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Trans-Disciplinary Communication in Collaborative Co-Design for Knowledge Sharing

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Abstract[1]

This article examines the importance of Trans-disciplinary Communication (TDC) in knowledge sharing when utilizing collaborative co-design (CCD) as a tool for large-scale collective change social innovation projects. The article describes CCD and important frameworks like "Collaborative Infrastructure" and the "Collaborative Convergence Pyramid." Next, the paper discusses knowledge sharing in this context as an essential mechanism to engage the participants effectively. As the co-design process is initiated and the work progresses, several tools of TDC are imperative, such as listening, translation, and facilitation. Then, the article presents how the tools of TDC allow for the effective CCD to progress and be led by the author. Finally, some practical, real-world examples of TDC in action for CCD will be shared. By illustrating practical, real-world examples of TDC in an effort for CCD, the article offers an insightful overview of this empowering process, not merely as a theoretical construct but as a dynamic and practical approach. This article underscores the innovative potential that TDC brings to knowledge creation and dissemination, making it an essential read for academics, practitioners, and policy-makers interested in collaboration, inclusivity, and transformative change.

Keywords: *Trans-Disciplinary Communication (TDC), Collaborative Co-Design (CCD), Knowledge Sharing, Collaborative Infrastructure, Collaborative Convergence Pyramid, Social Innovation, Facilitation, Translation, Inclusivity, Transformative Change*

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1. Introduction

In an era where complex problems defy singular disciplinary solutions, the role of Trans-Disciplinary Communication (TDC) becomes crucial for advancing large-scale social innovation projects. The context of this paper places TDC within the framework of Collaborative Co-Design (CCD). This powerful tool is a platform for multi-stakeholder involvement in shaping transformative change. Previous works in social innovation have often highlighted the siloed nature of disciplines, pointing to the limitations of a unidisciplinary approach in addressing societal issues. However, few have explored the operational mechanisms facilitating cross-disciplinary collaboration and knowledge sharing. This gap is particularly significant given the rising emphasis on Diversity, Equity, and Inclusion (DEI) in academic and policy discourses. This article aims to discuss and fill this gap by elucidating key frameworks such as "Collaborative Infrastructure" and the "Collaborative Convergence Pyramid," both of which play pivotal roles in catalyzing effective CCD. While knowledge sharing is universally acknowledged as a critical component for effective collaboration, this paper explores its practical application in trans-disciplinary settings.

This paper introduces critical TDC tools, such as active listening, translation, and facilitation, which serve as the cornerstone mechanisms for effective knowledge dissemination within CCD. We offer a refined understanding of engagement through a nuanced framework called the "Knowledge Generation & Communication Continuum" (KGCC). Additionally, the "Clarifying lexicon" section seeks to clarify essential recurring terms and concepts. Engineered to facilitate effective knowledge sharing, generation, and communication across diverse groups and innovative approaches, these TDC tools are particularly exemplified in our current project to develop the Newark Science, Technology, Engineering, and Mathematics Learning Ecosystem (Newark STEM)[2]. It's worth noting that the ultimate effectiveness of these tools and processes hinges on the competence and commitment of the individuals

[2] The website for the project is https://www.newarkstem.org/

who apply them.

2. Clarifying lexicon

In scholarly discussions concerning knowledge sharing, collaboration, and convergence, terminological precision is paramount for coherent dialogue and mutual understanding. This section, aims to elucidate critical recurring terms and concepts throughout this work. We will restrict what we mean by "Community of Practice," "Network," and "Convergence of Knowledge, Technology, and Society." The "Trans-Disciplinary Communication" concept will be addressed, as it is pivotal in fostering meaningful engagement across various domains. By establishing a lexicon, this section serves as a reference point for readers, enhancing clarity and facilitating interdisciplinary discussions.

Communities of Practice (CoPs) and Networks serve distinct but complementary roles in knowledge sharing and professional development. CoPs are characterized by the shared domain of interest among its members who engage in collective learning to improve their skills or understanding of a specific subject (Rock, 2020; Wenger-Trayner et al., 2023; Wenger-Trayner & Wenger-Trayner, 2011, 2015). This collective learning includes a shared passion for a subject and a structured methodology for community operation, as seen in the EU Framework (Catana et al., 2021). On the other hand, networks are broader and are not necessarily bound by a shared domain or interest. Networks serve as a medium for connectivity across different fields or interests and facilitate the transfer of information rather than deep collective learning. The concept of Convergence of Knowledge, Technology, and Society (CKTS) and the focus on multidisciplinary teams in addressing complex issues (Roco et al., 2013; Bainbridge & Roco, 2016) align more closely with networks, which are more flexible but may lack the depth of engagement found in CoPs.

2.1 Community of Practice (CoP):

According to Lave and Wenger, a "Community of Practice (CoP) is a group of individuals who share a common interest, passion, or domain of expertise" (1991). The members engage in collective learning through structured methodologies to enhance their skills or understanding of a specific subject. CoPs foster deep expertise within a specialized area and can catalyze systemic changes. CoPs tend to focus on deepening the expertise within a specialized area. They are also instrumental in systemic changes, as illustrated by the author's research on transitioning in-service educator training to blended learning (Yáñez León et al., 2023b).

2.2 Network:

A network is a broader construct not necessarily bound by a shared domain or interest. It serves as a medium for connectivity across varying fields or domains, facilitating the transfer of information. Unlike CoPs, networks prioritize breadth over depth, focusing on the dissemination of information rather than collective learning. As Henry Mintzberg said, "Networks connect; communities care" (Mintzberg, 2015).

2.3 Convergence of Knowledge, Technology, and Society (CKTS):

CKTS is an interdisciplinary framework integrating multiple domains such as science, technology, and societal concerns. It is aligned with the concept of networks, emphasizing the importance of multidisciplinary teams to address complex issues. CKTS operates on principles such as interdependence, creativity, and vision-inspired basic research to achieve solutions for societal challenges (Roco et al., 2013).

2.4 Collaborative Innovation:

This overarching concept entails the collective endeavor of stakeholders and team members to develop solutions or create products. It includes various similar terms used in interdisciplinary discourse, with the most inclusive category being co-

creation. Collaborative innovation sets the stage for assembling diverse participants to tackle shared challenges or opportunities, acting as an umbrella term that contains various subsets such as co-creation and co-design. It is marked by a level of consultation with the end-users or served population, although the creative team remains distinct from these end-users.

2.5 Co-creation:

Within the collaborative innovation framework, co-creation involves participants collaboratively working on a unified vision to develop solutions. It enhances team culture and promotes effective collaboration, often resulting in a distributed working style. Although the operating environment becomes more cooperative, the focus remains on co-creating and co-designing solutions. Co-creation emphasizes the significance of leadership spread across team members and is crucial for enabling a conducive working environment for researching and developing new solutions.

2.6 Co-Design:

This is a specialized facet of co-creation and involves a more targeted approach, often employing methodologies like experience-based, user-centered, and human-centered design. It also incorporates cooperative and participatory design principles. In co-design, the emphasis is on ongoing consultation with the users throughout the design process, informing each stage of the project. At its apex, users are integrated into every phase of the innovation process, providing feedback and participating in evaluation and redesign.

2.7 Social Innovation:

This is the process of developing and implementing positive collaborative changes that impact systems to overcome persistent vexing issues facing Society. Various approaches to social innovation utilize different levels of stakeholder involvement and degrees of collaboration and empowerment based on the scenario met and the

resources available. In our work, collective impact and collaborative infrastructure are two approaches needed for our social innovation efforts.

2.8 Collective Impact:

This is a network of interested stakeholders and influencers working on large-scale change in populations and systems. This a "collaborative approach to addressing complex social issues, consisting of five conditions: a common agenda; continuous communication; mutually reinforcing activities; backbone support; and shared measurement" (Graybeal, 2023).

2.9 Collaborative Infrastructure:

According to the website 'NSF INCLUDES Shared Measure' (2023) this is "a process by which partner organizations (1) engage their community to formulate a shared vision of what can be accomplished collaboratively; (2) provide a platform for collaborative action; (3) develop common goals, objectives, metrics, and data collection procedures to measure shared progress and inform decision making; (4) develop structures across partner organizations to enhance coordination, communication, and visibility; and (5) establish the capacity for the expansion, sustainability, and scaling of their shared efforts."

2.10 Collaborative Convergence Pyramid (CCP) framework:

The CCP framework is an analytical tool that fosters efficient and effective communication and collaboration among multi-sector stakeholders (Lipuma et al., 2023, p. 24). The pyramid features four external corners representing the academy, government, organizations, and society, forming an outer diamond. Recognizing that stakeholders can exist as individual entities and as systems, an additional internal diamond is introduced at the pyramid's base. This inner diamond accounts for the dual roles that individuals may occupy at different stages of their lives or careers. For example, a professor may transition to being a member of the broader society upon

retirement. Conceived as a dynamic model, the pyramid incorporates the concept of 'uncertainty,' which is most pronounced at the base level. As stakeholders ascend the pyramid, they engage in increasingly specific and targeted collaborative activities, reducing uncertainty. This culminates at the apex of the pyramid, where sustainable solutions are realized through collaborative convergence.

The CCP thus provides a multidimensional approach for understanding and navigating the complexities inherent in multidisciplinary collaborations. It is an invaluable tool for academics, policy-makers, and practitioners committed to fostering meaningful collaborative endeavors, especially in fields that intersect with STEM education and research. The CCP framework operationalizes critical elements such as communication paradigms, functional roles, linguistic barriers, and TDC. It is particularly relevant for convergence research, which necessitates the amalgamation of diverse disciplinary perspectives, including those from society, to address intricate and complex societal challenges.

2.11 Collaborative Co-Design:

In larger-scale social innovation projects, this approach engages all stakeholders to become part of the processes of design and implementation of innovations. It stresses listening and adjusting based on data and feedback as work progresses. It is inherently more complex and moves slower as the work is iterative and responsive to changes. However, engaging interested stakeholders and influencers at every stage provides voice, agency, and empowerment to the served community. This approach seeks to develop a bottom-up, community-sourced, and diversified set of actions and solutions that are personalized to each scenario to customize the individualized application of solutions within a larger population to attain positive system change.

2.12

Trans-Disciplinary Communication (TDC): TDC can be understood as an approach that facilitates the flow of information across different disciplines. It is

particularly relevant when discussing how CoPs and Networks might interact, especially when they share overlapping objectives (Callaos, 2022).

3. Knowledge sharing and collaboration

Before delving into the nuances of our research, it is pivotal to delineate the different types and degrees of knowledge creation and sharing that occur when working with others. While collaboration can broadly be understood as the synergistic efforts of two or more individuals or organizations, we employ a more nuanced framework for understanding this engagement: the "Knowledge Generation & Communication Continuum" (KGCC)" (Lipuma et al., 2023, p. 37). This framework illustrates how Trans-Disciplinary Communication (TDC) is critical across collaborative interactions (see Table 1).

Our research is mainly geared toward expanding and diversifying participation in STEM education across the entire educational expiriences from Pre-kindergarten (PK) to masters and doctoral. We have fostered a multi-sector trans-disciplinary research community by leveraging STEM education, digital learning, communication, and collaboration expertise. This community consists of diverse individuals focused on understanding and implementing necessary changes. In partnership with these stakeholders, we co-design solutions tailored for local enactment. These community-driven actions are both shareable and amenable to refinement, aiming for broader regional impact with the aspiration of eventually scaling to effect global societal change. Through this intricate mesh of collaborative planning, research, and action, we discern the potential for widespread success via STEM initiatives. In the forthcoming sections, we shall elaborate on the role of TDC in fostering such collaborative ecosystems and how it facilitates effective knowledge sharing at multiple levels of social engagement.

Table 1

Knowledge Generation & Communication Continuum

	Conceptual Degree of Integration				
Collaborations	Delegation	Cooperation	Connection	Integration	Innovation
Knowledge generation & Communication	Disciplinary	Multidisciplinary	Co-Disciplinary	Inter-Disciplinary	Trans-Disciplinary

Note. Adapted from *Reflections on Communication, Collaboration, and Convergence: Strategic Models for STEM Education and Research* p. 37, James Lipuma, Cristo E. Yáñez León, Victor Hugo Guzmán Zarate, 2023, Mito, Buenos Aires, Argentina.

Collaborative efforts are a developmental continuum that begins with delegation and progresses through successive stages of cooperation, connection, and integration to achieve innovation. In this perspective, collaboration is a shared activity and a committed, evolving process requiring mutual effort and alignment. The starting point is active listening and mutual learning, facilitating knowledge exchange and contributing to a vision of unified design and social innovation. The upcoming section will further elucidate this developmental trajectory of collaboration, articulating each stage's unique characteristics and conditions—Delegation, Cooperation, Connection, Integration, and Innovation. These stages represent the intricate dynamics that make collaborative work complex and a rich avenue for transformative change.

4. Timeline of expertise development

Many communication forms are required to develop sustainable solutions involving multiple organizations across diverse sectors (Lipuma et al., 2023). This is particularly true when the initiatives involve various stakeholders, such as educational professionals, government organizations, and the general public, especially within the K-12 educational context. Communication in these initiatives typically occurs in two scenarios: large-scale (lectures and town hall meetings) and small-scale (feedback sessions and working groups). Each of these requires different

communication tools and strategies. TDC is a framework that fosters effective interaction and facilitates the co-creation and exchange of knowledge, making it shareable with larger communities. CCD, the collective effort of stakeholders and targeted population members to seek synergistic and sustainable solutions, acts as a methodological approach for applying TDC. Over the last ten years, the authors have worked on research grants that provided them with expertise in collaborative change. As the scope and scale of these projects have expanded, and as the challenges faced have escalated into arenas of social transformation, there has been an increasing necessity to integrate multiple models and frameworks. This has led us to a holistic intersection of collaborative innovation and social innovation. To elucidate this trajectory, we will briefly review past projects to contextualize the approach adopted in our current project to develop the Newark STEM.

In 2014, the New Jersey Department of Education (NJDOE) issued a grant to develop an online professional learning exchange that utilized blended-learning modules. This project aimed to create a Professional Learning Community (PLC) to support curriculum changes tied to state standards and national movements, such as the Next Generation Science Standards (NGSS) (Yáñez León et al., 2023a). The project allowed for the decentralization of decision-making and design, facilitating the network's growth and adaptability. This work demonstrated the use of TDC as part of developing networks and a community of practice (CoP).

After completing the virtual network and CoP for the NJDOE, the author was granted a project to develop the Future Ready Schools - New Jersey (FRS-NJ) Certification Program (Lipuma & Yáñez León, 2022). This initiative, led by the NJDOE and several NJ non-governmental educational associations, aimed to cultivate technological readiness in schools through collaborative innovation strategies. This project utilized TDC as working groups, co-created and co-designed the FRS-NJ programs through volunteer committees, and hosted events to generate and share knowledge.

With these experiences, the authors brought together a multi-stakeholder group to

work on a social innovation issue around broadening the participation of women in STEM at the national level. The authors secured a grant from the National Science Foundation entitled the 'LiFE project' (Leadership in iSTEAM for Females in Education); in the NSF INCLUDES Design and Development Launch Pilot (Bukiet et al., 2021). This project utilized a collective impact framework and collaborative infrastructure to facilitate the collaborative innovation needed to build the functional components. These models required a great deal of knowledge sharing and communication facilitated by the tools of TDC. COVID-19 disrupted the project's regular operation and provided the opportunity to apply CCD solutions for virtualizing needed components for educators. This new focus brought about the STEM for Success project, designed to meet the needs of students, educators, and parents as STEM education was delivered in various instructional modes and learning environments.

Each of these past projects informs the various applications of TDC for knowledge sharing that are essential for our newest project, the development of the Newark STEM. This initiative aims to foster community engagement through collaborative co-design with interested stakeholders. It seeks to bring the national vision of STEM Learning Ecosystems to grassroots individuals interested in bottom-up design. This design aims to offer diverse, individualized, and resilient solutions, catering to the dynamic needs of K-20 STEM and STEAM education.

This article aims to elucidate the core principles underpinning collaborative co-design as a strategy for enabling TDC in the context of large-scale social innovation projects. When first developing the CoP for the NJDOE, the digital assets were drawn from the PowerPoint lectures of the agency officials. As we held feedback sessions and discussed the needs of the end-users, it became clear that the learning model needed to shift from sit-and-go presentations watched by educators (either virtually or in person) to demonstrations of the lesson development process and educator-led examples of teaching practice. As the needed mode of delivery was adjusted to the new methods of instruction and content, the community engaged more fully. By providing the opportunity for those at the point of contact to share knowledge, the

CoP was more about facilitating sharing and helping educators translate things to their own scenarios and school culture.

Drawing from this experience, the initiation of FRS-NJ began with predetermined content. However, this was merely a foundational framework for the broader national movement. Immediately, the work became sharing knowledge around these guidance frames and 'New Jerseyizing' them to allow the theoretical knowledge related to best practices for digital learning to be disseminated and discussed openly. Task forces were formed by bringing together interested stakeholders from the education community with parent organizations, government agencies, non-profits, and companies. These working groups grew organically over time as the community's shared knowledge was expanded through experiences. Moreover, the underlying network of stakeholders and interested influencers in the New Jersey educational space fostered continued growth of the FRS-NJ collective impact approach. Sharing the common agenda and vision for the work being accomplished allowed each local school district to co-design their own plan and co-create relevant solutions based on the community's shared knowledge. Over time, the communication about best practices and what worked in different arenas facilitated collaboration across district boundaries as organizations communicated about the shared metrics and their own culturally relevant knowledge of practice and problem-solving.

This was taken to a larger scale with the author's work on social innovation projects related to broadening participation in STEM (Bukiet et al., 2023). Starting with a collective impact approach, the various participants all saw the value of collaborative co-design through shared planning sessions, meetings of decision-makers at multiple levels, and open lines of communication. Knowledge generation and sharing were essential in these projects and worked at many different levels and sectors. Within the NJ educational community, teachers saw the value of sharing what they did to plan and implement lessons while also benefiting from presenting their lessons with a discussion of the local context, demographics, and limitations.

These collaborations allowed individuals to divulge their own best practices while

learning those of others in order to connect the academic research-based best practices to the practical experience and real-world conditions of teaching STEM to students. This knowledge sharing was made more critical with the shift to virtualized instruction during Covid-19. Thanks to the established relationships and the TDC strategies, educational professionals worked with a wide range of experts to learn, implement, and optimize mechanisms for teaching STEM within the demands of their own scenario. The ability to generate and share knowledge was essential for these projects. With TDC, the knowledge sharing helped highlight common problems and facilitated the co-creation of solutions.

Based upon the expertise generated in these projects, the authors were recruited to develop the Newark STEM. For this project, the team is applying TDC Strategies to enhance CCD at the early stages in order to facilitate knowledge sharing and give all stakeholders a means for voicing perspective and having agency to act towards the creation of a cradle to career network for fostering STEM college and career readiness.

5. Tools in the TDC approach

All the projects described in the 'timeline of expertise development' section involve varied groups of participants outside the world of research and academic disciplines. To effectively engage with these diverse groups in the different types of innovative approaches, the tools of TDC allow for effective knowledge sharing, generation, and communication of ideas. Moreover, these tools help facilitate the collaboration that must occur in the most complex scenarios. When working with a diverse group, TDC as a strategy is more appropriate than just a single set of skills to apply. At any one time, the critical mechanism of TDC may need to be leveraged to accomplish the innovation process. Ihlen (2020) underscores the value of interdisciplinary collaboration, precise rhetoric, science communication, and strategic communication, in addressing complex societal challenges like vaccine hesitancy. This approach is crucial for understanding how knowledge and credibility are socially constructed and

identifying how audiences interpret and interact with this information. By incorporating strategic and rhetorical elements, science communication can go beyond mere audience understanding to formulate targeted strategies to enhance credibility. Integrating these fields offers a comprehensive lens to navigate the intricacies of audience engagement and credibility building.

Each framework for collaboratively solving problems requires different aspects of TDC at other times. Communicating with members of a community of practice, stakeholders in a social innovation initiative, or partners in the collaborative infrastructure may seem straightforward, but all have a role for TDC. To create learning, this communication may need to divulge more about the underpinnings of the theory, translate methodologies into language that can be understood, or facilitate the participants' understanding through a series of different activities. Fostering understanding with TDC may require literal translation between languages. More often, the translation is from one culture to another to match the sociolects of the different communities coming together to collaborate on the problem. The different approaches can move beyond the need to find a common language to generate new knowledge while creating a space for discourse and sharing common understandings of problems and mechanisms for arriving at solutions. In this way, TDC makes common understanding with relevant analogies and metaphors to carry meaning beyond the literal transfer of knowledge as an accepted body of information to one of a culturally and community-generated set of understandings about the problem and pathways forward toward resolution.

Beyond this, those who can apply TDC tools can foster CCD by doing more than delivering the information to others and sharing their knowledge or that of their disciplines. Through CCD, the many participants come together to build common knowledge and form a shared vision of the work to be done. This collaborative innovation benefits from using TDC for knowledge sharing throughout the CCD process. As the common spaces are re-created and new partners are added, TDC helps facilitate the understanding and alignment of new participants, helping build momentum and supporting shared continuous communication. In addition, as the

complex problem shifts, an understanding of gathered data and changing aspects of the scenario can also be communicated across the many different types of participants and stakeholders through TDC.

7. Developing the Newark STEM

Much of the analysis and discussion of TDC for the different projects presented in the 'timeline of expertise development' is retrospective. Similarly, the other models and frameworks are often used descriptively rather than prescriptively. When developing the PLC, the authors did not fully understand the academic discourse on networks, CoPs, and other types of collective groups (León & Lipuma, 2023). When engaging with the development of social innovation and systems work, the authors worked to align their activities with the elements identified in the literature. However, these are often not applicable until the project reaches scale or can be at a sustainable stage. Over time, all of these various methods and frameworks were brought together through the application of TDC as the authors sought a shared working space for projects so that TDC as a strategy could augment their CCP approach to large-scale, innovative, collaborative change projects. When utilizing these strategies and approaches, TDC facilitates the CCD process for engaging and listening to stakeholders.

The process has become prescriptive during our most recent project, development of the Newark STEM, where TDC is used for knowledge sharing. Rather than think about what was done afterward by analyzing conversations and gathered data, these tools have been actively applied in small-scale working groups of three to five participants and large-scale meetings of up to fifty participants.

TDC helps facilitate sharing by fostering open dialogue and active listening to clarify points. For example, when working to design a webpage, the leadership team needed to identify the core actions of the intended group with a vision and mission. This was then shared with the larger community after several working sessions to reach

consensus about the needs of the participants around K-20 STEM learning needs in the region served by the new ecosystem.

On the other hand, when the larger group came together, individuals were asked to share their motivations for coming and the needs they saw. Rather than provide a list of actions the ecosystem wanted to offer or the larger organizational goals for STEM Learning, the CCD process invites everyone to provide contexts for their perspectives, allowing its participants to understand better the shared space in which we would all be working.

8. Conclusion

This CCD process for the Newark STEM is only beginning, but progress is more easily attained through the awareness of effective TDC strategies. TDC facilitates an open discussion amongst the participants and serves as a reminder to those who currently lead the activity to actively listen and work to generate the needed knowledge amongst the community. Rather than seeing themselves as the person to choose or organize, using TDC for CCD demonstrates how to facilitate, foster, and lead collaborative engagement and cultural exchange.

With a core built on the national vision of STEM learning for all applied to the local context of the Newark region in New Jersey, those who share similar interests can work more effectively with others in the same space. Ultimately, these tools and processes are only as good as those who will apply them. Any strategy may not yield the desired results, but knowing how to leverage best the strengths of all these different tools, approaches, and strategies for social innovation activity increases the likelihood of success. In the end, TDC and CCD mutually reinforce the work being done to empower the individuals as they work to share their voices to make a positive change for their community. Being active in this communication process also allows others to connect with those within the process to apply the new knowledge to the different contexts and scenarios each sub-group faces within any heterogeneous

community or system.

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