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# Continuum of Academic Collaboration: Issues of Inconsistent Terminology in Multilingual Context

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## ABSTRACT

This article investigates the challenges posed by inconsistent terminology in academic collaboration, particularly in multilingual contexts, focusing on Spanish and English. It begins by outlining the evolution of academic disciplines and the increasing need for collaborative research, providing foundational definitions that frame the discussion. The Continuum of Academic Collaboration (CAC) is introduced as a conceptual framework for categorizing different modes of collaboration. Through scholarly presentations and research discussions, the authors identified a significant gap in the translation and interpretation of key technical terms—especially those used to differentiate between multidisciplinary and interdisciplinary collaboration, such as the prefixes Co-, Cross-, and Across-. The findings indicate that inaccurate translations can lead to misinterpretations that undermine the conceptual integrity of these terms, as direct equivalents often fail to capture their nuanced meanings. A systematic literature review revealed limited clarity and a scarcity of research on these issues in Spanish-language publications. To address this gap, the authors interviewed esteemed experts whose insights underscore the need for further investigation into the multilingual translation of academic collaboration concepts, ultimately aiming to enhance transdisciplinary communication (TDC).

**Keywords**: Academic collaboration, Collaborative typology, Disciplinary prefixes, Disciplinary terminology, Interdisciplinarity, Knowledge integration, Research synergy, Scientific communication, Systematic review, Transdisciplinarity.

## 1. INTRODUCTION

Academic collaboration is vital in tackling complex scientific challenges in today's interconnected world. Yet, the need for clear definitions and categorizations of collaboration types poses a significant barrier to achieving effective synergy. This article introduces the Continuum of Academic Collaboration (CAC), a conceptual framework that systematizes the diverse forms of collaboration within scientific research. By addressing the challenges of language translation and integration, the CAC aims to enhance communication and cooperation across disciplines. Drawing inspiration from Richard Feynman's renowned approach to simplifying complex ideas (Feynman et al., 1997; Feynman & Zee, 2014), the framework endeavors to clarify terminology in academic collaboration, thereby developing precise and accessible language for a broader audience—a critical need in interdisciplinary research contexts.[i]

This article begins with foundational definitions and an explanation of the CAC. The authors highlight a key knowledge gap and controversy in the transition between multidisciplinary and interdisciplinary collaboration, where a collection of terms (Co-, Cross-, and Across-) cannot be easily translated or uniformly conceptualized across different contexts. The discussion synthesizes the findings and summarizes the implications, ultimately emphasizing the necessity for further research on the multilingual translation of ideas within transdisciplinary academic collaboration.

A notable gap in the literature arises from discrepancies in the definitions of various collaboration types. U.S. federal resources, for instance, often provide definitions that do not align with those found in global academic literature, encyclopedias, or disciplinary studies. In section 3.1, we present a range of terms—such as Disciplinary Research, Intradisciplinary Research, Unidisciplinary Research, Multidisciplinary Research, Codisciplinary (Cross-/Across-) Research, Interdisciplinary Research, and Transdisciplinary Research—that are defined differently across contexts[ii]. For example, while academic sources consistently describe Disciplinary Research as work confined within a single field, some federal guidelines blur distinctions between Intradisciplinary and Unidisciplinary approaches. Similarly, the term Multidisciplinary Research is often treated differently from Codisciplinary or Interdisciplinary Research in various governmental documents compared to scholarly definitions. This divergence underscores the urgent need for a unified framework like the CAC, which not only reconciles these inconsistencies but also enhances clarity and

facilitates more effective international and cross-sector collaboration.

## 2. DEFINITION OF KEY TERMS

This section will introduce and clarify the concepts of "Global Discipline," "Academic Collaboration," and "Multilingual Challenge." The authors agree that defining these concepts is essential for facilitating understanding throught the paper;

### 2.1. Definition of Global Discipline in the Context of Kuhn

Thomas Kuhn defines disciplines as structures organized around shared paradigms—comprising the theories, methods, and fundamental problems a scientific community accepts (1996, 2002). In other words, a discipline is more than a collection of topics; it is a framework that guides how practitioners view and study the world. Building on Kuhn's ideas, Repko and Szostak (2016) introduce the concept of a global discipline as an evolution of this traditional paradigm. They explain that "a global discipline is defined not only by the universality of the problems it addresses but also by its integration of diverse perspectives, methodologies, and cultural contexts, fostering a transnational and interdisciplinary approach to knowledge generation." In simpler terms, a global discipline tackles issues that affect people worldwide by drawing on ideas from various cultures and academic fields to create a more complete understanding. For example, consider climate science. This field does not limit itself to one country or one set of methods; instead, it integrates insights from physics, chemistry, biology, economics, and social sciences to address the global challenge of climate change. As a global discipline, climate science illustrates how merging diverse perspectives and methodologies can create a robust approach to solving problems that cross traditional disciplinary boundaries. While this evolving approach expands the limits of traditional disciplines, it still faces the challenge of fully integrating an intercultural worldview—an essential step toward achieving true transdisciplinarity by overcoming cultural and epistemic barriers (Bennett, 2015).

### 2.2. Academic Collaboration Among Disciplines

Academic collaboration among disciplines refers to the cooperation between researchers or institutions from different fields of study to address complex problems that cannot be solved within the confines of a single discipline. This type of collaboration is essential in contemporary research because it integrates diverse approaches, methods, and knowledge, fostering innovative and comprehensive solutions that transcend traditional disciplinary boundaries. While collaboration within a single discipline occurs, the focus is on the transformative potential that arises when distinct epistemological perspectives converge to tackle multifaceted challenges.

### 2.3. Multilingual Challenge

Inaccurate translation remains a significant challenge in academic collaboration, as technical terms often lose their nuanced meaning when translated between languages. While we acknowledge that similar issues arise in translations involving German, French, Mandarin, and other languages, this paper focuses explicitly on English and Spanish—languages in which the authors are native—to illustrate the problem. Frequently, direct equivalents do not exist, resulting in misinterpretations that undermine the conceptual integrity of key terms. This challenge hampers effective communication and highlights the need for researchers to establish standard operative definitions. Addressing this issue requires collaborating to develop culturally adapted terminologies and standardized definitions that facilitate more explicit, transdisciplinary dialogue across linguistic boundaries.

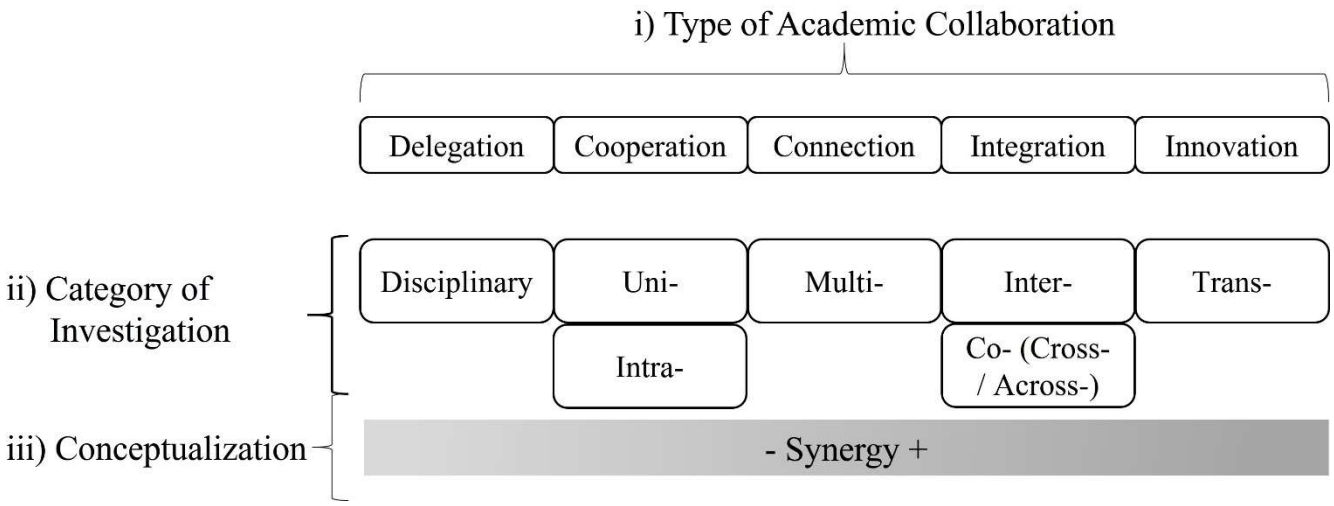
## 3. CONTINUUM OF ACADEMIC COLLABORATION

The CAC (Continuum of Academic Collaboration) is proposed as a theoretical framework to understand and categorize the different forms of academic collaboration. This continuum spans from disciplinary to transdisciplinary research, encompassing multidisciplinary and interdisciplinary approaches. Each form of collaboration is defined by the number of disciplines involved and their degree of integration. The theoretical framework is grounded in a combination of theories on collaboration, scientific convergence, and transdisciplinary communication (TDC). Convergence,[iii] in this context, is defined as an approach to problem-solving that cuts across disciplinary boundaries by integrating knowledge, tools, and ways of thinking from diverse fields into a comprehensive, synthetic framework (NAS, 2014, p. 21). The CAC emphasizes three fundamental dimensions for understanding interactions and evolutions within academic collaboration (see Figure 1).

### 3.1. The Three Dimensions of the CAC Framework

The CAC framework is structured around three critical dimensions: i) type of collaboration, ii) category of investigation, and iii) conceptualization. The first dimension, 'type of collaboration,' delineates the stages or levels of engagement among researchers—from essential task delegation to advanced forms of cooperation, connection, integration, and innovation. The second dimension, the 'category of investigation,' classifies research endeavors according to their disciplinary scope, ranging from purely disciplinary or unidisciplinary efforts to more complex collaborations such as multidisciplinary, codisciplinary (cross-/across-), interdisciplinary, and transdisciplinary research. Lastly, 'conceptualization' captures collaborators' depth of shared understanding and theoretical alignment. Importantly, as conceptualization deepens over time, synergy naturally emerges, fostering new insights and frameworks that transcend individual disciplinary boundaries. Provided that the collaboration remains stable and does not collapse, sustained communication leads to a higher degree of conceptualization, catalyzing greater synergy and innovation.

**Figure 1.** *Graphic Organizer of the Continuum of Academic Collaboration*




**Note.** Retrieved from *"Organizador Grafico del Continuum de la Colaboración Académica"* by Cristo Leon, 2024, IEU University, located in Puebla, Mexico. © 2024. Source: https://osf.io/7tx43

### 3.2. Dimension I Type of Academic Collaboration

The first dimension, "type of collaboration," delineates the stages or levels of engagement among researchers, progressing from essential task delegation to advanced forms of cooperation, connection, integration, and innovation. This progression is not static; instead, it evolves naturally as communication deepens and time allows for building trust and shared understanding. Initially, collaborators may focus on dividing tasks and responsibilities, but as interactions continue and researchers exchange ideas, a more dynamic integration of perspectives emerges. Over time, this sustained dialogue fosters the development of a common language and mutual respect, enabling participants to move beyond compartmentalized efforts toward a state of true synergy. Innovative insights and breakthrough ideas are more likely to materialize in this state, reflecting the intrinsic relationship between prolonged engagement and enhanced collaborative outcomes.

### 3.3 Dimension II Category of Investigation

This section presents a continuum of research approaches, ranging from traditional single-discipline studies to highly integrative efforts that transcend disciplinary boundaries. Drawing on the foundational works of Bainbridge and Roco (2016), Coyne (2018), Repko & Szostak (2016), and Stember (1991), we categorize these approaches according to the degree of integration among participating disciplines. Table 1 (see Appendix 1) illustrates how each type of collaboration operates in practice, shedding light on the distinct opportunities and challenges researchers face when moving from a narrowly focused project to one that fully merges multiple fields of inquiry.

- **Disciplinary Research:** Refers to research conducted within the boundaries of a single discipline. Researchers exclusively use methods, theories, and approaches inherent to their field of study without involving external perspectives.
- **Intradisciplinary research refers** to collaboration within a single discipline involving various subfields or specializations within the same broader field. This type of research enhances depth and specialization by drawing on diverse perspectives and expertise within the same discipline.
- **Unidisciplinary Research**: Describes research conducted by individuals or groups within a single discipline, focusing on a specific problem or topic. It fosters synergy among researchers by aligning their efforts within a unified theoretical and methodological framework.
- **Multidisciplinary Research:** Involves the participation of multiple disciplines in a project, where each works independently, contributing its knowledge and methodology without truly integrating the approaches of other disciplines.
- **Codisciplinary [Cross-/Across-] Research:** This refers to collaboration between disciplines that, while not fully integrating their approaches, work in a coordinated manner to achieve common goals while maintaining some methodological independence.
- **Interdisciplinary Research:** This approach integrates methods and theories from different disciplines. Researchers collaborate closely, creating a joint framework transcending each discipline's limitations.
- **Transdisciplinary Research:** Goes beyond interdisciplinarity by integrating and transcending disciplinary boundaries, creating new conceptual frameworks and methodologies that unite disciplines and address problems from a new and innovative perspective.

### 3.4. Dimension III Conceptualization

Conceptualization is the process by which researchers develop a shared framework and language to facilitate effective collaboration. This dimension involves aligning diverse perspectives and methodologies to create a shared understanding that enhances communication and integration. It reflects a natural progression—from basic, initial exchanges to deeply integrated approaches where participants progressively synchronize their ideas and methods, thereby generating genuine synergy. Conceptualization serves as a bridge that enables researchers to effectively convey their findings while overcoming both linguistic and methodological barriers. Notably, there is no

universal "*Esperanto*" for TDC; achieving a shared understanding necessitates continuous negotiation, adaptation, and, at times, the development of a tailored meta-language[iv] suited to the specific contexts and participants involved. This dynamic process reinforces collaborative ties and sets the stage for innovative outcomes. In the following section, we introduce an illustrative narrative to conceptualize the CAC, offering a conceptual model that encapsulates these progressive dimensions.

## 4. CONCEPTUAL MODEL FOR THE CAC

**Title:** A Health-Tech Project Involving Different Partners.

In this illustrative narrative, three university researchers—one specializing in Computer Science, another in Biomedical Engineering, and a third in Public Health—collaborate to develop a low-cost medical tool for early disease detection. They join forces with a nonprofit organization that works with local communities and a company that manufactures sensor technology. At the same time, several graduate students participate to acquire valuable research skills and contribute to the project. Initially, each faculty member focuses on their tasks: the Computer Science expert develops the software, the Biomedical Engineering specialist designs the device, and the Public Health researcher investigates community health trends. Recognizing the interconnected nature of their work, the team adopts a best practice by creating a Data Management and Sharing Plan (DMSP) to delineate resources and define stakeholders' roles, facilitating effective collaboration (León & Lipuma, 2024a). As communication deepens and time progresses, they meet regularly to align their timelines, integrate their contributions, and analyze the outcomes. With the nonprofit testing the tool in real-world settings and the company providing specialized components, the project naturally evolved beyond simple coordination. Based on the evaluation and assessment, the researchers adjusted the software to better interface with the sensors, refined the device design based on pilot feedback, and tailored the initiative to meet community health needs. This sustained dialogue fosters an environment where synergy emerges naturally among the participants, demonstrating that increased communication and prolonged engagement are essential for deep conceptual integration.

Ultimately, the researchers merge their expertise—coding, hardware design, and public health—into a cohesive system that produces the medical tool and includes training materials, community outreach initiatives, and live data monitoring. Having honed their research skills through active participation, graduate students form a unified team that transcends traditional disciplinary boundaries by integrating the community's needs. This conceptual model illustrates how the deliberate progression of collaboration, underpinned by best practices like a DMSP and sustained communication, naturally enhances synergy and drives innovation in academic research.

## 5. SYSTEMATIC LITERATURE REVIEW

This study is grounded in a systematic literature review (SLR) that examines the diverse approaches to describing interactions between disciplines in academic collaboration. The literature reveals that federal agencies in the United States have introduced varied—and sometimes conflicting—prefixes to the term "disciplinary," complicating precise comparisons and evaluations. Our SLR focused on identifying and clarifying these definitions while assessing their practical applications in collaborative contexts. Table 2 summarizes the critical sources identified by the review, following the Modelo General Particular Específico (GPE)[v] model (León et al., 2022).

A detailed account of the SLR methodology is provided below:

**i) Planning Stage:** Grounded in Kitchenham's orientations (2004), this stage involved defining the analytical tools and the strategic framework to support the literature review process. In this phase, we established clear protocols for data collection, set inclusion and exclusion criteria, and considered the ethical implications and epistemological orientations, drawing on the reflections of Suri et al. (2020, p. 42).

**ii) Conduction Stage:** This stage was organized into four distinct phases, following the contributions of Higgins et al. (2019) and informed by examples provided by Durach et al. (2015, p. 121) and Bedenlier et al. (2020, p. 15). The phases are:

- **Phase 1:** Extracting relevant literature through systematic searches across selected databases.
- **Phase 2:** Organization and preparation of the extracted data, ensuring that all literature was cataloged and ready for analysis.
- **Phase 3:** Coding and analysis of the literature to identify key themes, definitions, and gaps within the corpus.
- **Phase 4:** Drafting and presentation of the findings, with an emphasis on synthesizing the diverse terminological approaches to academic collaboration.

**iii) Reporting Stage:** Given the intrinsic complexity of the topic and the depth of both general and specific objectives, this stage followed the methodological recommendations of Bandara et al. (2015). The report was developed using a combination of inductive and deductive approaches to ensure both breadth and depth in the analysis, culminating in a comprehensive summary of our findings.

Notably, while the SLR yielded significant insights into the extremes of the Continuum of Academic Collaboration (CAC)—particularly in understanding disciplinary and transdisciplinary approaches—the review was less conclusive regarding the middle points of the continuum (i.e., codisciplinarity, crossdisciplinarity, and acrossdisciplinarity). This gap is primarily attributed to the scarcity of scholarly materials on these integrative forms of collaboration. Moreover, the SLR identified that these terms are too vaguely defined in the current literature, complicating precise evaluation and application, particularly in Spanish-language publications.

## 6. METHODOLOGY

This study employs a multi-method approach that integrates systematic literature reviews, expert consultations via the Delphi process,[vi] and advanced bibliometric tools to update the theoretical framework comprehensively. This integrated methodology introduces new perspectives and insights and reinforces the study's significance in contemporary academic discourse, positioning it as a valuable contribution to our understanding of scholarly collaboration. Over the past two years

(2022 to 2024), more than 20 in-depth discussions with researchers and other experts were conducted, totaling over 15 hours of recorded video exchanges. These interactions provided critical insights that enriched both the theoretical foundation and the practical relevance of the research. Additionally, the study was conducted following IRB protocol number 2208024059, which was granted exempt status under categories 1, 2, and 3.

In addition to its theoretical robustness, the Continuum of Academic Collaboration (CAC) framework is bolstered by practical applications. Currently, the dissertation *Colaboración Interdisciplinaria: Tablero de Control para una Institución Politécnica R01 en los EE. UU.* (León, 2024) is being published as a book to facilitate the dissemination of these ideas. Moreover, three full study cases are detailed in *Reflections on Communication, Collaboration, and Convergence, First Edition: Strategic Models for STEM Education and Research* (Lipuma et al., 2023). This free book, available via NJIT's digital repository, is also being prepared for release as an open digital resource, further demonstrating the practical impact and applicability of the CAC framework in academic settings.

Furthermore, three focused Delphi process meetings were held with Dr. Nagib Callaos—a distinguished expert in systems theory and cybernetics—whose contributions were pivotal in conceptualizing and refining the CAC through his critical insights on collaboration dynamics and interdisciplinary communication (Callaos & León, 2024; Cowin et al., 2023; León et al., 2023; Liendo et al., 2024). This collaborative effort has not only deepened the study's conceptual underpinnings but has also led to the production of several peer-reviewed articles that further explore and validate these findings (León & Lipuma, 2024b; Lipuma & León, 2022, 2024; Lipuma et al., 2023; Reich et al., 2024).

## 7. THE MULTILINGUAL CHALLENGE IN ACADEMIC COLLABORATION

The dominance of English-language literature in academic collaboration has marginalized perspectives and terminologies crucial for non-English-speaking contexts. This limitation restricts a comprehensive analysis of collaboration dynamics across cultural and linguistic boundaries, mainly where multilingual partnership is essential. Inaccurate translation remains a significant challenge; technical terms often lose their nuanced meaning when translated from English to languages such as Spanish, German, French, or Mandarin. Frequently, direct equivalents do not exist, resulting in misinterpretations that undermine the conceptual integrity of terms like 'Codisciplines,' 'Crossdisciplines,' and 'Acrossdisciplines.' Moreover, cultural and epistemic barriers—stemming from the absence of an integrated intercultural worldview—further hinder the realization of true transdisciplinarity. Historically, the challenge of inconsistent terminology in multilingual contexts has led to the adoption mathematics as the lingua franca[vii] of science, highlighting the persistent difficulty of relying solely on natural language for effective scientific communication. On a practical level, developing a standardized glossary or meta-language for academic collaboration could mitigate these issues, ensuring that diverse disciplinary and cultural perspectives are accurately represented. Additionally, while all interviewed faculty members are employed by our institution—and in compliance with human resources policies, we cannot disclose their country affiliations—the research team reflects a diverse international profile, including participants from Mexico, Spain, China, Japan, England, Australia, USA, France, Germany, Canada, Argentina, and Uruguay. This diversity underscores the need for robust strategies to address linguistic challenges and enhance TDC.

### 7.1. Codiscipline and Its Translation

*Codiscipline* (*Codisciplinary*) in English refers to collaboration between two or more disciplines that, while maintaining their methodological independence, work together in a coordinated manner to achieve shared goals. Translating "Codiscipline" into Spanish presents challenges, as no single term fully captures the balance of collaboration and autonomy. While "Codisciplina" is a direct adaptation, it lacks widespread recognition and may require contextual clarification. Alternatives like "Disciplinas Colaborativas" or "Colaboración entre disciplinas" attempt to convey the collaborative nature but may lose the nuance of maintaining distinct disciplinary perspectives. Clear definitions are crucial to avoid misinterpretations in multilingual academic contexts.

### 7.2. Crossdiscipline and Its Translation

*Crossdiscipline* (Crossdisciplinary) research refers to the collaborative engagement among distinct disciplines wherein each retains its methodological identity while contributing to a coordinated effort toward common objectives. Unlike approaches that analyze a problem solely from one disciplinary perspective and subsequently incorporate elements from another, crossdisciplinary research emphasizes an equitable partnership that preserves the integrity of each discipline's methods. This balanced interplay is challenging to render in Spanish, as no direct equivalent encapsulates both the collaborative nature and the maintained independence of the contributing disciplines. Translation attempts, such as "Cruzado-disciplinario," often fall short of conveying this nuanced meaning, leading to potential misunderstandings in multilingual academic contexts.

### 7.3. Acrossdiscipline and Its Translation

In English, the term *Acrossdiscipline (*Acrossdisciplinary) research describes a collaborative engagement between distinct disciplines wherein each maintains its methodological independence while contributing to shared objectives. Unlike approaches that fully integrate methods across fields, this research mode emphasizes coordinated interaction rather than complete methodological merging. Translating this concept into Spanish poses challenges, as literal translations such as "A través de disciplinas" often fail to balance collaboration and independent disciplinary contribution. Thus, careful consideration of terminology is required to ensure that the nuanced meaning is preserved in multilingual academic contexts.

### 7.4. Brief Definitions of the Terms

Building on the health-tech conceptual model presented in Section 4—where diverse experts from Computer Science, Biomedical Engineering, and Public Health initially worked independently before converging into a unified project—these definitions clarify distinct types of collaborative research:

**Codisciplinary:** This approach refers to collaboration between two or more disciplines that work together in a coordinated manner to achieve shared goals while maintaining their methodological independence. In the conceptual model, the researchers initially focused on their tasks (software development, device design, and community health analysis), which exemplifies codisciplinary collaboration where each

expert contributes their specialized knowledge without altering their disciplinary core.

**Crossdisciplinary:** In this model, collaboration creates a cross-section—a shared, temporary common space—where two disciplines intersect to apply one discipline's methods, theories, or concepts to address problems in another. For example, imagine the Public Health researcher in the conceptual model temporarily adopting a Computer Science analytical framework to understand community health data better. This temporary intersection enriches the research by enabling close interaction between disciplines while preserving their distinct methodologies.

**Acrossdisciplinary:** This approach is akin to a bridge that transfers elements of one discipline into another, facilitating collaboration by carrying methodological insights across disciplinary boundaries. In the later stages of the conceptual model, as researchers began integrating their contributions into a cohesive system, the work resembled an across-disciplinary collaboration—where techniques or insights from one field were brought into another to enhance the overall project without completely merging the distinct disciplinary identities.

## 8. CASE STUDY: INTEGRATIVE APPROACHES IN ACADEMIC COLLABORATION

Academic collaboration thrives on the interplay between disciplines, leveraging their unique strengths to address complex challenges. The CAC provides a framework to understand three pivotal forms of interaction—codisciplinarity, interdisciplinarity, and transdisciplinarity—each reflecting varying degrees of integration and methodological independence. This case study examines the practical applications, challenges, and transformative potential of these collaborative modes through illustrative examples, including experiences from the *Facultad de Filosofía y Letras en la Universidad de Buenos Aires* (UBA)[viii] in the context of university education.

### 8.1. Codisciplinarity in Archaeology and History

The CAC framework offers a valuable lens for understanding codisciplinary collaboration, particularly between Archaeology and History. In this example, both disciplines work in close coordination while maintaining methodological independence, a collaboration essential for addressing the specific challenges faced by History students. The course *Elementos de Prehistoria y Arqueología Americana para Historiadores*[ix] exemplifies how integrating diverse disciplinary perspectives can enrich academic inquiry and problem-solving (Campagno et al., 2024).

This course's codisciplinary relationship between Archaeology and History becomes indispensable for understanding complex archaeological terminology, dating systems, and contextual processes. Each discipline contributes unique tools and perspectives: historians need to incorporate archaeological concepts such as stratigraphic analysis and dating techniques, which offer precision in reconstructing the past and framing the meaning of findings. Conversely, archaeology benefits from historical contextualization, enabling the interpretation of material findings within their temporal and social frameworks.

For instance, studying archaeological sites related to pre-Columbian societies in the Americas necessitates close collaboration between these disciplines. Historians provide historical context by analyzing chronicles, records, and colonial documents, while archaeologists interpret material remains and data from radiocarbon dating, artifact analysis, and excavation contexts. This interaction not only enriches cultural understanding but also demonstrates how codisciplinarity can transcend the methodological limits of each field.

However, codisciplinary collaboration in teaching this subject faces significant challenges. Variations in technical terminology, methodological approaches, and epistemological priorities can impede effective interaction between students and faculty from both disciplines. The CAC framework offers practical strategies to overcome these obstacles by fostering a shared understanding of objectives and enhancing communication. This approach underscores the importance of establishing dialogic spaces where students can become proficient in archaeological tools and concepts while effectively applying them to address relevant historical questions.

In the course justification, we read:

> *"Las disciplinas sociales –se sabe bien– no constituyen compartimentos estancos. Caídas ya las distinciones decimonónicas acerca de qué ámbito corresponde en exclusiva a la Historia –el viejo reino de las fuentes escritas–, los historiadores han ingresado en mundos mucho más complejos y han entrado en diálogo con las más diversas disciplinas: entre ellas, la economía, la sociología, la geografía, la antropología y, ciertamente, también la arqueología. Esos diálogos no sólo han implicado la posibilidad de nuevas temáticas para el historiador: han implicado también, y de modo más decisivo, la posibilidad de nuevas herramientas para el arsenal de recursos de quien emprende un estudio histórico."*[x]

Reflecting on this codisciplinary relationship in university education underscores the potential of such collaborations to train professionals with a more comprehensive view of the past. Integrating archaeology and history not only facilitates problem-solving in the classroom but also contributes to developing innovative perspectives on the study of pre-Columbian societies. This case illustrates how codisciplinarity can evolve from a theoretical framework into an effective pedagogical practice addressing the complexities of humanities academic training.

## 9. ADVANCED COLLABORATIVE PARADIGMS

Exploring advanced collaborative paradigms, we delve into two key approaches that have reshaped contemporary research methodologies. The Interdisciplinary Research Approach emphasizes integrating diverse disciplinary methods to tackle complex challenges, fostering a collaborative environment where innovative solutions can emerge. In contrast, the Transdisciplinarity Research Approach transcends traditional boundaries by synthesizing knowledge across fields, creating holistic frameworks and novel methodologies to address multifaceted issues. Together, these paradigms underscore the

transformative potential of collaboration in advancing research across academic fields.

### 9.1. The Interdisciplinary Research Approach

Interdisciplinarity has become a cornerstone of contemporary research, driven by the recognition that many challenges cannot be fully understood or resolved within a single discipline. This approach combines methods and theories from diverse fields, enabling researchers to explore problems from multiple angles and leverage emerging technologies. Additionally, the development of digital tools—such as digital ontology or dictionaries—is underway to measure collaboration efficiency and support initiatives like university ranking corroboration.

### 9.2. Transdisciplinarity Research Approach.

While interdisciplinarity focuses on collaboration between disciplines, it is closely associated with transdisciplinarity. The latter seeks to transcend disciplinary boundaries further, promoting a knowledge synthesis beyond the mere sum of its parts (Klein, 1996). This integrative approach is crucial to overcoming the "false walls" between disciplines, recognizing the impact of culture on change, and how the exchange of principles, methods, and concepts can enrich the field of research (Klein, 2005).

This does not mean disciplines should be discarded (Camic, 2015); instead, we must embrace the idea of the interdisciplinary research process (Repko y Szostak, 2016) and its studies (Augsburg, 2016) to transform our educational institutions and impact their sustainability (Klein y Schneider, 2010).

### 9.3 Practical example of advanced collaboration

A practical example illustrating the utility of the CAC comes from a multi-institutional project on sustainable urban development centered on urban gardens (Stinchcombe, 2025). As part of the NSF-funded Research Coordination Network (RCN) on Urban Food, Energy, and Water, a series of workshops held at NJIT brought together researchers from environmental science, urban planning, sociology, and technology, along with community practitioners such as the Director of NYC Parks GreenThumb and local urban gardeners. Initially, these diverse participants faced challenges due to differing disciplinary languages and methodological approaches—computer scientists emphasized sensor and data integration, urban planners focused on sustainable design and policy, and sociologists examined community engagement and historical context. By applying the CAC framework, the author could map the stakeholder's interactions along the CAC, thereby facilitating the identification of areas for deeper integration and effective communication.

## 10. RESULTS, DISCUSSION, AND CONCLUSIONS

The results of this study clarify the diverse forms of academic collaboration, culminating in the development of the "Continuum of Academic Collaboration" (CAC). From disciplinary to transdisciplinary research, the CAC offers a robust framework for understanding and evaluating collaborative dynamics in scientific research. It is a conceptual and practical tool that helps researchers align their collaborative practices by clarifying terminology and resolving ambiguities in academic discourse.

Our analysis further reveals that challenges in academic collaboration extend beyond multilingual translation issues. Disciplinary-specific terminologies and methodological nuances complicate cross-cultural academic exchanges, as seen in variations in mathematical processes across different countries. This observation supports our thesis: a refined and unified framework like the CAC is essential for overcoming language barriers and bridging the epistemological and cultural divides between disciplines.

The emergence of open AI tools, such as ChatGPT, is beginning to transform TDC. These technologies facilitate real-time translation, context-sensitive interpretation, and integration of diverse disciplinary languages, thereby redefining traditional models of knowledge exchange. We identify two conventional modes of TDC—Mode 1, which is focused on theoretical knowledge integration, and Mode 2, which is oriented toward practical problem-solving. Our study suggests the emergence of a new "Mode 3," in which AI acts as a catalytic force that enhances communication processes and creates new opportunities for inclusive collaboration.

In conclusion, the CAC provides a strategic platform for more effective collaborative practices by ensuring all partners share a common conceptual language. Future research should explore how this framework can be operationalized across diverse academic settings to improve collaborative outputs further. By moving beyond traditional translation issues and focusing on the intrinsic languages of different disciplines, scholars can generate synergies that address complex research challenges in today's rapidly evolving scientific landscape.

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### 11.2 Materiales en español[xi]

To facilitate academic dialogue and broaden participation across linguistic communities, we provide access to supplementary study materials and a podcast in Spanish.

## 12. SOURCES


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## APPENDICES

### Appendix 1 Tables

**Table 1.-** Typology of Disciplinary Collaboration

| Prefix | Name | Definition | Example | S&E (HERD |
|---|---|---|---|---|
| intra- | Intradisciplinarity | Intradisciplinarity refers to collaboration within a single discipline, encompassing various subdisciplines or specializations within the field. It allows for greater specialization without crossing the general boundaries of the discipline. | A group of medical researchers collaborating on a study involving cardiology, neurology, and endocrinology conducts intradisciplinary research, with each subdiscipline providing a specialized | Medical Sciences |
| uni- | Unidisciplinarity | Unidisciplinarity describes research collaboration within the same discipline, focusing on a common problem. It fosters synergy among subfields or specialized areas without involving other | A team of economists working together to develop an economic model combining macroeconomic and microeconomic theory engages in unidisciplinary | Economics |
| multi- | Multidisciplinarity | Multidisciplinarity involves the participation of multiple disciplines in a research project. Each discipline contributes independently without truly integrating the approaches of other disciplines. | A research project on sustainability involving environmental engineers, economists, and sociologists, each working from their perspective, is | Environmental Engineering, Economics, |
| inter- | Interdisciplinarity | Interdisciplinarity is characterized by integrating methods, theories, and approaches from different disciplines to create a joint framework. It enables researchers to develop innovative solutions by overcoming disciplinary boundaries. | A study combining biotechnology, chemistry, and informatics to design new medications exemplifies interdisciplinary research, integrating knowledge and techniques from various disciplines to achieve a | Biotechnology, Chemistry, Informatics |
| co- | Codisciplinarity | Codisciplinarity refers to collaboration between disciplines that, while not fully integrating their approaches, cooperate in a coordinated manner to achieve common objectives. The disciplines | A team of historians and anthropologists jointly investigating the culture of an ancient civilization is engaged in codisciplinary research, where each | History, Anthropology |
| trans- | Transdisciplinarity | Transdisciplinarity transcends traditional disciplinary boundaries, integrating and synthesizing knowledge from diverse fields to create new conceptual frameworks and methodologies. It addresses complex problems with a holistic perspective. | An example of transdisciplinary research is a project that brings scientists, policymakers, and community leaders together to develop climate change mitigation policies by integrating science, technology, and | Environmental Sciences, Public Policy, Sociology, Engineering |

***Note:*** Although Table 1 provides a comprehensive typology of disciplinary collaboration, it reflects definitions primarily in English. Future iterations should include definitions and translations in additional widely used academic languages—such as French, German, and Mandarin—to enhance the global relevance of this work and address its limited linguistic scope. Moreover, the author's dissertation is in Spanish by Cristo Leon, 2024, IEU University, located in Puebla, Mexico. © 2024., and we are actively working on translating this table; these translations will be shared via the Open Science Framework. Source: https://osf.io/adxju

**Table 2.-** Specific Sources Identified in the GPE Model

| | General | Particular | Specific |
|---|---|---|---|
| Term | Definitions | Dimensions and Measures | Models |
| Convergence | *Fostering the Culture of Convergence in Research* (NAS et al., 2019) | The Definition, Recognition, and Interpretation of Convergent Evolution, and Two New Measures for Quantifying and Assessing the Significance of Convergence (Stayton, 2015) | *Convergence* (NAS, 2014) |
| Interdisciplinary | Defining Interdisciplinary Research | A Taxonomy of Interdisciplinarity<br><br>Approaches to Understanding and Measuring Interdisciplinary Scientific Research (IDR) (Wagner et al., 2011) | A Model for Interdisciplinary<br><br>Sustainability and Collaboration (Klein, 2020) |
| Collaboration | Defining a Collaborative Infrastructure (Selloni, 2017)<br><br>*Collaborative Research in the United States* (Link, 2020) | *Mapping the Common Collaborative Change Models to the NSF INCLUDES Five Elements of Collaborative Infrastructure* (NSF INCLUDES Coordination Hub,<br><br>Cultures and Organizations (Hofstede et al., 2010) | Collective Impact (Kania y Kramer, 2011)<br><br>*Collaborative Research in Organizations* (Adler et al., 2003) |

*Note.* Adapted from "General, Particular, Specific (GPE) Model" by Cristo E. Yáñez León, Patricia del C. Gerónimo Ramos, Yessica M. Borjas Mayorga, and Víctor H. Guzmán Zarate, in *Ciências Socialmente Aplicáveis: Integrando Saberes e Abrindo Caminhos: Vol. VI* (p. 179), 2022, Editora Artemis. CC-BY-NC-ND 2022.

## ENDNOTES

i Referencing Richard Feynman's approach underscores the value of simplicity and clarity in complex scientific explanations. His method involves breaking down ideas to the point where they can be explained in layperson's terms without losing rigor—a sound principle in transdisciplinary communication.

[ii] Our literature review revealed that "Cross-disciplinary" and "Across-disciplinary" are used interchangeably in our sources; therefore, we have adopted a single, comprehensive definition under the umbrella of codisciplinary research. However, should future studies indicate subtle differences—such as one term emphasizing coordinated yet independent contributions while the other implies a more integrated sharing of methodologies—it may be advantageous to delineate separate definitions to clarify these nuances for the reader.

iii The concept of convergence has become increasingly central to 21st-century scientific and technological research. As articulated by Mihail Roco and William Bainbridge, convergence describes a cyclical process of integration and divergence that drives innovation across disciplines (Bainbridge & Roco, 2016). It is both a historical phenomenon and a strategic response to complex, interconnected global challenges. Convergence fosters multidimensional research by promoting collaboration across traditionally distinct fields, emphasizing the integration of knowledge, methods, and technologies. Within institutional contexts—particularly R01 polytechnic universities—adopting a convergent approach has direct implications for faculty hiring, cross-departmental collaboration, and research capacity building. By facilitating interdisciplinary synergy, convergence supports the development of innovative frameworks that are vital for addressing contemporary problems and advancing institutional excellence.

[iv] A *meta-language* is a language or set of terminologies developed to facilitate communication across disciplines. In the context of the CAC, a meta-language helps clarify ambiguous or culturally bound terms that might otherwise hinder collaboration.

v The GPE Model, adapted from León et al. (2022), is a bibliographic tool used to classify literature based on its conceptual scope: general theories, particular frameworks, and specific applications. It supports clarity and traceability in systematic reviews.

[vi] The Delphi technique, developed in the 1950s by Norman Dalkey and Olaf Helmer at the RAND Corporation (Frey, 2018, p. 1092), was initially designed to forecast technological trends. It employs a structured, iterative process in which a panel of experts anonymously responds to questionnaires across multiple rounds. After each round, a summary of the group's responses is shared, allowing participants to revise their views in light of emerging consensus. The method integrates both qualitative (e.g., open-ended responses) and quantitative (e.g., Likert-scale items) data collection. Widely applied in education, business, and health care, the Delphi technique has also gained prominence in counseling, psychology, and transdisciplinary research. Its strength lies in its ability to build consensus in areas characterized by complexity, uncertainty, or limited empirical evidence. In this study, the Delphi process was particularly valuable for refining conceptual frameworks such as the Continuum of Academic Collaboration (CAC), enabling expert validation and cross-disciplinary alignment.

[vii] Lingua franca is a language used as a standard means of communication among speakers of different native languages, facilitating interaction in diverse linguistic contexts. Historically, Latin served as a lingua franca in Europe, while today English fulfills this role in many international and academic settings.

[viii] Personal translation: Faculty of Philosophy and Letters at the University of Buenos Aires.

[ix] Personal translation: Elements of Prehistory and American Archaeology for Historians.

[x] Personal translation: As is well known, social sciences are not isolated compartments. With the fall of 19th-century distinctions about what domain exclusively belongs to History—the old realm of written sources—historians have entered much more complex worlds and engaged in dialogue with a wide range of disciplines: among them, economics, sociology, geography, anthropology, and indeed, archaeology. These dialogues have enabled new themes for historians to explore and, more decisively, have provided new tools for the arsenal of resources available to those undertaking historical studies.

[xi] These resources are made available via the Open Science Framework (OSF) and include translated tables, typologies, and explanatory figures related to the Continuum of Academic Collaboration (CAC). Access the study materials here: https://osf.io/7v5ac. Access the podcast here: https://osf.io/zum67