Journal of Systemics, Cybernetics and Informatics (2024) 22(6), 18-34
https://doi.org/10.54808/JSCI.22.06.18

Overcoming Obstacles to Interdisciplinary Research: Empirical Insights and Strategies

[*] Cristo Leon[1], James Lipuma[2]

[1]New Jersey Institute of Technology
[2]New Jersey Institute of Technology
[1]Leonc@njit.edu, [2]Lipuma@njit.edu

Abstract[1]

This paper presented the significant obstacles to effective interdisciplinary research and discussed strategies to enhance transdisciplinary communication necessary to overcome them. To effectively tackle complex global issues, it is crucial to recognize the pivotal role of interdisciplinary collaboration. This study examined the importance of overcoming communicative barriers to foster innovation and progress. The researchers employed a systematic literature review with a grounded theory approach to navigate the empirical landscape surrounding interdisciplinary research barriers and communication strategies. The findings identified critical barriers, including diverse disciplinary jargon, methodological differences, and a prevailing culture of disciplinary silos. The researchers identified effective strategies for surmounting these challenges, such as promoting inclusive research environments, establishing a common language for interdisciplinary dialogue, and creating transdisciplinary training and collaboration opportunities. The implications of this research suggested that strategic transdisciplinary communication can significantly mitigate barriers to interdisciplinary research, thereby enhancing collaborative outcomes. The authors included two practical examples of the application of transdisciplinary communication to the research collaboration.

Moreover, the paper examined specific, actionable strategies that institutions and researchers can implement to foster a more conducive environment for interdisciplinary endeavors. Future directions highlighted in this paper included the need for further empirical research to refine the identified strategies and explore new methodologies for facilitating interdisciplinary collaboration. Additionally, the researchers emphasized the importance of institutional support in implementing these strategies, suggesting a holistic approach to encouraging transdisciplinary communication and collaboration.

Keywords: *Transdisciplinary Communication, Interdisciplinary Collaboration, Disciplinary Silos, Communication Barriers, Collaborative Convergence Pyramid (CCP), Universal Strategic Planning (USP) Model, Multi-disciplinary Engagement, Research Methodologies, Inclusive Research Environments, Empirical Strategies.*

---

[*] Cristo Leon is the contact author.

[1] The peer editors for this article are Jose Ernesto Malpica Rosendo, Colegio Preparatorio Vespertino de Xalapa, and Jasmin Cowin, Touro University, Graduate School of Education.

1. Introduction and Background

Addressing complex global challenges necessitates integrating diverse disciplinary knowledge, essential for advancing scientific exploration. However, significant communication barriers from each discipline's specialized languages, methodologies, and worldviews often obstruct this synthesis. These barriers frequently lead to misunderstandings, misaligned research objectives, and conflict (Pellmar & Eisenberg, 2000, p. 42). While much analysis has focused on the disputes that arise from such barriers, there is a need for more discussion on how to foster collaboration effectively (Rieley, 2014).

Transdisciplinary communication (TDC) is crucial in overcoming these divides by bridging intercultural and interdisciplinary gaps. This paper explores how TDC can be harnessed more effectively to mitigate conflict and enhance collaboration among diverse research teams (Ho et al., 2021). What strategies can be implemented to ensure that TDC effectively unifies varied research endeavors, thereby driving collective progress? Furthermore, the National Academy of Sciences emphasizes the insights from "Social sciences and humanities scholarship on the effectiveness of multi-, inter-, and transdisciplinary teams can inform theory, best practices, and organizational structures employed in convergence programs" (2014, p. 96).

Enhancing transdisciplinary communication has substantial implications for the future of interdisciplinary research. By employing strategies such as fostering inclusive environments and utilizing structured frameworks for collaboration, researchers can effectively mitigate barriers to communication. This seamless integration of diverse disciplinary insights amplifies the potential for innovative solutions to complex global challenges and enhances the overall effectiveness of research collaborations.

A case study from Mexico exemplifies the necessity of understanding historical educational developments and their impact on interdisciplinary communication.

In 1960, the University Council of the National Autonomous University of Mexico (UNAM) formally approved the curriculum for the Psychology degree. This curriculum created a mosaic of subjects that barely related their theoretical and methodological contents to each other, accompanied by professors from diverse knowledge fields. This diversity inadvertently promoted an unclear disciplinary profile and perpetuated a distortion of the graduate profile based on superficial eclecticism. This scenario illustrates how historical, educational decisions continue to impact modern educational and interdisciplinary practices, highlighting the importance of addressing these foundational issues through TDC.

The Evening Preparatory College of Xalapa (CPVX) in Veracruz is a modern example of addressing these challenges. It aims to train students competent for entry into higher education institutions by generating innovative strategies that impact student training. Within the framework of Psychology, CPVX designed a plural teaching program, choosing Behaviorism as the initial approach due to its structured theoretical and methodological body. This approach allows for effective comparison of student performance before and after intervention (pre-post test). Analysis of these results reveals diverse conceptions of what Psychology entails—its concepts, methods, and operations—highlighting the need for tailored communication strategies that respect each discipline's cognitive and cultural contours. By adapting communication methods to suit each discipline, TDC can bridge gaps in understanding and foster a more productive research environment.

To further explore the theoretical underpinnings of transdisciplinary communication and its impact on educational structures and collaborative practices, the following section delves into critical theories and models that inform our approach to understanding and improving interdisciplinary interactions.

2. Theoretical Framework

We classify research approaches into six categories: Disciplinary, uni-disciplinary, multi-disciplinary, cross-disciplinary, inter-disciplinary, and trans-disciplinary, as these distinctions are critical for understanding the scope and methodology of collaborative scientific endeavors (Callaos & Leon, 2024; Choi & Pak, 2006; Hall et al., 2012; NAS, 2014; Stember, 1991).

Disciplinary research (DR) refers to research conducted within the boundaries of a specific academic discipline or field of study. In disciplinary research, scholars investigate and advance knowledge within their specialized area of expertise, adhering to their discipline's established methods, theories, and paradigms. For example, an individual mathematician uses mathematic modeling in isolation.

Uni-disciplinary research (UDR or Intra-disciplinary Research) occurs within a single discipline, utilizing norms and methods specific to that discipline to address research questions applicable solely to that field. This approach maintains a focused perspective, delving deeply into subject-specific nuances without integrating insights from other disciplines. For example, an individual mathematician uses mathematic modeling and collaborates with a mathematical statistician.

Multi-disciplinary research (MDR) draws on knowledge from different disciplines, but each stays within its borders. This approach provides various perspectives to address complex, real-world problems by juxtaposing insights in parallel without integrating them, thereby enriching the analysis through diverse disciplinary lenses. For example, an individual mathematician uses mathematic modeling to develop a product, which a Chemist then uses to create a suit of different experiments.

Co-disciplinary research (CDR) involves using methods and assumptions from a single discipline to cross disciplinary borders to address questions outside the scope of the original discipline. This approach does not integrate methodologies or theories from other fields but applies its tools to new, often unrelated areas. For example, a mathematician works with a chemist to design and refine a mathematical model that the Chemist will use to create a suite of different experiments, and the Chemist provides feedback to the mathematician.

Inter-disciplinary research (IDR) integrates research methods, knowledge, assumptions, and frameworks from separate disciplines to address a shared research question. This form of research relies on a synergistic combination of discipline-oriented viewpoints to solve a common problem collaboratively. Interdisciplinary research is distinguished by its integrative method, which blends and synthesizes disparate disciplinary perspectives into a coherent whole that addresses complex questions more effectively than any single discipline alone. For example, a mathematician and a chemist collaborate to understand each other's areas of expertise, integrating diverse methods into the mathematical model the research group will use to create different experiments. They will both review the feedback to improve the model.

Trans-disciplinary research (TDR) occurs when ideas from one or more disciplines provide insights that transcend traditional disciplinary boundaries. This approach not only crosses but also blends and synthesizes these boundaries to create new frameworks and understandings beyond the scope of any contributing field. For instance, consider a collaboration involving a mathematician, a chemist, a pharmaceutical company, and a community health organization. Together, they integrate their distinct expertise to address real-world needs and contexts. This partnership leads to the development of innovative mathematical models tailored for community use, demonstrating how TDR generates methods and solutions that are directly applicable and beneficial to society, which involves perspectives from all groups.

Trans-disciplinary communication (TDC) The etymological root of the prefix "trans-" was chosen for "Transdisciplinary Communication" because it generally covers the specific meanings that have subsequently emerged, making it a general term from which more specific meanings are derived. The term indicates communication that goes "across" or "beyond" various disciplines. This definition underscores the role of TDC in facilitating communication that spans and extends beyond traditional disciplinary boundaries, thus fostering a more integrated approach to addressing complex challenges.

We focused on interdisciplinary research for our discussion, emphasizing the importance of a synergistic and integrative approach to tackling shared research challenges. We believe that Transdisciplinary Communication (TDC) is crucial in increasing the effectiveness of interdisciplinary research (IDR). TDC facilitates the exchange of ideas, methods, and knowledge across disciplinary boundaries, enhancing understanding and cooperation among diverse research teams. This communication strategy is essential for achieving a deeper integration of varied academic perspectives, which is necessary to effectively address complex, multifaceted problems. The methods section will detail the approaches used to assess the efficacy of these strategies, drawing on empirical insights from the authors' extensive experience in submitting over 1500 research proposals and collaborating with multiple stakeholders in transdisciplinary research projects. This section will explain the systematic approaches and data collection techniques that underpin our empirical investigations, providing a comprehensive understanding of how theoretical strategies are translated into practical actions. This experience enriches our analysis, offering a real-world perspective on the challenges and successes of implementing transdisciplinary communication and collaboration across diverse research settings.

3. Methods

Our approach to understanding and addressing the communication barriers in interdisciplinary research involves a literature review guided by the General, Particular, Specific (GPS) model (Yáñez León, Gerónimo Ramos, et al., 2022). This methodology facilitates a constructivist grounded theory (CGT) approach, providing a structured method to examine the empirical evidence surrounding the challenges and strategies of transdisciplinary communication (Charmaz, 2017). Through this analytical lens, combined with the authors' practical expertise of over ten years in collaborative research, we dissect the literature to identify barriers to effective interdisciplinary research (IDR) and the empirical strategies suggested for overcoming these challenges. To expand our perspective on these topics, we integrated an author from Mexico, which enriches our analysis with diverse cultural insights.

4. Systematic Literature Review

Within the broader discourse on interdisciplinary and transdisciplinary research, we employed a Grounded Theory (GT) Codification Funnel, a systematic approach to qualitative data analysis, as outlined by Bryant & Charmaz (2007). This methodology has evolved into a Constructivist Grounded Theory (CGT) approach, which begins with a comprehensive review of document titles and abstracts, segmenting these texts into manageable parts (Charmaz, 2017). These segments are subsequently coded with descriptive labels that encapsulate key ideas. Through iterative refinement, codes are streamlined to eliminate redundancy and overlap, ultimately consolidating into a cohesive set of themes. As the literature review progresses, patterns emerge, and a theory takes shape (Booth et al., 2012).

Our systematic review identified 2,189 documents focusing on collaboration, interdisciplinary, and transdisciplinary research. Our inclusion criteria required

that documents contain terms such as measurement, definitions, dimensions, or models in their titles, abstracts, or keywords. This led to excluding 2,116 documents due to non-compliance with these terms. The remaining 73 papers underwent axial codification and coding processes, from which only 14 were selected for in-depth review based on the commonality and relevance of the codes applied to these documents.

4.1 Report of the review

The literature suggests that creating research environments that are inclusive and welcoming can bridge these divides by encouraging and supporting interdisciplinary collaboration (Hess, 2022) by involving physical spaces and institutional cultures that value and reward transdisciplinary engagements. According to Pokojska, providing interdisciplinary training and fostering connections among researchers from various fields can also be crucial (2022). Another strategy is to establish a mature transdisciplinary dialogue based on a translation of perspectives, which involves understanding the point of view of others and creating intersubjectively shared senses and meanings (Donovan, 2020). Additionally, guidance from supervisors, informal exchange with transdisciplinary early career researchers, and access to resources and training are essential in supporting early career researchers in acquiring the necessary methods and skills for transdisciplinary research (Yanaky & Guastavino, 2022). Advanced strategies for enhancing transdisciplinary communication have emerged, highlighting the importance of carefully defining research problems and establishing a dialogue that transcends disciplinary boundaries. The Collaborative Convergence Pyramid (CCP) framework, for example, offers a dynamic model for fostering effective communication and collaboration among diverse stakeholders, reducing uncertainty as participants move towards the pyramid's apex where collaborative convergence yields sustainable solutions (Lipuma et al., 2023, pp. 24–25).

Similarly, the Universal Strategic Planning (USP) model serves as a tool for facilitating collaboration and communication across a wide array of stakeholders, utilizing a logic model diagram enhanced with dimensions for pre-planning and assessment (Yáñez León, Lipuma, et al., 2022). These models and strategies underscore the potential of transdisciplinary communication in overcoming the entrenched barriers of disciplinary differences, fostering a culture of collaboration that can address the complex challenges of our time more effectively. Moving forward, we will delve into one of the most significant impediments—disciplinary silos—examining how these silos manifest within research environments, the cultural and communicative norms that reinforce them, and their impact on collaborative efforts. This exploration is crucial for elucidating the necessity of dismantling these barriers to foster a more integrated and productive research community.

5. Disciplinary Silos

Disciplinary silos tend to create a significant communication barrier. Different academic disciplines develop unique jargon, theories, and methodologies, which can be incomprehensible to outsiders (Davies, 2023). This specialization is further compounded by variations in communication styles and expectations, making it difficult for researchers to find common ground (Daniel et al., 2022). The challenge is not merely linguistic but rooted in fundamentally different ways of seeing and interpreting the world. Moreover, more professional integration and collaborative practice are needed to address these issues. Researchers often operate within their disciplinary confines, with limited opportunities or incentives to engage across these boundaries (Chan & Wheeler, 2023). Even when interdisciplinary projects are initiated, the absence of a shared language and mutual understanding can hinder effective collaboration and innovation (Shellock et al., 2023). Various barriers can impede effective communication among researchers across different disciplines. These barriers include disciplinary assumptions, differences in

communication styles, variations in the scale and scope of partner contributions, failure to integrate holistically, and an inability or unwillingness to share project control (Djinlev et al., 2023). We now turn to examine specific strategies that can enhance this transdisciplinary communication.

6. Strategies for Enhanced Transdisciplinary Communication

Several strategies can be implemented to unify varied research endeavors within Transdisciplinary Communication (TDC) and drive collective progress. First, fostering interdisciplinary research through design strategies can promote rich conversations and decision-making among diverse experts (Mittal et al., 2023). Implementing a coherent Data Management Sharing (DMS) plan can facilitate the generation of diverse and multimodal research data, incentivizing incremental communication while respecting research-specific requirements (LaPensee & Doshi, 2020; León & Lipuma, 2023). Additionally, adopting a stakeholder-oriented evaluation approach, such as Participatory Impact Pathways Analysis (PIPA), can facilitate mutual learning and the development of socially robust knowledge among participants. This approach enables monitoring and indicators of future outcomes (van Drooge & Spaapen, 2022). By integrating these strategies, TDC can effectively coordinate research efforts and advance collective progress in addressing complex societal challenges. The necessity for transdisciplinary communication stems from the diverse composition of research groups, which often include stakeholders from both academic and non-academic backgrounds. The following section will delve into how effectively implemented TDC strategies facilitate cross-disciplinary collaboration and significantly influence the outcomes and impacts of research projects. We will examine the ripple effects of these strategies on the broader scientific and societal landscapes, highlighting the potential for transformative change when diverse perspectives are seamlessly integrated.

7. Discussion and Recommendations

This paper has outlined the significant role that transdisciplinary communication (TDC) plays in enhancing collaboration across diverse disciplinary boundaries and in tackling complex global challenges. The strategies proposed aim to foster inclusive environments and employ structured frameworks for collaboration, deemed essential for mitigating communication barriers and maximizing the integration of interdisciplinary insights. However, this section will incorporate specific empirical evidence and explore potential criticisms to bolster the arguments presented and enhance the study's robustness.

7.1 Empirical Evidence and Case Studies:

To substantiate the theoretical propositions made, providing empirical evidence that illustrates the successful implementation of TDC strategies is helpful. For example, over the past four years, the Collaborative for Leadership, Education, and Assessment Research (CLEAR) has implemented a structured framework for TDC, resulting in various initiatives:

- STEM for Success 2021
- Journal of Roleplaying Studies and STEAM 2022
- A conference for the Association for Trans-Disciplinary Communication (AFTDC) 2024
-

CLEAR has facilitated numerous interdisciplinary projects by incorporating diverse methodologies and perspectives from science, engineering, and social sciences. Data derived from these projects can demonstrate the tangible benefits of TDC in terms of increased innovation, improved problem-solving capabilities, and enhanced participant satisfaction (Lipuma et al., 2022).
Furthermore, integrating best practices, frameworks, and methodologies has led to a series of articles consolidated in the book *Reflections on Communication, Collaboration, and Convergence: Strategic Models for STEM Education and*

Research (Lipuma et al., 2023). This book served as the foundational framework for a case study from a regional collaboration, such as the Newark STEM Ecosystem[2]. This case study, which involved teams from different geographical cities and academic backgrounds across the state of New Jersey, provides insights into the challenges and successes associated with implementing TDC on a regional scale, focused on workforce readiness and student success. TDC was essential in fostering collaboration and leading the group's strategic planning in creating the community's Vision, Mission, and Goals. An outcome of this effort was that on January 11, 2024, the re-launch event successfully convened a diverse group of stakeholders, drawing participation from 31 educational institutions and 39 organizations spanning various sectors. The event brought together over 100 stakeholders from K-12 and higher education, government, industry, community organizations, and nonprofits. This broad assembly underscores the comprehensive and multi-sectoral engagement aimed at fostering collaborative initiatives. Currently, volunteers are communicating with the executive committee and task forces to implement the various initiatives needed to accomplish the vision and mission developed at the collaborative event.

7.2 Exploration of Counterargument**s:**

While TDC offers numerous benefits, it is also necessary to acknowledge and address potential criticisms and limitations of interdisciplinary approaches. Critics may argue that TDC can dilute disciplinary depth in favor of breadth, potentially undermining the expertise required to tackle highly specialized research areas

.

However, proponents emphasize integrating diverse perspectives to address complex issues effectively (Croucher, 2023; Klein, 2022; Pokojska, 2022). Transdisciplinary approaches aim to bridge the gap between disciplines by

[2] The Newark STEM Ecosystem (Newark STEM) focuses on workforce readiness and envisions a support system that prepares the Pre-K-20 students to participate in the 21st Century STEM/STEAM workforce.

fostering collaboration and understanding across domains, enhancing problem-solving capabilities (Patry, 2022). This facet has been explored in the Arts especially (Burnard, 2022). By combining General Theories that transcend specific disciplines with practical action models, Trans-Domain Approaches (TDA) offers a structured framework for addressing multifaceted problems. While some may fear a loss of specialized knowledge, the inclusive nature of transdisciplinary communication enables a holistic view that can lead to innovative solutions and a deeper understanding of interconnected issues. Additionally, skepticism often arises regarding the practical implementation of TDC, particularly in traditional research environments where disciplinary silos are deeply entrenched (Krishnan, 2009). Addressing this concern involves discussing strategies for gradual cultural change within institutions, advocating for policy adjustments, and highlighting leadership roles in fostering an environment conducive to TDC.

7.3 Recommendations:

Based on the discussion above, the following recommendations are proposed to help individuals who wish to begin exploring interdisciplinary collaboration with TDC:

- Consider divulgation and not just dissemination; for example, communicate your work to members of other disciplines, stakeholders, and different communities.
- Create physical spaces and allocate time to foster collaboration: workshops and face-to-face meetings with multi-stakeholders to facilitate conversations.
- Seek collaboration outside your discipline, with an intentional effort to understand the value and methods of the other collaborators.

Additional recommendations for systemic changes that can be enacted are:

Source: https://www.newarkstem.org/

- Develop and deploy targeted training programs for researchers that focus on skills essential for TDC, such as effective communication, conflict resolution, and cultural competence.
- Establish clear guidelines and frameworks for TDC that different research organizations can adapt to fit their specific needs and contexts.
- Encourage funding bodies to prioritize projects demonstrating genuine interdisciplinary collaboration, incentivizing researchers to engage in TDC practices.

8. Future Directions

Looking ahead, the research community should prioritize further empirical studies to refine the identified strategies and discover new methods for fostering effective interdisciplinary collaboration. A significant need exists for institutional support in implementing these strategies, underscoring the importance of a holistic approach to encouraging transdisciplinary communication and collaboration. This approach should establish transparent processes that can be articulated into policies. Additionally, developing new models and frameworks to support these endeavors represents a promising area for future research. This concerted effort will enhance the quality and impact of interdisciplinary research and contribute to a more integrated and cohesive scientific community.

9. Conclusion

Effective communication among researchers from different disciplines is essential for addressing the complex challenges of our time. This study underscores the critical barriers to such communication and offers empirical insights and strategies for overcoming these obstacles through Transdisciplinary Communication (TDC). By embracing these strategies and

frameworks, the research community can enhance interdisciplinary collaboration, paving the way for groundbreaking innovations and solutions.

10. Acknowledgments

The authors thank Sandy Chang and Cynthia Shafer for their unconditional support.

Peer Editors

Jose Ernesto Malpica Rosendo, Maestro.
Colegio Preparatorio Vespertino de Xalapa.

Non-blind Reviewer

Edgar Meritano
Department of Sciences and Arts for Design, Research and Knowledge.
Universidad Autónoma Metropolitana.

Resources

Booth, A., Papaioannou, D., & Sutton, A. (2012). *Systematic Approaches to a Successful Literature Review, First Edition* (1st ed.). SAGE Publications Ltd.

Bryant, A., & Charmaz, K. (Eds.). (2007). *The SAGE Handbook of Grounded Theory, First Edition* (1ra Edición). SAGE Publications Ltd.

Burnard, P. (2022). Critical Openings in Performing Transdisciplinary Research as/in Rebellion. In *Doing Rebellious Research* (pp. 15–33). Brill. https://doi.org/10.1163/9789004516069_003

Callaos, N., & Leon, C. (2024). *Communicación Transdisciplinaria (Versión 3/2/2024) [Preprint]* (CLDM_Dv). Academia; /Research/Collaboration & Convergence. https://www.researchgate.net/publication/378681635_COMMUNICACION_TRANSDISCIPLINARIA_Version_322024

Chan, K. Y. (Karen), & Wheeler, J. D. (2023). Common Interests Without Common Expertise: Reflections on Early-career Experiences in Cross-disciplinary Research. *Integrative and Comparative Biology*, *63*(6), 1543–1549. https://doi.org/10.1093/icb/icad035

Charmaz, K. (2017). The Power of Constructivist Grounded Theory for Critical Inquiry. *Qualitative Inquiry*, *23*(1), 34–45. https://doi.org/10.1177/1077800416657105

Choi, B. C. K., & Pak, A. W. P. (2006). Multidisciplinarity, Interdisciplinarity, and Transdisciplinarity in Health Research, Services, Education and Policy: 1. Definitions, objectives, and evidence of effectiveness. *Clinical and Investigative Medicine*, *29*(6), 351–364.

Croucher, S. M. (2023). Introduction to the interdisciplinary nature of communication. *Review of Communication*, *23*(2), 95–97. https://doi.org/10.1080/15358593.2023.2207259

Daniel, K. L., McConnell, M., Schuchardt, A., & Peffer, M. E. (2022). Challenges facing interdisciplinary researchers: Findings from a professional development workshop. *PLOS ONE*, *17*(4), e0267234. https://doi.org/10.1371/journal.pone.0267234

Davies, J. A. (2023). Understanding and Crossing Disciplinary Boundaries. In F. (Kevin) Jiang, J. Dong, & L. Buckingham, *Interdisciplinary Practices in Academia* (1st ed., pp. 93–109). Routledge. https://doi.org/10.4324/9781003263067-8

Djinlev, V., Dallo, I., Müller, S. M., Surchat, M., von Rothkirch, J., Wenger, A., & Späth, L. (2023). Challenges and strategies in transdisciplinary research - early career researchers' perspectives. *GAIA - Ecological Perspectives for Science and Society*, *32*(1), 172–177. https://doi.org/10.14512/gaia.32.1.16

Donovan, S. (2020). The Landscape of Challenges for Cross-Disciplinary Activity. In *The Toolbox Dialogue Initiative*. CRC Press.

Hall, K. L., Vogel, A. L., Stipelman, B., Stokols, D., Morgan, G., & Gehlert, S. (2012). A Four-Phase Model of Transdisciplinary Team-Based Research: Goals, Team Processes, and Strategies. *Translational Behavioral Medicine*, *2*(4), 415–430. https://doi.org/10.1007/s13142-012-0167-y

Hess, A. (2022). Crossing Disciplinary Borders to Improve Requirements Communication. In M. Felderer, W. Hasselbring, H. Koziolek, F. Matthes, L. Prechelt, R. Reussner, B. Rumpe, & I. Schaefer (Eds.), *Ernst Denert Award for Software Engineering 2020: Practice Meets Foundations* (pp. 115–141). Springer International Publishing. https://doi.org/10.1007/978-3-030-83128-8_7

Ho, E., Jeon, M., Lee, M., Luo, J., Pfammatter, A. F., Shetty, V., & Spring, B. (2021). Fostering interdisciplinary collaboration: A longitudinal social network analysis of the NIH mHealth Training Institutes. *Journal of Clinical and Translational Science*, *5*(1), e191. https://doi.org/10.1017/cts.2021.859

Klein, J. T. (2022). Inter-/Transdisciplinary Research. In *The International Encyclopedia of Health Communication* (pp. 1–6). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119678816.iehc0943

Krishnan, A. (2009). *What Are Academic Disciplines? Some Observations on the Disciplinarity vs. Interdisciplinarity Debate*. ESRC National Centre for Research Methods, NCRM Working Paper Series. http://eprints.ncrm.ac.uk/783/1/what_are_academic_disciplines.pdf.

LaPensee, E., & Doshi, A. (2020). Collective creativity: Strategies for catalyzing interdisciplinary research. *Journal of Science Communication*, *19*(4), C05. https://doi.org/10.22323/2.19040305

León, C., & Lipuma, J. (2023, September 12). *Data Management Sharing Plan: Fostering Effective Trans-Disciplinary Communication in Collaborative Research [Keynote]* [Keynote]. Proceedings of the 27th World Multi-Conference on Systemics, Cybernetics and Informatics: WMSCI 2023, Online. https://www.iiis2023.org/wmsci/website/keynotespeakers.asp?vc=1

Lipuma, J., Bukiet, B., & León, C. (2022). *STEM for Success Inaugural Annual Report [Report]* (CLDM_Dv; Annual Report 1; p. 18). New Jersey Institute of Technology; /Research/Education. https://digitalcommons.njit.edu/stemresources/36

Lipuma, J., Yáñez León, C. E., & Guzmán Zarate, V. H. (2023). *Reflections on Communication, Collaboration, and Convergence: Strategic Models for STEM Education and Research [Mito Editorial]* (CLDM_LDO; 1ra Edición). Mito; /Research/Collaboration & Convergence. https://digitalcommons.njit.edu/stemresources/37/

Mittal, D., Mease, R., Kuner, T., Flor, H., Kuner, R., & Andoh, J. (2023). Data management strategy for a collaborative research center. *GigaScience*, *12*, giad049. https://doi.org/10.1093/gigascience/giad049

NAS. (2014). *Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond* (1ra Edición). The National Academy Press. https://doi.org/10.17226/18722

Patry, J.-L. (2022). From Trans-Disciplinary Research to Trans-Domain Approaches. *Journal of Systemics, Cybernetics and Informatics*, *20*(3), 1–12. https://doi.org/10.54808/JSCI.20.03.1

Pellmar, T. C., & Eisenberg, L. (2000). Barriers to Interdisciplinary Research and Training. In *Bridging Disciplines in the Brain, Behavioral, and Clinical Sciences*. National Academies Press (US),

Behavioral Institute of Medicine (US) Committee on Building Bridges in the Brain. https://www.ncbi.nlm.nih.gov/books/NBK44876/

Pokojska, J. (2022). The New Paradigm of Communication Within the Transdisciplinary Research. *Journal of Systemics, Cybernetics and Informatics*, *20*(4), 60–65. https://doi.org/10.54808/JSCI.20.04.60

Rieley, J. B. (2014). Overcoming the Barriers to Effective Collaboration. *Global Business and Organizational Excellence*, *33*(3), 37–45. https://doi.org/10.1002/joe.21542

Shellock, R. J., Cvitanovic, C., Badullovich, N., Catto, D., DelBene, J. A., Duggan, J., Karcher, D. B., Ostwald, A., & Tuohy, P. (2023). Crossing disciplinary boundaries: Motivations, challenges, and enablers for early career marine researchers moving from natural to social sciences. *ICES Journal of Marine Science*, *80*(1), 40–55. https://doi.org/10.1093/icesjms/fsac218

Stember, M. (1991). Advancing the social sciences through the interdisciplinary enterprise. *The Social Science Journal*, *28*(1), 1–14. https://doi.org/10.1016/0362-3319(91)90040-B

van Drooge, L., & Spaapen, J. (2022). Evaluation and monitoring of transdisciplinary collaborations. *The Journal of Technology Transfer*, *47*(3), 747–761. https://doi.org/10.1007/s10961-017-9607-7

Yanaky, R., & Guastavino, C. (2022). Addressing transdisciplinary challenges through technology: Immersive soundscape planning tools. *Proceedings of the Annual Conference of CAIS / Actes Du Congrès Annuel de l'ACSI*. https://doi.org/10.29173/cais1257

Yáñez León, C. E., Gerónimo Ramos, P. del C., Borjas Mayorga, Y. M., & Guzmán Zarate, V. H. (2022). Capítulo 14.- Modelo General Particular Especifico (GPE): Una Herramienta Convergente para la Revisión Sistemática de la Literatura. *Ciências socialmente aplicáveis: integrando saberes e abrindo caminhos*, *VI*, 173–183. https://doi.org/10.37572/EdArt_16122271214

Yáñez León, C. E., Lipuma, J. M., & Guzmán Zarate, V. H. (2022). Capítulo 15. Modelo Universal de Planificación Estratégica (UPE): Una Herramienta Deductiva para la Investigación Académica [Editora Artemis]. In A. Carvalho de Oliveira & V. Carvalho Mocellin (Eds.), *Ciências Socialmente Aplicáveis: Integrando saberes e abrindo caminhos.: Vol. VI* (CLDM_LDO; 1st ed., pp. 184–194). Editora Artemis; /Research/Business & Management. https://www.editoraartemis.com.br/artigo/33001/