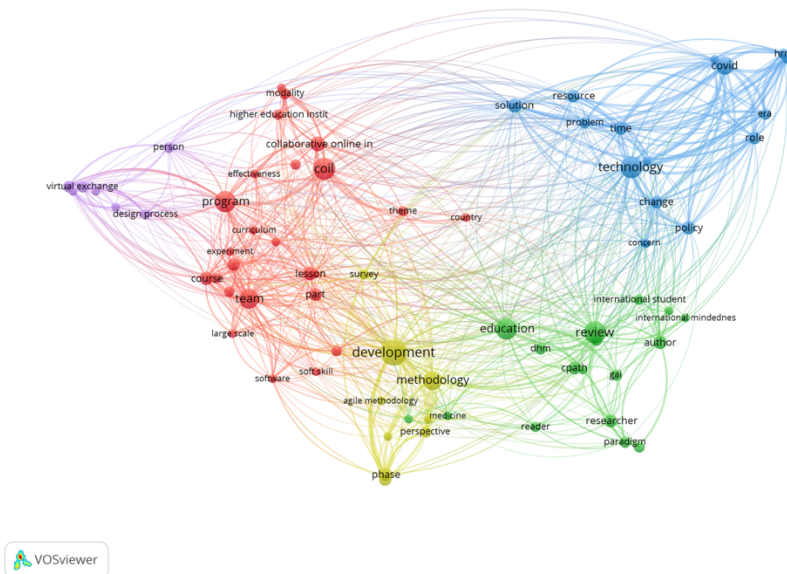


Figure 1: Keyword co-occurrence network of collaborative international learning and mobile development literature (n=26, 2020–2025).

Collaborative Online International Learning in Engineering Education

The evolution of COIL in engineering education clearly progresses from pandemic-driven necessity to pedagogical innovation (Appiah-Kubi & Annan, 2020). Early implementations (2020–2021) primarily positioned COIL as a cost-effective alternative to traditional study abroad programs, addressing mobility restrictions exacerbated by COVID-19 (Appiah-Kubi & Annan, 2020; Walter et al., 2021). However, recent studies reveal COIL's emergence as a sophisticated pedagogical framework specifically designed to develop the intercultural competencies essential for global engineering practice (Vaquerizo et al., 2025).

These findings align with longitudinal analyses of engineering COIL programs that reveal careful preplanning between faculty, balanced team composition, and unified communication platforms as critical success factors that evolve across program iterations (Vaquerizo et al., 2025).

The competency development outcomes show remarkable consistency across diverse engineering disciplines. Studies consistently report enhanced intercultural communication, global citizenship awareness, and adaptability as primary learning outcomes (De Regil Sanchez et al., 2024; Katz et al., 2024). However, a significant contradiction emerges regarding the relative effectiveness of virtual versus hybrid modalities. Katz et al. (2024) reported that compared with purely virtual COIL, COIL+ programs (combining virtual collaboration with short-term travel) generated deeper cultural understanding and stronger professional aspirations. This contradicts De Regil Sanchez et al. (2024), who reported equivalent learning outcomes between face-to-face and virtual modalities, with COIL offering superior accessibility advantages.

Assessment methodologies reveal limitations in measuring long-term impact (Walter et al., 2021). While most studies employ pre-post survey designs with Likert scales to measure perceived competency development, few address the challenge of validating these perceptions against actual professional performance (Katz et al., 2024). Response rates as low as 26% suggest potential selection bias toward globally minded students. The temporal gap between educational intervention and professional application remains largely unaddressed in the current literature (Cuevas Álvarez et al., 2025).

Industry-Aligned Software Development in Educational Settings

Software engineering education has undergone a significant transformation toward industry alignment, with Agile methodologies, particularly Scrum, becoming the dominant pedagogical frameworks (Tolhoek et al., 2025). Analysis of implementation patterns reveals that 84% of surveyed academic programs now employ agile approaches, with Scrum achieving 56% adoption rates across institutions (Al-Rabaiah & Medina-Medina, 2021). This shift represents more than methodological preference; it reflects the fundamental recognition that traditional academic project scales inadequately prepare students for industry complexity (Li et al., 2023).

The emphasis on real-world deployment experiences marked a critical evolution in software engineering pedagogy (Chatley & Procaccini, 2020). Programs increasingly require production-level deployment rather than prototype development, with students utilizing cloud platforms, continuous integration pipelines, and automated testing frameworks that mirror professional environments. Imperial College London's requirement for public deployment via platforms such as Heroku exemplifies this trend, forcing students to confront operational challenges rarely encountered in traditional academic settings (Chatley & Procaccini, 2020).

However, a persistent gap exists between technical skill development and professional competency preparation (Li et al., 2023). While students demonstrate proficiency in programming languages, frameworks, and development tools, employers consistently identify deficiencies in soft skills, particularly communication, team coordination, and knowledge management (Quek et al., 2023). Large-scale team experiments reveal that technical implementation constitutes the least challenging aspect of software engineering education, with inter-team coordination, requirement negotiation, and conflict resolution emerging as primary learning obstacles (Li et al., 2023).

The integration of DevOps practices from introductory courses represents an important pedagogical innovation, yet implementation remains inconsistent (Chatley & Procaccini, 2020). While some programs successfully integrate CI/CD pipelines and containerization technologies, others continue treating these as advanced topics (Tolhoek et al., 2025). This inconsistency creates graduates with variable operational readiness, potentially explaining industry complaints about entry-level engineer preparedness (Al-Rabaiah & Medina-Medina, 2021).

Interdisciplinary Collaboration Framework and Communication Protocols

Engineering–medical collaboration in educational settings involves sophisticated communication protocols that transcend traditional disciplinary boundaries (Infante et al., 2023). Successful interdisciplinary projects consistently employ role-based frameworks in which medical professionals function as “product owners” or “clients”, defining clinical requirements, while engineering teams serve as “development teams”, implementing technical solutions (Infante et al., 2023). This structure, exemplified in mobile health application development projects, creates shared vocabulary centered on deliverable outcomes rather than disciplinary expertise (Indika et al., 2025).

The development of common languages emerges as a critical success factor, requiring conscious effort from both disciplines to minimize technical jargon and cultural assumptions (Varpio & Macleod, 2020). Medical collaborators must articulate clinical needs without assuming engineering knowledge of healthcare workflows, whereas engineering teams must explain technical constraints without relying on computer science terminology (Varpio & Macleod, 2020). This bilateral translation process appears essential for productive collaboration but requires explicit training that current curricula rarely provide (Hosseini et al., 2024).

Knowledge integration methodologies clearly demonstrate a preference for iterative, agile-inspired approaches that parallel software development best practices (Al-Rabaiah & Medina-Medina, 2021). Domain input provides content validation and relevance verification, whereas engineering expertise determines technical feasibility and implementation approaches (Infante et al., 2023). However, this division of labor creates potential conflicts when medical requirements exceed technical capabilities or when engineering solutions lack practical utility (Hosseini et al., 2024).

The “multidisciplinary edge effect” emerges as a particularly generative phenomenon when different scientific paradigms intersect (Varpio & Macleod, 2020). The emphasis of medical education on evidence-based practice and objective measurement contrasts with the focus of engineering on optimization and systematic problem-solving (Demirel et al., 2022). While these paradigmatic differences can create productive tension leading to innovative solutions, they also generate fundamental conflicts about what constitutes valid evidence and appropriate problem-solving approaches (Varpio & Macleod, 2020).

Assessment of interdisciplinary learning outcomes reveals significant methodological challenges (Hosseini et al., 2024). Traditional disciplinary metrics inadequately capture the complexity of interdisciplinary competency development (Dekkers et al., 2022). Projects producing functional mobile applications for global health challenges demonstrate tangible integration success, yet measuring the depth of cross-disciplinary understanding remains problematic (Indika et al., 2025). Current approaches rely heavily on student self-reports and faculty observations, neither of which provide reliable indicators of sustainable interdisciplinary capability (Pombo & Santos, 2023).

The gap between educational collaboration and real-world implementation through engineering applications represents a persistent challenge (Pombo & Santos, 2023). While student projects often produce technically sophisticated prototypes addressing SDG-related challenges, translation to practice faces regulatory, institutional, and adoption barriers that educational settings cannot adequately simulate (Ulnicane et al., 2021). This limitation raises questions about the authenticity of interdisciplinary learning experiences that remain isolated from real-world implementation contexts (Infante et al., 2023).

RESEARCH METHODOLOGY

Research Design

This study employs a descriptive multiple case study approach (Yin, 2018) to explore and document the implementation and graduate outcomes of a medicine-engineering COIL program across three consecutive iterations. The methodology emphasizes a narrative description of lived experiences rather than experimental hypothesis testing, aligning with the exploratory nature of this novel educational integration (Patton, 2015). Each program edition constitutes a distinct case within the broader phenomenon of interdisciplinary international collaboration in engineering education.

Multiple Case Structures

The study examines three sequential program editions, which have an engineering view from the mobile development area, broadcasting information through Android application development, as interconnected cases, each presenting distinct pedagogical challenges and collaborative dynamics:

Case 1 (First Edition): Foundational cross-disciplinary collaboration with 43 students to establish initial communication protocols and workflow integration between engineering and medical teams.

Case 2 (Second Edition): Large-scale coordination challenges with 100 students addressing scalability issues and rotating medical cohort management.

Case 3 (Third Edition): Technology-enhanced collaboration with 77 students exploring immersive learning through metaverse technologies and advanced mobile development frameworks.

This sequential case design allows the examination of program evolution while maintaining a focus on consistent outcomes: mobile health application development and intercultural competency development among engineering participants.

Participants and Sampling

Target population and scope justification

The study focuses specifically on engineering students (currently titled engineers) from Universidad Católica de Colombia who participated in the COIL program between 2022-2 and 2023-2. This engineering-only focus reflects three methodological considerations: (1) the researcher's institutional affiliation and direct access to engineering graduates for postgraduate follow-up; (2) the study's primary interest in understanding how software development education integrates with international health collaboration; and (3) practical constraints where medical student outcomes fall under separate institutional review processes at Tecnológico de Monterrey. While this scope limits the bidirectional analysis of the collaboration, it provides depth in understanding engineering graduates' professional development trajectories—an underexplored perspective in the COIL literature that predominantly examines medical or health sciences students.

All participants were enrolled in Android development coursework and collaborated with medical students from Tecnológico de Monterrey in one of the three program editions.

Sample Characteristics

Total COIL participants: 213 students across three editions

Engineering focus group: Twenty-five students from Universidad Católica de Colombia

Survey respondents: 8 engineering graduates (32% response rate)

Sampling strategy: Purposive sampling of engineering graduates accessible for postgraduate follow-up (Palinkas et al., 2015).

The 32% response rate from engineering graduates reflects the inherent challenges of longitudinal educational research with mobile populations. With respect to descriptive case study methodology, this response rate provides sufficient depth to capture the range of graduate experience while acknowledging the limitations of generalizable claims (Vasileiou et al., 2018).

Data collection procedures

Primary Data Sources

Postgraduation Survey: A structured questionnaire was administered to engineering graduates 12–24 months after program completion to measure the perceived impact on professional development, intercultural competencies, and technical skills application. The survey employed Likert-scale responses (1–5) for quantitative indicators and open-ended questions for experiential narratives. Survey items were administered in Spanish, the native language of all engineering participants.

Digital Artifacts: Documentation and analysis of 11 Android applications published on Google Play Store across the three program editions, representing tangible collaborative outcomes and real-world deployment success.

Program Documentation: Institutional records, faculty reflections, and pedagogical materials from each edition, providing evidence of the evolution of context and implementation.

Data Analysis Approach

Methodological triangulation is employed in this study, combining quantitative survey responses, qualitative narrative analysis, and artifact examination to provide a comprehensive understanding of program impact (Patton, 2015). Thematic analysis of open-ended survey responses identifies patterns in graduate experiences, while descriptive statistics summarize Likert-scale responses. Mobile applications were published in each edition, along with the functional complexity and evidence of interdisciplinary content integration.

RESULTS

This section presents the findings from a descriptive multiple case study of three COIL editions, graduate survey responses (n=8), and an analysis of mobile application artifacts. The results are organized and presented chronologically by edition, followed by graduate perceptions and technological outcomes.

Program Implementation: Three COIL editions

First edition (2022-2): Foundational Cross-Disciplinary Collaboration

Total Participants: 43 students

Universidad Católica de Colombia (Engineering): 8 students with 1 teacher.

Tecnológico de Monterrey (Medicine): 35 students with 2 teachers.

Courses: Programming for Android Devices (Engineering) and Kidney Disorders (Medicine)

Pedagogical context and challenges: This inaugural edition represented the first collaboration between the lead faculty members, requiring extensive planning to accommodate the distinct curricular structures of both institutions. A critical structural challenge emerged from the pedagogical organization at Tecnológico de Monterrey: while Universidad Católica de Colombia maintained a single engineering cohort throughout the semester, Monterrey's medical program divided the same course across three sequential groups called “blocks” within a single semester.

To provide engineering students with sufficient time for mobile development tool mastery, the collaboration strategically paired the Colombian engineering cohort with Monterrey's third and final medical block. This decision proved fortuitous—medical students from the first and second blocks, upon observing the collaborative outcomes achieved by their peers in the final block, approached faculty leadership requesting inclusion in subsequent iterations. This unsolicited student demand validated the program's value proposition and influenced planning for future editions.

A significant milestone occurred when faculty leaders met in person at Tecnológico de Monterrey to plan the second edition, enabling face-to-face refinement of pedagogical strategies on the basis of first-edition insights. This in-person coordination proved essential for developing the complex rotating cohort model implemented in subsequent editions.

Developed Mobile Applications:

Nefrocare

Renis

Diamel

Hiperinfo

Key Outcomes: Established foundational collaboration protocols, validated student interest in international interdisciplinary learning, and created replicable workflows for subsequent editions.

Second edition (2023-1) Large-Scale Coordination

Total Participants: 100 students

Universidad Católica de Colombia (Engineering): 7 students with 1 faculty member.

Tecnológico de Monterrey (Medicine): 93 students with 2 faculty members.

Courses: Programming for Android Devices (Engineering) and Metabolic and Endocrine Disorders (Medicine)

Pedagogical Context and Challenges: In response to the strong student demand from the first edition, this iteration expanded the collaboration to include all three medical blocks at Tecnológico de Monterrey, creating unprecedented

coordination complexity. The planning phase proved particularly demanding as faculty developed strategies to manage continuous input from three sequential medical cohorts contributing to the same mobile application development projects.

The operational model required engineering students to engage iteratively with rotating medical teams: Each medical block contributed requirements and feedback before transitioning to the next block, which then joined the ongoing development process. This structure provided engineering students with extended time for requirement definition and feature negotiation but presented significant challenges in managing the product owner role, with 93 medical students functioning as clients across three distinct time periods.

The rotating cohort structure necessitated creative pedagogical adaptations. Engineering students repeated the icebreaker and reflection activities three times, prompting the faculty to diversify topics to maintain engagement: the first icebreaker invited participants to share favorite desserts, the second showcased beloved locations from each country, and the third featured popular singers from Colombia and Mexico. This repetition, while challenging, deepened cross-cultural understanding through multiple interaction opportunities.

Developed Mobile Applications:

Diabett

Dislipidemias App

Meta

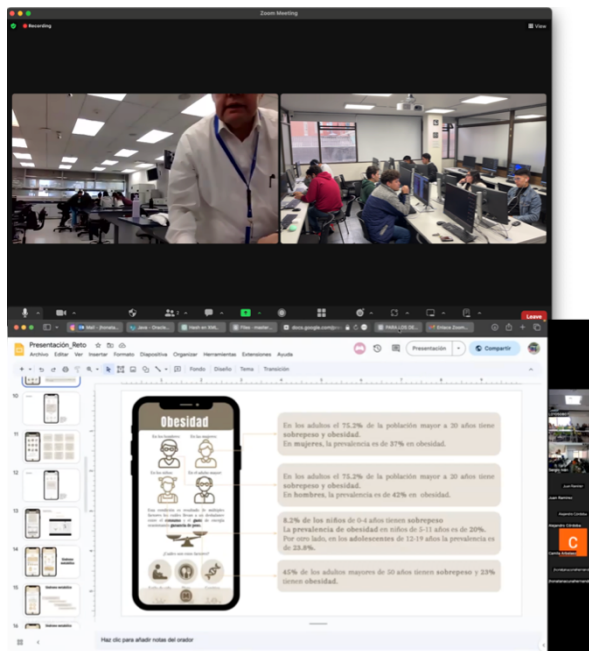


Figure 2: Collage with memories of the second edition. By Author

Key Outcomes: Demonstrated scalability potential while revealing coordination limits; refined communication protocols for large, distributed teams; and established repeatable strategies for rotating cohort management.

Third edition (2023-2) Technology-Enhanced Immersive Collaboration

Total Participants: 77 students

Universidad Católica de Colombia (Engineering): 8 students with 1 teacher.

Tecnológico de Monterrey (Medicine): 69 students with 2 teachers.

Courses: Programming for Android Devices (Engineering) and Kidney Disorders (Medicine)

Pedagogical context and challenges: Building on lessons from the second edition's three-block coordination challenges, this iteration strategically engaged medical students beginning with the second block, balancing workload distribution more effectively. The defining innovation was the integration of Tecnológico de Monterrey's academic metaverse platform, introducing immersive virtual collaboration capabilities unprecedented in prior editions.

The metaverse environment unlocked novel pedagogical affordances: virtual theaters for presentations, customizable virtual classrooms for collaborative sessions, and even virtual concerts for cultural exchange. Colombian engineering students experienced a virtual presence in Mexico upon logging into the platform, creating symbolic international mobility. Students created and customized personal avatars, explored the virtual campus and conducted team meetings within these immersive spaces.

Synchronous activities—including icebreakers, requirement gathering sessions, and design reviews—occurred within the metaverse, transforming the collaboration from video-conference-mediated to spatially embodied virtual interaction. This technological enhancement both enriched the collaborative experience and introduced new learning curves as students adapted to avatar-based communication and virtual environment navigation.

Developed Mobile Applications:

DiabeBot
RenalLife Plus
Kidney
Ercapp



**Figure 3: Collage with metaverse interactions and the Google Play Store.
By Author**

Key Outcomes: Successfully integrating emerging metaverse technology into COIL pedagogy, demonstrating the feasibility of immersive virtual environments for international collaboration, and providing comparative data on traditional videoconference versus embodied virtual collaboration effectiveness.

Graduate Survey Findings

Participant Demographics

Eight engineering graduates from Universidad Católica de Colombia participated in the survey, representing 32% of the engineering participants across the three editions. The respondents graduated between 2022 and 2025 and were surveyed 1–3 years post-graduation. Among the participants, one currently works in mobile development, six have professional experience in international projects, and participation was distributed across program editions: one from 2022–3 (13%), three from 2023–1 (38%), and four from 2023–3 (50%).

Table 1: Descriptive Statistics for Likert Scale Responses. By Author

Competency Area	Mean	SD	Mode
Engineering Problem-Solving	4.88	0.33	5
Awareness			
COIL Modality Effectiveness	4.88	0.33	5
Schedule/Methodology	4.88	0.33	5
Management			
Professional Value in	4.88	0.33	5
Globalized World			
Intercultural Communication	4.75	0.43	5
Adaptation			
Interdisciplinary Perspective	4.75	0.43	5
Understanding			
Multidisciplinary Team	4.75	0.43	5
Effectiveness			
Technology Solution	4.75	0.43	5
Motivation			
Public Health Education	4.63	0.48	5
Contribution			
Cultural Enrichment from	4.63	0.48	5
Mexican Students			
International Projects	4.63	0.50	5
Confidence			
Engineering Problem-Solving	4.88	0.33	5
Awareness			

Note. Scale: 1 = strongly disagree, 5 = strongly agree. Overall mean: 4.75 (SD = 0.43). n = 8 respondents

The quantitative findings reveal exceptionally positive perceptions across all competency areas, with 75% of the responses indicating “Strongly Agree” and 25% indicating “Agree,” with no neutral or negative responses recorded. The highest-rated competencies ($M \geq 4.85$) were engineering problem-solving awareness, COIL modality effectiveness, methodology management, and professional value in a globalized context—all tied at 4.88. While it has the lowest mean (4.50), international project confidence still indicates strong agreement and represents the competency area with the greatest variation among respondents.

Qualitative Findings: Narrative Themes

Analysis of the open-ended responses revealed five primary themes related to graduate experience and professional impact:

Theme 1: Communication Adaptation and Professional Development

Graduates consistently reported developing more precise, professional communication styles when working with medical professionals. Representative

experiences include adapting technical language to be accessible across disciplines and developing structured communication protocols.

"When working with medical students, I noticed that the use of technical terms generated confusion... I adapted my communication using simpler language, relying on visual examples and focusing on the practical functioning of the app." [Original: *"Al trabajar con estudiantes de medicina, noté que el uso de términos técnicos generaba confusión... adapté mi comunicación usando un lenguaje más sencillo, apoyándome en ejemplos visuales y enfocándome en el funcionamiento práctico de la app."*] (Graduate 5)

"Communication in work teams for this type of project became more specific and professional; on many occasions, we had to reduce the amount of chat and focus on specific descriptions." [Original: *"La comunicación en equipos de trabajo para este tipo de proyectos se volvió más específica y profesional, en muchas ocasiones tuvimos que reducir la cantidad de charla y enfocarnos en descripciones específicas."*] (Graduate 7)

Theme 2: Medical domain understanding and health technology awareness

Participants gained significant insights into medical terminology, treatment protocols, and preventive healthcare approaches, particularly regarding chronic kidney disease and diabetes management.

"Owing to this collaboration, I better understood the importance of preventive medical education, especially in chronic diseases such as chronic kidney disease... I learned how medical information directed at patients is organized and communicated." [Original: *"Gracias a esta colaboración, comprendí mejor la importancia de la educación médica preventiva, especialmente en enfermedades crónicas como la enfermedad renal crónica... Aprendí cómo se organiza y comunica la información médica dirigida a pacientes."*] (Graduate 5)

"The medical terms that had to be researched and discussed in the meetings, in addition to learning about the entire medical topic." [Original: *"Los términos médicos que tuvieron que investigarse y que se discutieron en las reuniones, además de que se aprendió de todo ese tema médico."*] (Graduate 7)

Theme 3: Social Impact Perspective and Engineering Responsibility

The experience broadened graduates' understanding of engineering's social responsibilities and potential for addressing real-world health challenges.

"It changed my perspective as an engineer, making me understand that our work should focus on creating solutions that positively impact society." [Original: *"Cambió mi perspectiva como ingeniera, haciéndome entender que nuestro trabajo debe enfocarse en crear soluciones que impacten positivamente en la sociedad."*] (Graduate 5)

"The perspective of engineering as a tool to solve the world's problems personally expanded, and since then I understand how different technology industries work." [Original: *"La perspectiva de la ingeniería como herramienta para resolver los problemas del mundo, personalmente, se amplió y desde*

entonces entiendo como funcionan las distintas industrias de tecnología"]
(Graduate 7)

Theme 4: Technical Skill Development and Industry Alignment

Graduates acquired practical mobile development skills, particularly in Kotlin and Android Studio, while experiencing industry-like client–developer relationships.

"During the collaboration, I learned to develop mobile applications using Kotlin for Android, as well as to implement good practices in user-centered interface design." [Original: "*Durante la colaboración, aprendí a desarrollar aplicaciones móviles utilizando Kotlin para Android, así como a implementar buenas prácticas en diseño de interfaces centradas en el usuario.*"] (Graduate 5)

"Being a client–developer relationship, it improved the approach to how the project was handled; this made it feel like reality, unlike projects managed internally at the university." [Original: "*Al ser un trato de cliente desarrollador, mejoró el enfoque del como se trató el proyecto, esto hizo que se sintiera como en la realidad a diferencia de los proyectos manejados internamente en la universidad.*"] (Graduate 2)

Theme 5: Cross-Cultural Collaboration and International Professional Preparation

Participants developed enhanced capabilities for international teamwork and cultural adaptability, preparing them for globalized professional environments.

"The most motivating thing was working with people from another culture and country, since it was the first time I participated in a project with this dynamic at the university. This multicultural experience made the project more interesting." [Original: "*Lo más motivador fue trabajar con personas de otra cultura y país, ya que fue la primera vez que participaba en un proyecto con esta dinámica en la universidad. Esta experiencia multicultural hizo que el proyecto fuera más interesante*"] (Graduate 5)

Cross-case analysis: Evolutionary patterns

Evolution of the Collaboration Approaches

Comparisons across the three editions reveal systematic improvements in the following:

- Efficacy of the communication protocol
- Team coordination strategies
- Technology integration sophistication
- Medical content accuracy and relevance

Persistent Challenges

Despite evolutionary improvements, certain challenges remained consistent:

- Difficulties in time zone coordination
- Variations in technical skill level
- Medical terminology translation
- Project scope management

DISCUSSION

The current study examined medicine–engineering COIL collaboration across three iterations, revealing exceptionally high graduate perceptions ($M=4.75/5.0$) and eleven deployed mobile health applications. These outcomes must be interpreted through critical eyes and topics.

Faculty dedication and program sustainability

The sustained three-semester collaboration required faculty roles beyond those of typical COIL programs—functioning simultaneously as disciplinary experts, cultural mediators, and technical translators (Vaquerizo et al., 2025). The face-to-face planning meeting in Monterrey following the first edition enabled the complex second-edition design to accommodate three rotating medical blocks, an innovation absent from the single-cohort COIL literature (Munoz-Escalona et al., 2022; Vaquerizo et al., 2025).

However, managing 100 students with three faculty members in the second edition raises sustainability concerns. The willingness to repeat icebreaker activities three times demonstrates adaptive commitment but suggests an unsustainable workload model for institutional scaling. The third edition's strategic decision to begin with the second medical block represents evidence-based refinement, contradicting assumptions that longer collaborations uniformly improve outcomes (De Regil Sanchez et al., 2024).

Future COIL programs must systematically document faculty compensation structures and workload requirements to enable replication beyond enthusiastic early adopters. The study reveals that successful interdisciplinary collaboration depends critically on faculty dedication that current institutional reward systems inadequately recognize.

Technological Mediation: Sophistication versus Effectiveness

The progression from video conferencing through metaverse integration provides comparative data on the role of technology. Notably, COIL effectiveness perceptions remained consistently high ($M \geq 4.85$) across all editions regardless of technological sophistication, suggesting that structured pedagogical design matters more than immersive platforms do (Caneppele et al., 2024). Graduate narratives reveal that fundamental collaboration challenges—vocabulary

translation, requirement negotiation, and time zone coordination—persist across technological environments.

The metaverse’s symbolic international mobility (Colombian students “present” in virtual Mexico) created novel affordances, yet one graduate observed that task-focused collaboration minimized the cultural learning opportunities traditionally emphasized in COIL programs (Cuevas Álvarez et al., 2025). This finding warrants investigation of whether technological sophistication enhances or distracts from intercultural learning objectives.

The eleven applications deployed on the Google Play Store distinguish this program from typical software engineering education, where projects remain academic exercises (Chatley & Procaccini, 2020; Li et al., 2023). Real-world deployment forced students to confront operational challenges—app store policies, accessibility requirements, and medical accuracy standards—that authentically simulated professional practice. However, the apparent lack of significant user adoption mirrors clinical integration challenges in health technology (Hosseini et al., 2024), exposing a critical gap between educational success (application creation) and real-world impact (sustained use).

iOS Platform Expansion

Limiting development to Android excluded significant user populations, particularly those with higher-income demographics where iOS is dominant and health literacy may be higher. Future editions should incorporate iOS development using Swift, creating truly cross-platform health technology ecosystems. This expansion requires the incorporation of these technologies at the core of an assignment as a mandatory course, faculty expertise development, laboratory infrastructure investment, and potential industry partnerships providing development hardware and technical mentorship.

Sustainability and Maintenance Infrastructure

Eleven applications deployed without ongoing maintenance plans represent technical debt and potentially abandoned digital resources. Health information requires continuous updating as medical knowledge evolves; deprecated applications containing outdated treatment information could harm users. Future COIL programs must either (1) establish multisemester maintenance pipelines where subsequent cohorts update predecessors' applications, (2) partner with organizations assuming postdeployment responsibility, or (3) explicitly scope projects as proof-of-concept prototypes not intended for sustained use. The current approach—deploy and abandon—contradicts both software engineering best practices and responsible health technology development.

Institutional Structures: Enablers and Inequities

Program success depended on specific institutional affordances: Universidad Católica's consistent semester-long cohorts, Monterrey's block structure enabling

multiple iterations, and metaverse platform access. These factors were neither universal nor guaranteed but profoundly shaped pedagogical possibilities.

The asymmetric participation (8 Colombian engineering students versus 35-93 Mexican medical students across editions) reveals structural inequality. While positioned as bidirectional collaboration, the reality resembled that of Colombian students serving multiple Mexican cohorts as application developers. The product owner/developer framework, while pedagogically productive for teaching requirements engineering, may inadvertently reinforce disciplinary hierarchies where medicine defines problems and engineering implements solutions. This contradicts the “multidisciplinary edge effect” (Varpio & Macleod, 2020), which requires equal paradigmatic contributions from both disciplines.

Graduate descriptions of “adapting technical approaches to medical requirements” but rarely “adapting medical thinking to engineering possibilities” suggest asymmetric knowledge integration. Without explicit institutional value signals—credit differentiation, transcript notations, employer partnerships, and faculty promotion criteria—COIL risks remaining extracurricular enrichment rather than curricular innovation.

Graduate Development: Beyond Positive Ratings

The 75% “Strongly Agree” responses require critical interpretation. The 32% response rate introduces potential self-selection bias, as satisfied participants respond disproportionately. Without non-COIL comparison groups or preparticipation baselines, attributing competencies specifically to COIL participation remains speculative.

Nevertheless, graduates articulated three substantive impacts. First, they developed “more professional” communication styles for disciplinary boundary crossing—a concrete skill applicable beyond international contexts. Second, they demonstrated an enhanced understanding of engineering’s social responsibilities, exemplified by statements about technology’s “direct impact on quality of life” (De Regil Sanchez et al., 2024). Third, several studies have explicitly connected COIL participation to career decisions, including entrepreneurial ventures and international employment seeking.

The integration of the COIL methodology with industry-aligned development and health-focused collaboration addresses the literature gap identified through VOSviewer analysis. However, scaling beyond enthusiastic faculty to systematic institutional practice requires addressing the structural, resource, and equity challenges this study revealed. In the current case, for the three editions, the Engineering course (Android Development) is an optional course, and it could be considered a good practice because mandatory courses implement other strategies, such as Rozo-Rojas et al. (2018), where the students also show a product or evidence such as *prismatica* (Gutierrez et al., 2024). Educational success should not be conflated with sustainable development contribution without evidence of continued real-world utility.

Implications

Theoretical Implications: This study extends the COIL literature by demonstrating its feasibility

of integrating international virtual exchange with industry-aligned software development and interdisciplinary health collaboration—a previously unexplored intersection. The findings suggest that pedagogical design quality supersedes technological sophistication in determining collaboration effectiveness.

Practical Implications: Institutions considering medicine-engineering COIL partnerships should anticipate asymmetric participation ratios and develop explicit strategies for achieving collaborative parity. Faculty workload models must account for coordination complexity, which increases nonlinearly with increasing participant numbers and rotating cohort structures.

Policy Implications: Universities that claim the contributions of SDGs through student projects require validation mechanisms that extend beyond deployment metrics to demonstrate real-world utility assessment.

CONCLUSION

This longitudinal descriptive case study examined a medicine-engineering COIL program across three consecutive semesters (2022–2023), involving 213 students and three faculty members, resulting in eleven deployed mobile health applications addressing chronic kidney disease awareness. Graduate survey findings demonstrated high competency development perceptions ($M = 4.75/5.0$) across the intercultural communication, interdisciplinary collaboration, and technical skill domains. The study contributes empirical evidence that the COIL methodology can integrate industry-aligned software development practices and interdisciplinary health collaboration, produce deployable technological solutions while develop engineering graduates' intercultural competencies. However, the following critical challenges emerged: asymmetric participation ratios (8 engineering students serving 35–93 medical students), faculty workload sustainability concerns, and the gap between deployment success and demonstrated public health impact. Future programs must address structural equity in collaborative roles, establish validation mechanisms for SDG contribution claims, and develop sustainable maintenance infrastructure for deployed applications. The integration of international collaboration, interdisciplinary problem-solving, and real-world technological deployment demonstrated in this program offers a model for engineering education in globalized contexts—contingent upon institutions committing resources matching faculty dedication, expanding participation toward collaborative parity, and establishing mechanisms ensuring that educational outcomes translate into societal benefit.

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REFERENCES

- Al-Rabaiah, H. A., & Medina-Medina, N. (2021). Agile beeswax: Mobile app development process and empirical study in real environment. *Sustainability (Switzerland)*, 13(4), 1–34. <https://doi.org/10.3390/su13041909>
- Appiah-Kubi, P., & Annan, E. (2020). A review of a collaborative online international learning. *International Journal of Engineering Pedagogy*, 10(1), 109–124. <https://doi.org/10.3991/ijep.v10i1.11678>
- Bahroun, Z., Anane, C., Ahmed, V., & Zacca, A. (2023). Transforming Education: A Comprehensive Review of Generative Artificial Intelligence in Educational Settings through Bibliometric and Content Analysis. *Sustainability (Switzerland)*, 15(17). <https://doi.org/10.3390/su151712983>
- Baker, S. E., & Edwards, R. (2012). *How many qualitative interviews is enough? Expert voices and early career reflections on sampling and cases in qualitative research.*
- Caneppele, F. D. L., Alvarez, J., & De Leon, A. (2024). *Application of the COIL Methodology to Learn About Clean and Affordable Energy in the Metaverse.* <https://doi.org/10.1109/EDUNINE60625.2024.10500463>
- Chatley, R., & Procaccini, I. (2020). *Threading DevOps Practices through a University Software Engineering Programme.* 90–94. <https://doi.org/10.1109/CSEET49119.2020.9206211>
- Cuevas Álvarez, M. C., Pérez Mendoza, M., Tellez, M. A. V, Zetina Pérez, C. D., Calcáneo, I. A. C., & García, S. M. A. (2025). Virtual Exchange Program as Part of the Internationalization of the Curriculum Strategy in a Mexican Context: An Ethnographic Study. *Journal of International Students*, 15(1), 25–42. <https://doi.org/10.32674/2n3mm069>
- De Regil Sanchez, I. L., Gayh, U., & Brown, A. (2024). *Humanitarian Engineering: Collaborative Online International Learning (COIL) for young students of higher education, to develop skills and social consciousness.* <https://doi.org/10.1109/IHTC61819.2024.10855033>

- Dekkers, R., Langhorne, P., & Carey, L. (2022). Making Literature Reviews Work: A Multidisciplinary Guide to Systematic Approaches. In *Making Literature Reviews Work: A Multidisciplinary Guide to Systematic Approaches*. <https://doi.org/10.1007/978-3-030-90025-0>
- Demirel, H. O., Ahmed, S., & Duffy, V. G. (2022). Digital Human Modeling: A Review and Reappraisal of Origins, Present, and Expected Future Methods for Representing Humans Computationally. *International Journal of Human-Computer Interaction*, 38(10), 897–937. <https://doi.org/10.1080/10447318.2021.1976507>
- Gutierrez, J. S., Torres, J. P., Vela, C. D., Galvis-Motoa, S. I., Perez, J. F., & Romero, D. A. (2024). Prismatic: A physical computing prototype for color theory. *Congreso Internacional de Innovacion y Tendencias En Ingenieria, CONIITI*, (2024). <https://doi.org/10.1109/CONIITI64189.2024.10854828>
- Hong, B., Bista, K., & Timmons, P. C. (2025). Mapping the Scholarship on International Students: Systematic Review of Past Publications in the Journal of International Students, 2011-2024. *Journal of International Students*, 15(1), 1–24. <https://doi.org/10.32674/sfwrch85>
- Hosseini, M. S., Bejnordi, B. E., Trinh, V. Q.-H., Chan, L., Hasan, D., Li, X., Yang, S., Kim, T., Zhang, H., Wu, T., Chinniah, K., Maghsoudlou, S., Zhang, R., Zhu, J., Khaki, S., Buin, A., Chaji, F., Salehi, A., Nguyen, B. N., ... Plataniotis, K. N. (2024). Computational pathology: A survey review and the way forward. *Journal of Pathology Informatics*, 15. <https://doi.org/10.1016/j.jpi.2023.100357>
- Indika, A., Lee, C., Wang, H., Lisoway, J., Peruma, A., & Kazman, R. (2025). *Exploring Accessibility Trends and Challenges in Mobile App Development: A Study of Stack Overflow Questions*. 7401–7410. <https://doi.org/10.24251/hicss.2025.885>
- Infante, J. S., Lopez, B. S., Trujillo, J. L., & Galvis-Motoa, S. I. (2023). Engineering Curricula Flexibilization since International Colaborative with a Medical Program, Trough Software Development Process. *2023 9th International Conference on Innovation and Trends in Engineering, CONIITI 2023 - Proceedings*. <https://doi.org/10.1109/CONIITI61170.2023.10324026>
- Katz, J. E., Dougherty, H., Goldstein, M. H., Ignacio, E.-J., & Woodard, B. (2024). *Focus group analysis of engineering Collaborative Online International Learning (COIL+) compared to short-term study abroad programs*. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85202041186>
- Li, Z. S., Arony, N. N., Devathanan, K., & Damian, D. (2023). “Software is the easy part of Software Engineering” - Lessons and Experiences from A Large-Scale, Multi-Team Capstone Course. 223–234. <https://doi.org/10.1109/ICSE-SEET58685.2023.00027>
- Mareye, M. (2025). Reframing International Mindedness: A Critical Review of its Role in International Education. *Journal of International Students*, 15(9), 27–46. <https://doi.org/10.32674/8fw0rv70>

- Munoz-Escalona, P., de Crespo, Z. C., Marin, M. O., & Dunn, M. (2022). Collaborative online international learning: A way to develop students' engineering capabilities and awareness to become global citizens. *International Journal of Mechanical Engineering Education*, 50(1), 89–104. <https://doi.org/10.1177/0306419020934100>
- Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. *Administration and Policy in Mental Health and Mental Health Services Research*, 42(5), 533–544. <https://doi.org/10.1007/S10488-013-0528-Y>
- Patton, M. Q. (2015). *Qualitative Research & Evaluation Methods: Integrating Theory and Practice*. (4th ed.). Sage publications.
- Pombo, N., & Santos, H. (2023). *Lessons Learned from the Development of a Computerised Badge-based Reward Tool for Student Engagement in Learning Activities*. <https://doi.org/10.1109/EDUNINE57531.2023.10102849>
- Quek, S. W. D., Fu Teo, J. K., Louahemmsabah, N., Cyrus Tong, Y. B., Rong Poh, A. Z., Cao, Q., Seow, C. K., Yau, P. C., & Chen, A. Q. (2023). *Improving Teamwork in Software Engineering Projects in Higher Education*. <https://doi.org/10.1109/FIE58773.2023.10343476>
- Rozo-Rojas, I., Jaimes, H., Cartagena, C., Cuarán, J., & López, N. (2018). *Implementation of the pedagogical strategy Integrated Project in four engineering bachelor programs at Bogota*. <https://doi.org/10.1109/CONITI.2018.8587107>
- Stange, D. M. C., & Stange, R. M. (2020). *Integrate global sustainability virtual exchange into teaching computer science concepts*. 1286. <https://doi.org/10.1145/3328778.3372580>
- Tolhoek, E., Alpár, G., & Rahimi, E. (2025). *ScrumQuest Software Engineering Educational Tool: Teaching Planning in Scrum*. 2, 789. <https://doi.org/10.1145/3724389.3730791>
- Ulnicane, I., Eke, D. O., Knight, W., Ogoh, G., & Stahl, B. C. (2021). Good governance as a response to discontents? Déjà vu, or lessons for AI from other emerging technologies. *Interdisciplinary Science Reviews*, 46(1–2), 71–93. <https://doi.org/10.1080/03080188.2020.1840220>
- Vahdat, S. (2022). The role of IT-based technologies on the management of human resources in the COVID-19 era. *Kybernetes*, 51(6), 2065–2088. <https://doi.org/10.1108/K-04-2021-0333>
- Vaquerizo, L., Gil, I. D., Tututi-Avila, S., & Mato, R. B. (2025). Collaborative Online International Learning (COIL) in chemical engineering: Preparing students for multicultural and international work environments. *Education for Chemical Engineers*, 53, 26–36. <https://doi.org/10.1016/j.ece.2025.07.001>
- Varpio, L., & Macleod, A. (2020). Philosophy of Science Series: Harnessing the Multidisciplinary Edge Effect by Exploring Paradigms, Ontologies, Epistemologies, Axiologies, and Methodologies. *Academic Medicine*, 95(5), 686–689. <https://doi.org/10.1097/ACM.0000000000003142>

- Vasileiou, K., Barnett, J., Thorpe, S., & Young, T. (2018). Characterising and justifying sample size sufficiency in interview-based studies: Systematic analysis of qualitative health research over a 15-year period. *BMC Medical Research Methodology*, 18(1), 1–18. <https://doi.org/10.1186/S12874-018-0594-7>
- Walter, D., Lavery, M. D., & Fleishman, B. (2021). *Global Engineering Competencies Learned Through Virtual Exchange Project Collaboration*. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85124516242&partnerID=40&md5=7d158f94e2cdad406633e51082010d48>
- Yin, R. K. (2018). *Case study research and applications: Design and methods*. (6th ed.). Sage.

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