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The Miniature Guide for COIL Educators in Engineering

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Abstract

Collaborative Online International Learning (COIL) represents a transformative approach to education, fostering global engagement and cross-cultural exchange through online platforms. The COIL approach is relevant for engineering educators as it facilitates cross-cultural collaboration and problem-solving. It enables students to work on global engineering projects and gain diverse perspectives essential for sustainable and innovative engineering solutions in Industry 4.0 and beyond. This paper presents a practical guide to support engineering educators in effectively implementing COIL methodologies. The study begins with an overview of COIL, emphasizing its role in enhancing intercultural competencies and global awareness among engineering students. Drawing on over a decade of experience applying the COIL approach, the authors have participated in numerous projects between LATAM and Europe, enriching their insights into effective cross-regional collaboration and educational innovation. One of the most important findings is that, despite its potential, engineering educators often face challenges executing COIL programs due to a lack of structured guidance and resources. This study addresses these gaps by introducing a concise, user-friendly guide tailored to engineering educators' needs. The methodology involves analyzing 20 case studies and pilot programs to identify key obstacles and solutions. These real-world applications illustrate the guide's principles, providing concrete examples of successful COIL implementation. Common challenges, such as technological barriers and cultural misunderstandings, are explored, and practical solutions are proposed to equip educators with the tools needed to overcome these difficulties. The guide's development is detailed, outlining its structure and content. It is organized into sections covering essential strategies and best practices, including course design, curriculum integration and alignment with learning outcomes, identifying partners, building relationships with international institutions, establishing effective collaboration techniques, and fostering meaningful cultural exchanges. It offers actionable tips for educators to enhance student engagement and ensure the sustainability of COIL initiatives. The guide is valuable for educators seeking to integrate COIL into their curricula. Providing clear, practical guidance empowers the global community of engineering educators to create enriching, culturally immersive online learning experiences. The impact of this guide extends beyond immediate classroom benefits, fostering a generation of students equipped with the skills and perspectives necessary for the future workforce.

Keywords

COIL, Global Classroom, Educational Innovation, Higher Education, Global Citizenship Skills, Engineering Educators

Introduction

The evolving landscape of global engineering education demands innovative pedagogical approaches that foster cross-cultural collaboration and equip students with skills for a globalized workforce. Collaborative Online International Learning (COIL) has emerged as a transformative educational approach that includes the required intercultural competency, enhances collaborative skills, and promotes global engagement among students [1]. This paper introduces a practical and concise guide tailored specifically for engineering educators aiming to integrate COIL methodologies into their curricula.

The foundation of COIL lies in its structured, cross-institutional collaboration, which involves educators co-designing and co-facilitating online learning assignments across different countries. Unlike broader Virtual Exchange (VE) practices, COIL emphasizes mutual learning through carefully designed collaborative tasks, providing students with an authentic international experience without requiring physical mobility [2]. This method aligns seamlessly with the demands of Industry 4.0 and Industry 5.0, allowing engineering students to approach complex, multidisciplinary challenges from a global perspective [3].

Intercultural competencies are regarded as vital components for academic achievement, personal growth towards becoming a global citizen, and relevance in the labor market [4]. The COIL methodology aims to cultivate digital and intercultural competencies as an integral component of the academic curriculum. Typically, COIL projects are characterized by a shared syllabus collaboratively engaged in by all participating students, although there is no singular, definitive methodology [5].

Several theoretical frameworks inform the use of technology in education to support intercultural learning. Some models emphasize cultural orientation [6], others focus on the social dimension of learning [7], and yet others highlight technological aspects [8]. However, there is limited discussion on the process universities must undertake when incorporating this methodology into their courses and how it must be tailored to accommodate the diverse professors who teach the subject, enabling them to address various challenges effectively.

Drawing from over a decade of experience implementing COIL initiatives, the authors offer insights from case studies and pilot programs conducted between institutions in Latin America and Europe [9], [10], [11] . These cases reveal COIL's potential to transform engineering education by integrating theoretical knowledge with real-world applications. However, the findings also underscore the persistent challenges faced by educators, such as technology integration, cultural misunderstandings, and lack of structured resources [12]. To address these challenges, this guide provides actionable recommendations organized into thematic sections: Instructor Training, Designing COIL Courses, Building Partnerships, Engaging Students, Technology Integration, and Assessment and Reflection.

The guide emphasizes integrating theoretical frameworks, such as social constructivism and collaborative learning models, to enhance the COIL experience. For example, incorporating structured collaborative scripts and promoting positive interdependence among student groups has been identified as a critical factor in fostering productive engagement and learning outcomes. Key findings from the analyzed case studies highlight the importance of preparing educators to navigate technological and cultural complexities. The authors propose implementing pre-COIL training workshops, providing templates for course design, and creating a repository of best practices to support educators. Additionally, the guide underscores the significance of student-centered approaches, including reflective exercises, to deepen learning and intercultural understanding.

This study contributes to the global discourse on engineering education by offering a robust framework for embedding COIL within curricula, ensuring students acquire essential skills and perspectives for the evolving demands of the global workforce. The paper concludes by advocating for the widespread adoption of COIL in engineering education as a sustainable, inclusive alternative to traditional internationalization methods. By equipping educators with a clear roadmap, this guide aims to empower them to create enriching, culturally immersive online learning environments that prepare students for the interconnected challenges of the future.

COIL Structure and Design

COIL aims to generate internationalization experiences with significant learning, linking the student to a multicultural, collaborative, knowledge-integrating environment. Through Global Learning, students identify, analyze, discuss, and develop proposals for solutions to real problems in an international context, fostering an ideal environment to develop key skills for global citizenship and employability [13]. During the planning period of the COIL experience, Professor A, responsible for course A in country A, agrees with Professor B, responsible for course B in country B, through strategic planning meetings to jointly hold sessions and adapt the part of the course that corresponds so that the hybrid class between the groups has the same topic [14]. COIL aims to link, partially or totally, a course of the institution with another course of another foreign university with internationalization at the core. There is a planning period before the beginning of the semester, in which teachers agree to examine the possibility of carrying out a global classroom experience. This period is crucial because Teacher A from Country A establishes contact with Teacher B from Country B. The courses within which the COIL will take place are established [15]. In addition, a demographic analysis of the students in each group, the number of male and female students, the semester, and the programs in which they are enrolled, among others, is performed. After agreeing on the course topics to be developed, typical evaluation rubrics must be designed for the participating groups. The language for teaching the course and the appropriate schedules for both groups are established. The Global Classroom experience consists of three moments: a) Icebreaker, b) Collaborative and multicultural work, and finally, c) personal reflection on what was learned during the experience. Professors design a website on Google Sites that both institutions use. They create the learning activities on this site using technologies such as Slack, Zoom, and Padlet [16], [17]. Teachers and students use the Zoom tool for synchronous communication. Students are surveyed about their satisfaction with their professors, activities, and interactions among team members. They are also allowed to propose

new ideas for activities and improvements in the collaborative environment.

Challenges in COIL Implementation

Common problems faced by COIL educators and proposed solutions. Despite its promise, implementing COIL programs in engineering education presents specific challenges, including:

- **Technological barriers:** Disparities in digital infrastructure and access remain critical impediments to COIL implementation. Variability in internet bandwidth, availability of hardware, and familiarity with virtual collaboration tools can create inequities in participation. Instructors and students in regions with limited resources may face significant difficulties maintaining seamless communication and engagement during collaborative activities [18].

- **Cultural misunderstandings:** COIL bridges diverse educational, cultural, and linguistic contexts, often resulting in misaligned expectations and communication challenges. Variations in academic norms, assessment standards, and interpersonal dynamics may lead to participant misunderstandings. Educators must proactively address these gaps through preemptive cultural orientation, open discussions, and structured activities that foster mutual respect.

- **Curriculum integration:** Aligning COIL activities with existing course objectives and institutional learning outcomes is often complex. Differences in academic calendars, course structures, and evaluation methods between partnering institutions can hinder the seamless integration of COIL modules. Instructors may find it challenging to balance traditional course requirements with the additional demands of international collaboration.

- **Sustaining partnerships:** Building and maintaining robust international partnerships is a resource-intensive endeavor. Variations in institutional priorities, administrative policies, and faculty turnover can disrupt continuity. Ensuring sustained collaboration requires clear communication, institutional support, and ongoing stakeholder engagement.

- **Instructor Training:** The success of COIL largely depends on well-trained instructors equipped with COIL-specific skills. However, gaps in faculty preparedness can hinder effective implementation. Key challenges include:

  - Intercultural Communication: Instructors may lack experience in navigating and mediating cultural differences among participants, which is critical for fostering effective collaboration.

  - Technology Use: Many educators are unfamiliar with advanced virtual collaboration tools and platforms. This creates hurdles in designing and managing COIL activities effectively.

  - Curriculum Integration: Designing COIL modules that align with local and international course objectives demands pedagogical alignment and collaborative course design training.

- Facilitating Cross-Cultural Teamwork: Effective facilitation of diverse student teams requires understanding group dynamics, conflict resolution, and strategies for equitable participation

The significance of creating a guide for educators involved in COIL. The success of a COIL depends heavily on the preparedness of educators to navigate the complexities of cross-cultural, interdisciplinary, and virtual collaboration. Creating a structured guide for educators is essential to ensure effective implementation. This guide can provide targeted training on intercultural communication, technology use, curriculum integration, and facilitating cross-cultural teamwork, all of which are critical components for successful COIL projects. Educators require a clear framework to manage technological barriers, such as ensuring equitable access to digital platforms and troubleshooting connectivity issues during synchronous sessions. Furthermore, the guide should include cultural awareness and sensitivity modules to help instructors address potential misunderstandings arising from diverse educational norms and expectations. By offering detailed methodologies for integrating COIL into existing curricula, the guide would support educators in aligning international collaboration activities with specific course objectives and accreditation requirements. Additionally, it should emphasize the importance of establishing sustainable international partnerships, which often involve extensive planning and coordination between faculty across institutions. Including practical tools, such as step-by-step icebreaker activities and evaluation frameworks, ensures educators are equipped to foster engagement and effectively assess learning outcomes. A well-crafted guide is vital for empowering educators to leverage COIL as a transformative pedagogical approach in engineering education and beyond.

Methodology

COIL framework facilitates collaboration between universities from different countries. At Tecnológico de Monterrey, various collaborations and projects have been developed over the past five years, emphasizing key aspects of COIL programs, such as fostering teamwork and enhancing skills in multicultural and international contexts. The primary aim of this methodology was synthesized into a concise *miniature* guide outlining critical aspects for COIL educators in engineering. We reviewed eight articles detailing cases and collaborations between universities from different countries utilizing the COIL model to achieve this objective. Each project discussed in these articles provided valuable information, enabling us to analyze common challenges, strategies, and outcomes in engineering education contexts. This analysis allowed us to examine how universities have developed case studies or pilot programs related to the COIL model over the past five years.

The guide's development draws on insights from case studies and pilot programs involving COIL projects between Latin America and Europe. These projects, spanning over a decade, provided a rich dataset to analyze common challenges, strategies, and outcomes in engineering education contexts. The authors synthesized findings to create a user-friendly guide structured around practical solutions and actionable advice [3, 6].

The miniature guide for COIL educators addresses several critical gaps hindering effective implementation. Despite COIL's potential to foster intercultural competence and collaborative

skills, challenges persist in curriculum integration, instructor training, and equitable access to resources. Many educators lack structured training in co-designing culturally sensitive, interdisciplinary activities that align with learning objectives across institutions [14].

Furthermore, the variability in technological resources and digital fluency among participants complicates facilitating virtual collaboration. The miniature guide also seeks to mitigate issues in sustaining international partnerships and ensuring consistent engagement from all stakeholders. The guide aims to equip educators with practical tools and foster inclusive, effective, and sustainable COIL practices by addressing these gaps. [18]

The Miniature Guide for COIL Educators in Engineering

The guide is structured to provide step-by-step assistance to educators, covering the following five key COIL stages:

1. **Training the Educators:** This section outlines essential training for instructors to acquire COIL-specific skills. This includes modules on intercultural communication, technology use in virtual collaboration, curriculum integration, and facilitating cross-cultural teamwork. The guide emphasizes the importance of workshops, peer mentoring, and access to a repository of resources to equip educators with the tools needed for successful COIL implementation.

2. **Course Design and Curriculum Alignment:** Practical advice on embedding COIL activities within engineering curricula to achieve desired learning outcomes, including aligning those learning outcomes with COIL principles and incorporating elements of collaborative and experiential learning.

3. **Partner Identification and Relationship Building:** Guidance on identifying and fostering effective and long-term collaborations with international institutions.

4. **Cultural Exchange Facilitation:** Tips for fostering meaningful intercultural dialogue and understanding among students, sustaining engagement, and addressing common barriers to participation. Recommendations for selecting and leveraging digital tools to support seamless collaboration and communication.

5. **Dissemination, Communication, and Impact Assessment:** Methods to evaluate students' performance, focusing on intercultural competencies, collaborative problem-solving, and the quality of deliverables.

The TOP 10 typical problems Educators face when designing a COIL experience

The non-systematic literature mapping allowed the authors to systematically identify 53 distinct challenges related to designing and implementing Collaborative Online International Learning (COIL) experiences. These challenges spanned various stages of COIL implementation, reflecting the complexity of creating and sustaining effective international collaborations. However, due to space constraints in this conference paper, we focus on presenting the Top 10 typical problems educators face when designing COIL experiences, alongside their proposed solutions. These

problems are organized across the five critical stages of COIL implementation: Training the Educators, Course Design and Curriculum Alignment, Partner Identification and Relationship Building, Cultural Exchange Facilitation and Dissemination, Communication, and Impact Assessment. The five stages and the methodology employed in the development of the miniguide are comprehensively synthesized in Figure 1. For each stage, this section highlights two prevalent issues and corresponding solutions, providing practical insights for educators and institutions aiming to implement COIL successfully. This focused approach ensures the most impactful challenges and actionable strategies are shared, benefiting practitioners navigating the nuanced landscape of COIL education.
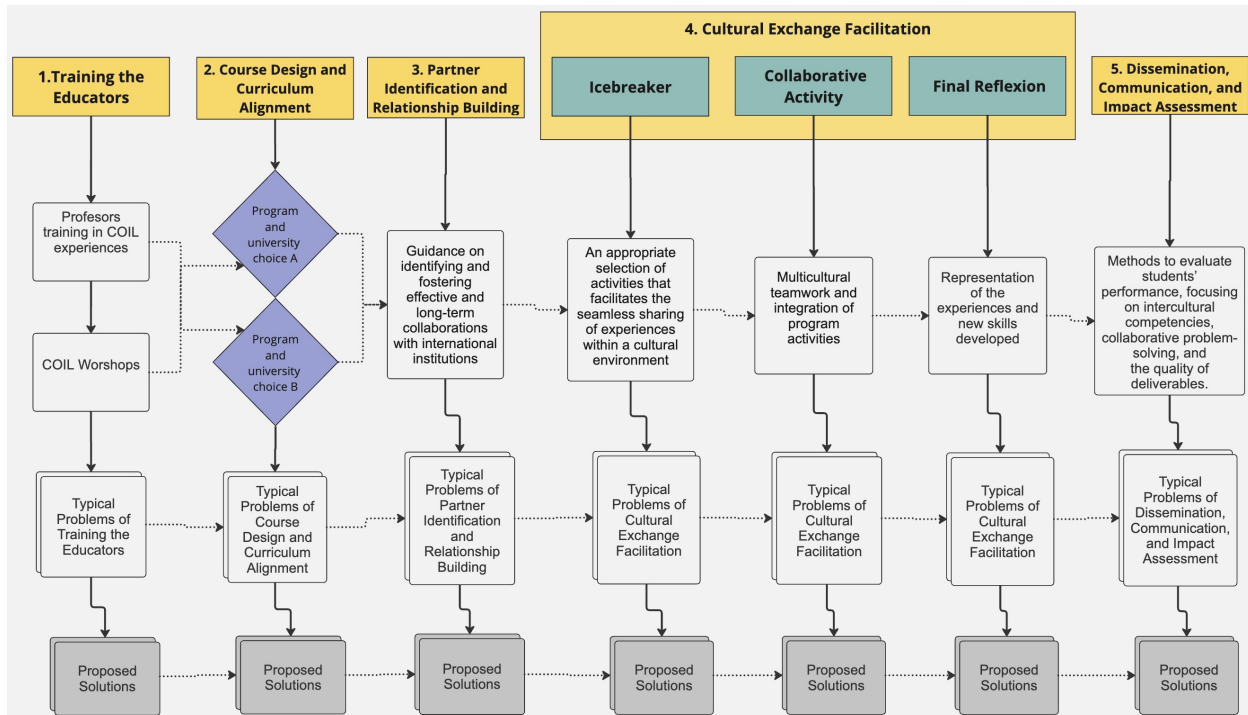

Figure 1: Miniature Guide elements using the COIL structure and stages.

Typical problem 1: Insufficient Focus on Intercultural Communication Skills. Many COIL training programs neglect the critical role of intercultural communication skills. Educators may not fully understand how cultural differences affect communication, collaboration, and expectations among students. (at COIL stage #1: Training the Educators)

> **Proposed solution:** Include comprehensive modules on intercultural communication within the training program. These modules should cover: Common cultural dimensions (e.g., individualism vs. collectivism); Strategies for managing cultural misunderstandings; Case studies and role-playing exercises to practice navigating cross-cultural scenarios.

Typical problem 2: Overemphasis on Technology Without Practical Application. Educator training often prioritizes introducing technological tools but fails to integrate them into realistic COIL scenarios. This results in educators feeling overwhelmed and unprepared to use these tools effectively in a collaborative learning environment. (at COIL stage #1: Training the Educators)

Proposed solution: Adopt a "learn-by-doing" methodology in the training process; Provide hands-on workshops where educators actively use COIL platforms (e.g., Padlet, Slack, or Miro) to complete tasks similar to those they will assign to students; and pair this with clear, context-specific use cases and troubleshooting sessions.

Typical problem 3: Misalignment Between COIL Activities and Course Objectives. One common mistake is designing COIL activities that do not align with the learning outcomes of the participating courses. This misalignment can lead to COIL being perceived as an add-on rather than an integral part of the curriculum, reducing its impact on student learning. (at COIL stage #2: Course Design and Curriculum Alignment)

Proposed solution: Incorporate a structured curriculum mapping process during the course design phase. Educators from partner institutions should collaboratively identify: Shared learning objectives; Key competencies to be developed (e.g., intercultural communication, teamwork); and assessment criteria tied to both the COIL activities and broader course goals.

Typical problem 4: Neglecting Realistic Timeframes for Collaborative Tasks Another frequent issue is underestimating the time needed for students to complete COIL tasks, considering differences in academic calendars, time zones, and working styles. This can result in rushed deliverables and a subpar learning experience. (at COIL stage #2: Course Design and Curriculum Alignment)

Proposed solution: During training, emphasize the importance of realistic scheduling. Provide templates and best practices for: Structuring tasks with built-in flexibility; Synchronizing academic calendars and planning around time zone differences; and allowing time for iterative feedback and reflection.

Typical problem 5: Partner Selection Based on Limited Compatibility. Educators or institutions often select partners based on convenience (e.g., pre-existing connections) rather than considering compatibility in teaching goals, course content, and institutional support. This can result in mismatched expectations and challenges in collaboration. (at COIL stage #3: Partner Identification and Relationship Building)

Proposed solution: Introduce a structured partner vetting process during training. This process should include: A checklist for evaluating partner compatibility, focusing on shared educational goals, complementary course content, and logistical alignment (e.g., academic calendars, time zones); Guided exercises on conducting exploratory meetings to assess mutual expectations and capabilities; and a repository of potential partners and successful case studies to aid in informed decision-making.

Typical problem 6: Insufficient Focus on Relationship Sustainability. Educators often underestimate the effort needed to maintain strong, long-term partnerships. This can lead to lapses in communication, unmet commitments, and eventual collaboration breakdowns. (at COIL stage #3: Partner Identification and Relationship Building)

Proposed solution: Provide training on sustainable relationship-building strategies, such as: Establishing formal partnership agreements outlining roles, responsibilities, and conflict resolution mechanisms; Encouraging regular check-ins and joint reflection sessions to

evaluate progress and address challenges; and incorporating joint professional development activities to foster a sense of shared purpose and continuous improvement.

Typical problem 7: Lack of Structured Intercultural Activities. A common mistake is assuming that cultural exchange will naturally occur without intentional facilitation. This often results in superficial interactions and missed opportunities for meaningful cultural learning. (at COIL stage #4: Cultural Exchange Facilitation)

> **Proposed solution:** Incorporate specific training on designing and facilitating intercultural exchange activities. Educators should learn how to: Create structured icebreakers and team-building activities that encourage students to share personal and cultural perspectives; Design assignments requiring collaborative problem-solving rooted in cultural contexts (e.g., case studies or scenario analysis); and use reflective practices, such as journaling or group discussions, to deepen understanding of cultural differences and commonalities

Typical problem 8: Inadequate Preparation for Managing Cultural Misunderstandings. Educators may lack the skills to address cultural misunderstandings or conflicts, leading to unresolved issues that hinder collaboration and learning. (at COIL stage #4: Cultural Exchange Facilitation)

> **Proposed solution:** Provide training on conflict resolution and cultural sensitivity. This should include: Role-playing scenarios of common cultural misunderstandings and strategies for resolution; Guidance on fostering inclusive environments where students feel comfortable discussing cultural differences; and tools for facilitating open dialogue and mediating conflicts constructively, emphasizing empathy and mutual respect.

Typical problem 9: Ineffective Communication of COIL Outcomes. One common mistake is failing to communicate the impact and achievements of COIL projects effectively to stakeholders such as students, faculty, institutional leaders, and potential partners. This can limit awareness and support for future initiatives. (at COIL stage #5: Dissemination, Communication, and Impact Assessment)

> **Proposed solution:** Train educators on strategic communication techniques, including: Creating concise and compelling project summaries and visuals (e.g., infographics, video testimonials); Leveraging digital platforms and social media to share successes broadly; and organizing events like webinars or showcases where students present their COIL experiences and outcomes.

Typical problem 10: Limited or Inconsistent Impact Assessment. Educators often overlook or inconsistently assess the learning outcomes and broader impact of COIL initiatives. This can result in a lack of data to demonstrate the effectiveness of the program or inform improvements. (at COIL stage #5: Dissemination, Communication, and Impact Assessment)

> **Proposed solution:** Include training on designing and implementing robust impact assessment frameworks. This should involve: Defining clear, measurable outcomes (e.g., intercultural competence, teamwork skills, curriculum integration); Using mixed-methods approaches (e.g., surveys, interviews, and reflective essays) to gather qualitative and quantitative data; and teaching educators how to analyze and present assessment results to stakeholders to guide program improvement and secure funding.

Other tips. Some miscellaneous tips for educators to succeed in effective collaboration and cultural exchange collected from the case studies:

- Workshops and Seminars: Focused on intercultural competencies, technological proficiency, and COIL-specific methodologies.

- Peer Mentoring: Pairing novice COIL instructors with experienced mentors to share best practices and insights.

- Resource Repositories: Providing access to curated materials, case studies, and templates to guide instructors in developing effective COIL programs.

- Ongoing Support: Establishing a network of institutional support for troubleshooting, collaborative opportunities, and recognition of faculty efforts.

Conclusion and Impact

The analysis of 20 case studies allowed the authors to systematically identify 53 distinct challenges related to designing and implementing Collaborative Online International Learning (COIL) experiences. These challenges spanned various stages of COIL implementation, reflecting the complexity of creating and sustaining effective international collaborations. However, due to space constraints in this conference paper, we focus on presenting the Top 10 typical problems educators face when designing COIL experiences, alongside their proposed solutions. These problems are organized across the five critical stages of COIL implementation: Training the Educators, Course Design and Curriculum Alignment, Partner Identification and Relationship Building, Cultural Exchange Facilitation and Dissemination, Communication, and Impact Assessment. For each stage, this section highlights two prevalent issues and corresponding solutions, providing practical insights for educators and institutions aiming to implement COIL successfully. This focused approach ensures the most impactful challenges and actionable strategies are shared, benefiting practitioners navigating the nuanced landscape of COIL education.

The miniature guide empowers educators to design culturally immersive, interdisciplinary learning experiences by addressing these challenges and offering tailored solutions. This ultimately fosters a new generation of globally competent engineering students equipped with the skills and perspectives required to address the complexities of a globalized workforce. Through this guide, the transformative potential of COIL as an educational methodology is reinforced, making it an invaluable resource for educators seeking to integrate international collaboration into engineering education.

Acknowledgment

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