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SOME REFLECTIONS ON STEAM EPISTEMIOLOGIES: SYNKRASIS, MIXIS OR SYNTHESIS?

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Abstract: The introduction focuses on the ancient Greek concepts of *synkrasis* and *mixis*, linking them to modern interdisciplinary frameworks and STEAM education methodologies. It emphasizes the importance of evaluating the integration quality among STEAM subjects, highlighting a tendency among educators to oversimplify these relationships. The historical emergence of disciplines in the 19th century and their implications for knowledge production is discussed, noting critiques of rigid boundaries that limit inquiry. Interdisciplinarity, while a contemporary focus, has roots in ancient understandings, yet it now often struggles against the fragmentation of knowledge. The distinctions between interdisciplinary, multidisciplinary, and transdisciplinary approaches are clarified, with transdisciplinarity positioned as a more collaborative and integrative method that transcends traditional boundaries. Transdisciplinarity is identified as a vital research principle that fosters holistic integration, essential for addressing complex global challenges. It contrasts with temporary interdisciplinary collaborations by advocating for sustained change in scientific inquiry structures. The conclusion underscores the need for a nuanced understanding of disciplines and their historical context, advocating for a revival of coherent disciplinary concepts within transdisciplinary frameworks.

Keywords: interdisciplinarity, transdisciplinarity, synkrasis, mixis, STEAM.

INTRODUCTION

In initiating this discussion on a complex subject, we will first examine the ancient Greek concepts of *synkrasis* and *mixis*, before linking these ideas to contemporary frameworks of interdisciplinarity. This connection will subsequently inform our exploration of STEAM education methodologies. A critical aspect of this inquiry involves assessing the quality of integration among the diverse subjects within the STEAM paradigm, both in practical implementation and epistemological coherence.

To provide a context, the ancient Greeks offered valuable insights into the relationship between parts and wholes, which can illuminate the complexities

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modern science introduces. Galen, along with pre-Socratic thinkers, articulated the interconnectedness of elements as constitutive of a cohesive whole. Aristotle's contributions further enriched this discourse; however, it was Werner Jaeger (1959) who provided a clear distinction:

> The Greek term translated as "proper mixture" is *krasis*, signifying a specific kind of blend, contrasting with mere juxtaposition (*mixis*). S*ynkrasis*, derived from *krasis*, underscores a profound interpenetration, suggesting a "blend" that results in a harmonious unity among elements. Initially employed in Greek medicine to denote an indissoluble unity, it later found relevance in political philosophy to describe an ideal synthesis of social elements within the polis, and was also applied to the cosmos.

Moving forward, we will explore the relationships among subjects within the STEAM framework, questioning whether these connections are primarily interdisciplinary—facilitating easier integration—or transdisciplinary, necessitating more complex interrelations and thereby presenting greater challenges. Our focus will predominantly center on the epistemological implications of these connections.

Moreover, evidence suggests that educators often oversimplify the relationships among subjects within the STEAM framework, viewing them as additive associations rather than as integrative or blended interactions.

Disciplinary classifications emerged in the early 19th century, aiming to organize diverse fields of knowledge within European academia, with further refinements occurring in the 20th century (Stichweh, 2001). Each discipline possesses unique methodologies and epistemic practices tailored to specific objectives, leading to the theorization of disciplines as structures of power that classify and prioritize certain forms of knowledge while marginalizing others (Foucault, 1977; Moran, 2001). Critics have highlighted the limitations inherent in establishing boundaries that constrain the epistemological breadth of inquiry (Fam et al., 2018; Gibbs, 2017; Ingold, 2010). Consequently, the delineations between disciplines may be both distinct and ambiguous (Osborne, 2015).

Examining the interactions among the disciplines involved is imperative to effectively analyze the boundaries within and across science, STEM, and STEAM. Interdisciplinary interactions can be conceptualized in various ways: as efforts to create a unified knowledge framework that links disciplines, as challenges to traditional knowledge production, or as means to transcend the limitations of individual disciplines (Moran, 2001). For instance, interdisciplinary curricula may promote culturally responsive approaches to teaching mathematics (Zaslavsky, 1993) or encourage innovative methods for navigating rigorous student assessment standards (Kaufman et al., 2008). Conversely,

transdisciplinarity emphasizes a holistic integration of approaches, prioritizing the co-equal blending of disciplines (Choi & Pak, 2006; NASEM, 2018; Osborne, 2015). Peter Galison posits that interdisciplinarity facilitates "trading zones" for collaboration, whereas transdisciplinary approaches foster new ways of knowing through deeper integration of knowledge and methodologies (Galison & Stump, 1996).

Scholars have increasingly argued for the necessity of interdisciplinary and transdisciplinary approaches to address complex global challenges and enhance higher education to prepare future generations for a globalized world better (Fam et al., 2018; Gibbs, 2017). Others suggest that transdisciplinary strategies can highlight and connect core cognitive skills across disciplines, thereby enhancing creativity as a pedagogical goal (Henriksen & Deep-Play Research Group, 2018). Within the STEAM context, the "nexus of practice" (Scollon, 2001) serves as a useful theoretical framework for understanding the integration of practices across disciplinary boundaries, emphasizing unique outcomes arising from the intersection of STEM and the arts (Peppler & Wohlwend, 2018). This exploration of disciplinary boundaries and interactions informs our understanding of STEM and STEAM, revealing the complexities of interdisciplinary and transdisciplinary work that are often overlooked when defining STEAM. Additionally, prior research underscores the latent power dynamics intrinsic to transdisciplinary efforts, highlighting the critical role of communication and power in shaping these collaborative spaces (McGarr & Lynch, 2017; Weinstein et al., 2016).

Recent scholarship on STEM and STEAM has begun to frame inter- and transdisciplinary work in terms of the shared epistemic practices between the arts and sciences (Bevan et al., 2019, 2020; Costantino, 2018). For instance, Costantino (2018) advocates for a mutually engaged transdisciplinary curriculum model focused on creative inquiry, encompassing iterative processes of problem definition, multimodal exploration, critique, design, refinement, and exhibition. This model emphasizes epistemic practices across arts and sciences, fostering exploration, meaning-making, and critique. Costantino posits that such an approach cultivates a "third space" that generates hybrid content and epistemology for arts and engineering.

At this juncture, it is essential to delineate significant distinctions: The terms interdisciplinary and multidisciplinary, while often used interchangeably, hold distinct meanings. Interdisciplinary refers to the integration of two or more academic disciplines to examine a problem or topic from multiple perspectives, leading to insights unattainable through a singular discipline study. The goal is to synthesize and integrate methods and knowledge for a comprehensive understanding. Conversely, multidisciplinary involves multiple

disciplines addressing a project while maintaining their distinct methodologies and perspectives, without necessarily integrating their insights.

Transdisciplinary research transcends these boundaries by bringing together experts from various fields and including stakeholders directly affected by the issue at hand. This approach aims not only to generate new knowledge but also to apply it in ways that address real-world challenges, emphasizing collaborative, inclusive processes among all participants.

In summary, transdisciplinary approaches are characterized by their focus on collaboration, co-creation, and practical application, distinguishing them from both interdisciplinary and multidisciplinary methodologies.

INTERDISCIPLINARITY

Interdisciplinarity, despite its contemporary popularity, is rooted in ancient concepts of science. Historically, the interconnection of knowledge across disciplines was paramount, with figures like Aristotle embodying a holistic understanding where science and philosophy were inseparable. The prevailing unity of science was a lived reality rather than an abstract ideal. Today, interdisciplinarity lacks a distinct epistemic and organizational status; it often appears merely as a way to bridge the gaps created by specialization, where diverse knowledge exists within disciplinary silos, diminishing the Aristotelian universality.

Assuming that reviving thinkers such as Aristotle could restore interdisciplinarity to its former prominence is unrealistic given the vast expansion and diversification of scientific knowledge. Modern science increasingly transcends its internal inquiries, addressing real-world issues that intertwine scientific and societal questions. This interconnectedness reflects both organizational and epistemic dimensions, complicating the differentiation between scientific problems and broader societal challenges.

A significant issue lies in defining interdisciplinarity, which has emerged as a buzzword without a consensus on its precise meaning (Hoffmann et al., 2013). Scholarly literature typically distinguishes between multidisciplinarity (the coordinated efforts of distinct disciplines), interdisciplinarity (the theoretical or methodological integration of disciplines), and transdisciplinarity (which challenges traditional disciplinary boundaries) (Choi & Pak, 2006; Holbrook, 2013; Klein, 1990, 2010). The concept of integration is often considered central to distinguishing interdisciplinarity, as emphasized by Klein, who argues that true interdisciplinarity involves the contributions of one discipline to the theories and problems of another.

However, not every interdisciplinary interaction leads to successful integration (Grüne-Yanoff, 2016). Many collaborations may yield "model templates" or similar constructs rather than achieving genuine integration (Knuuttila & Loettgers, 2016; Ankeny & Leonelli, 2016; Bradley & Thébault, 2017). Thus, it is posited that multidisciplinarity, interdisciplinarity, and transdisciplinarity might be viewed as stages within a singular process, evolving from initial disciplinary involvement to potential boundary-breaking integration.

Interdisciplinarity is not a recent phenomenon; several scientific disciplines, such as biochemistry, originated from interdisciplinary interactions across overlapping fields. Recent discussions underscore its potential to tackle urgent global challenges, suggesting that it can foster new methods of knowledge production and generate "mutual knowledge" through novel insights and integrative frameworks (Klein, 2008; Frodeman et al., 2010). This perspective indicates that interdisciplinarity can catalyze significant transformations in scientific paradigms, akin to Kuhn's notion of scientific revolutions.

Despite some successful interdisciplinary initiatives, the lack of a universally accepted methodology raises concerns about its overall effectiveness. Researchers often struggle with clarity regarding the methodologies they employ (Robertson et al., 2003). Analysts remain divided on the existence of a coherent interdisciplinary method; some propose prescriptive frameworks (Newell, 2007), while others advocate for understanding interdisciplinarity through case studies (Krohn, 2010).

Frodeman (2014) argues against rigid methodologies, emphasizing the importance of scientists' virtues, such as openness to new perspectives and adaptability. This viewpoint challenges the establishment of fixed rules for interdisciplinarity, which could contradict its very nature. Ultimately, without a consensus on methodologies or a clear definition of problems, assessing the outcomes of interdisciplinary practices remains complex and ambiguous, complicating our understanding of when and if a problem has been successfully resolved.

TRANSDISCIPLINARITY

Transdisciplinarity is best conceptualized as a specialized subset of the broader interdisciplinary framework, having evolved its distinct discourse (Klein, 2009). This discourse often conveys the notion that transdisciplinarity signifies a radical departure from traditional disciplinary paradigms in research and pedagogy.

Transdisciplinary research encompasses a collaborative effort that integrates both academic and non-academic contributions, placing participants or

subjects of study on equal footing with researchers. This approach is particularly applicable to complex issues—such as global climate change, nanotechnology, and conflict resolution—that transcend the capabilities of disciplinary or even interdisciplinary methodologies. Indeed, complexity serves as a central criterion for transdisciplinary research, as highlighted by Nowotny, Scott, and Gibbons (2001) and others.

While conventional interdisciplinarity focuses on the analysis, synthesis, and harmonization of existing disciplinary insights into a cohesive framework, transdisciplinarity aims to reconstruct knowledge from foundational elements. It seeks to recombine the content knowledge of various disciplines into innovative formations that facilitate a comprehensive understanding of multifaceted problems (Madni, 2007; Pop & Mathies, 2008; Wallerstein, 2004). The etymology of "transdisciplinarity" suggests a movement "across and through the disciplines," thereby questioning the fundamental assumptions that underpin the segmentation of knowledge.

This approach has emerged in response to a growing recognition among scholars and educators of the limitations and misaligned priorities inherent in traditional disciplinary frameworks. By adopting the term "transdisciplinarity," we assert that this approach transcends the constraints of conventional disciplinarity, fostering new methodologies and paradigms that integrate insights derived from prior discipline-based studies. The exploration of knowledge is particularly well-suited to transdisciplinary methodologies, especially considering the evolving social, economic, and political contexts of knowledge production, as identified by Gibbons et al. (1994). This framework necessitates an examination of various dimensions—including psychological, epistemic, social, and cultural—as well as different perspectives, such as idealistic, semantic, bibliographical, service-oriented, and results-oriented.

Much of the literature on transdisciplinarity continues to utilize terminology from the earlier frameworks, such as "interdisciplinary" or "multidisciplinary," which can lead to conceptual ambiguities. Kline's work (1995) is particularly relevant, as it discusses concepts of hierarchy, complexity, and dimensionality to elucidate the relationships among disciplines. The analytic features he describes as fundamental to multidisciplinary thinking are grounded in the principles of the Category Theory (Ehresmann & Vanbremeersch, 2007; Goguen, 1999).

Transdisciplinarity is gaining traction in educational settings, particularly in the realms of science, technology, and planning, as well as in addressing pressing global challenges. This approach is timely and pertinent for reinterpreting the meaning of knowledge in contemporary society, with the potential to invigorate both the humanities and social sciences.

The increasing complexity of the scientific landscape presents challenges not only due to the exponential growth of knowledge—rendering comprehensive understanding of any single field increasingly difficult—but also concerning the institutional structures that govern scientific inquiry. The capacity to think beyond narrowly defined disciplinary boundaries is diminishing, raising concerns that these boundaries may confine the pursuit of knowledge itself. It is essential to recognize that the delineations between disciplines are not intrinsically natural or fixed; rather, they are historically constructed and often influenced by specific research subjects, theories, methodologies, and objectives that may not conform to traditional disciplinary frameworks.

There is a notable asymmetry between the evolution of problems and the development of disciplines, a situation exacerbated by the trends toward increasing specialization. When problems do not conform to predefined disciplinary categories, addressing these challenges often necessitates efforts that transcend such boundaries, a principle central to both interdisciplinary and transdisciplinary approaches. However, transdisciplinarity signifies more than a mere terminological shift. While interdisciplinary collaborations tend to be temporary, transdisciplinarity promotes a sustained scientific paradigm that fundamentally alters the structure of disciplines. It serves as a principle of research, addressing real-world challenges—such as those related to environmental sustainability, energy, and health—while simultaneously reshaping the organization of scientific inquiry itself.

In essence, transdisciplinarity operates as an integrative concept that seeks to dismantle the isolation that often characterizes scientific practice. It addresses the historical shortcomings that have arisen due to excessive specialization within disciplines, yet it does not aim to replace these traditional frameworks. Transdisciplinarity rather functions as a research and organizational principle that prioritizes problem-solving, extending beyond conventional disciplinary boundaries. It does not constitute a transscientific principle that supersedes scientific inquiry; rather, it is a scientific perspective directed toward a world increasingly shaped by scientific and technological reasoning.

Ultimately, transdisciplinarity is primarily a research principle, with theoretical implications emerging secondarily from transdisciplinary research endeavors. This distinction is crucial, as the nature of the problems addressed—whether they originate from internal scientific inquiries or external societal challenges—shapes the character of transdisciplinarity, which encompasses both theoretical and practical dimensions.

CONCLUSION

The interaction among disciplines, inter- and transdisciplinarity—akin to Karl Popper's "game of science" (Popper, 1959)—is a crucial endeavor that reshapes both scientific and institutional frameworks. The past reliance on lecture series or general studies as mere supplements to promote interdisciplinarity is outdated; such initiatives have often lacked genuine engagement with redefining boundaries.

Transdisciplinarity represents a robust form of collaboration that transcends disciplines, emphasizing that they remain essential. Disciplines provide foundational knowledge; without them, transdisciplinary efforts risk superficiality. Furthermore, the distinctions between disciplines cannot be oversimplified; they require complex justifications.

Recognizing that disciplines are historically constructed enhances their significance and underscores the need for systematic approaches. While the role of disciplinary knowledge remains vital, transdisciplinary tasks elevate the demand for clarity in understanding disciplinarity and its forms. The phrase "from disciplinarity to transdisciplinarity and back" reflects this need to restore a viable disciplinary concept in a transdisciplinary context. Ultimately, navigating scientific inquiry is a complex endeavor, even when it pertains to the discipline of science itself.

REFERENCES

Bernstein, J. H. (2014). Disciplinarity and transdisciplinarity in the study of knowledge. *Informing Science: the International Journal of an Emerging Transdiscipline*, 17, 241–273. Available at: http://www.inform.nu/Articles/Vol17/ISJv17p241-273Bernstein0681.pdf

Danermark, B. (2019): Applied interdisciplinary research – a critical realist perspective. *Journal of Critical Realism*, 18(4): 368–382.

Kelley, T. R. & Knowles, G. J. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 3:11. DOI 10.1186/s40594-016-0046-z

Mejias, S., Thompson, N., Sedas, R. M., et al. (2021). The trouble with STEAM and why we use it anyway. *Science Education*, 105, 209–231. Available at: https://doi.org/10.1002/sce.21605

Mittelstrass, J. (2018). The Order of Knowledge: From Disciplinarity to Transdisciplinarity and Back. *European Review*, 26(S2), 68–75. DOI:10.1017/S1062798718000273

Politi, V. (2019). The interdisciplinarity revolution. Theoria. *An International Journal for Theory, History and Foundations of Science*, 34(2), 237–252. Available at: https://doi.org/10.1387/theoria.18864.

Rodrigues-Silva, J. & Alsina, A. (2023). Conceptualising and framing STEAM education: what is (and what is not) this educational approach? *Texto Livre: Belo Horizonte*: 16, 2–13, DOI: 10.1590/1983-3652.2023.44946