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Relational co-creation in work-integrated learning: Contextual validation of the DART framework

Bárbara Barroso¹, Cláudia S. Costa², Inês Barbedo³, Pedro Rodrigues⁴, Fernando Pereira⁵, Juliana Almeida-de-Souza⁶, Celeste Antão⁷, Rebeca Lachovicz⁸, Vera Ferro-Lebres⁹

¹CeDRI, Research Centre in Digitalization and Intelligent Robotics, Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal, <https://orcid.org/0000-0001-6323-2309>

²Transdisciplinary Research Center in Education and Development (CITeD), Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal, <https://orcid.org/0000-0001-8294-2218>

³Transdisciplinary Research Center in Education and Development (CITeD), Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal, <https://orcid.org/0000-0001-6350-9697>

⁴Research Centre for Active Living and Wellbeing (LiveWell), Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal, <https://orcid.org/0009-0002-4920-7398>

⁵CIMO, LA SusTEC, Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal, <https://orcid.org/0000-0002-2578-3684>

⁶CIMO, LA SusTEC, Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal, <https://orcid.org/0000-0002-2578-3684>

⁷Research Centre for Active Living and Wellbeing (LiveWell), Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal, <https://orcid.org/0000-0003-1721-5836>

⁸CIMO, LA SusTEC, Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal, <https://orcid.org/0000-0003-3691-9791>

⁹CIMO, LA SusTEC, Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal, <https://orcid.org/0000-0002-3782-9264>

Corresponding author: Bárbara Barroso, bbarroso@ipb.pt

Abstract

Work-Integrated Learning (WIL) is increasingly understood as a governance-intensive ecosystem in which universities, students, and external stakeholders co-create knowledge across institutional boundaries. While co-creation has gained relevance in WIL research, empirically validated instruments to assess the relational conditions that support such collaboration remain limited. The DART framework – Dialogue, Access, Risk Assessment, and Transparency – was originally developed in commercial innovation settings to capture key dimensions of value co-creation. However, its structural validity in higher education and WIL contexts remain underexplored. This study examines whether the DART framework retains its original dimensional structure when applied to a governance-intensive WIL setting. A Portuguese adaptation of the DART scale was administered to external stakeholders (n = 46) participating in the WE: Working and Envisioning Community of Practice at Bragança Polytechnic University (Instituto Politécnico de Bragança, IPB). The WE programme engages multidisciplinary student teams and external partners in challenge-based collaboration around real-world problems. Exploratory Factor Analysis (EFA) was conducted to examine how the framework performs in this context. The original four-dimensional structure was not replicated. Instead, two integrated domains emerged: one combining Dialogue and Access, and another combining Risk Assessment and Transparency. These findings suggest that, in this WIL ecosystem, the relational dimensions captured by DART may be experienced as structurally interconnected rather than clearly distinct. Although exploratory, based on a modest sample, and limited to one institutional context, this study highlights the importance of adapting and validating relational measurement instruments when transferring them across different institutional settings.

Keywords: Co-creation, Collaborative governance, DART framework, Exploratory factor analysis, Social learning spaces, Work-integrated learning

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Introduction

Work-Integrated Learning (WIL) is increasingly recognized not merely as a pedagogical approach but as a transdisciplinary field that explores the dynamic relationship between work and learning across institutional and societal boundaries (Areskoug Josefsson et al., 2024; Lundh Snis et al., 2025). Emerging literature positions WIL at the forefront of addressing global societal challenges, fostering collaborative knowledge generation among Higher Education Institutions (HEIs), students, professionals, and external stakeholders (Lundh Snis et al., 2025; Sunnemark et al., 2024). In today's rapidly evolving technological landscape, shifting labour market demands, and growing expectations for sustainable and socially responsible innovation in higher education, WIL must emphasize practical relevance and conceptual integrity to shape the future trajectory of higher education (Vallo Hult et al., 2025). Lundh Snis et al. (2025) argue that WIL should be viewed as a collaborative, ecosystemic process that democratizes knowledge production and engages diverse actors in co-creating solutions to complex societal issues. Furthermore, WIL has been framed not only as a seamless integration of academia and professional life (Bernhard & Olsson, 2023) but also as a participatory model that enhances broader societal engagement and contributes to sustainable development (Lundh Snis et al., 2025; Gankhuyag et al., 2025). This dual perspective extends the understanding of WIL beyond a narrow focus on employability, viewing it instead as a relational and governance-intensive ecosystem in which universities, organizations, and communities collaboratively produce knowledge and value. This broadened perspective necessitates further theoretical exploration and robust empirical assessment of the relational processes that sustain effective collaboration across institutional divides (Vallo Hult et al., 2025).

As HEIs undergo significant transformations, including digital innovation, the integration of artificial intelligence, cybersecurity commitments, internationalization pathways, and accountability for graduate employability (Amanzhol et al., 2024; Msomphora, 2025; Parambil et al., 2024; Schueller, 2023), there is an urgent need for models that bridge theoretical understanding with practical application while maintaining academic integrity and societal responsiveness (Jackson & Dean, 2023). In this context, WIL is ideally positioned as a promising link between theory and practice. However, critical perspectives suggest that its conceptualizations may be too diverse and occasionally lack sufficient theoretical grounding, advocating for a multidimensional understanding of WIL (Björck & Willermark, 2025; Vallo Hult et al., 2025). Consequently, several authors have endeavoured to define perspectives on WIL more rigorously. In their work, Sunnemark et al. (2024) argue that WIL should not be viewed in isolation from placements, but rather as an organized mode of collaborative knowledge-building that requires careful alignment of pedagogical design with stakeholder interaction and institutional governance. This perspective echoes calls for more consistent conceptual frameworks to ensure the long-term quality of WIL as perceived by stakeholders (Dean et al., 2020; Dollinger & Brown, 2019; Vallo Hult et al., 2025). Without such frameworks, WIL risks fragmentation and heterogeneity, diluting its core concepts.

Framing WIL in this manner means considering a governance-intensive positioning understood not as an imposition of bureaucratic control, but as structured and relational coordination mechanisms essential for fostering principled engagement and shared responsibility among institutions. Within this evolving landscape, understanding how value is co-constructed in WIL ecosystems becomes critical. Service-Dominant Logic posits that value is generated through the integration of resources among multiple stakeholders, rather than being delivered unilaterally (Vargo & Lusch, 2004). This relational perspective aligns well with sociocultural and practice-based learning theories, which view knowledge as derived

from participation in social actions and shared practices. Wenger-Trayner and Wenger-Trayner (2020) specifically frame value creation as occurring within social learning environments where members collectively negotiate meaning, align practices, and generate value through collaborative engagement. In WIL settings, universities, students, companies, and facilitators contribute collaborative resources – such as expertise, networks, problem framings, and organizational capabilities – that must be integrated into existing social learning contexts to yield meaningful outcomes. Recent conceptual synthesizations of co-creation in higher education underscore the emergent nature of value in interactive, dialogic, and agency-focused processes (Omland et al., 2025).

From another standpoint, Prahalad and Ramaswamy (2004) operationalized co-creation through the DART paradigm, which emphasizes Dialogue, Access, Risk Assessment, and Transparency as fundamental elements of the co-creation process. Developed it within the field of marketing and innovation management and grounded in the principles of Service-Dominant Logic, the model reflects a shift from traditional, firm-centric views of value creation, where value is embedded in products and delivered to passive consumers, towards a relational perspective in which value emerges through interactions among multiple actors (Nagarethenam et al., 2018). Taghizadeh et al. (2016) then developed a scale to assess these dimensions in business innovation contexts. The model remains an evolving research domain as it is adopted to diverse areas of application, due to its conceptual clarity and flexibility, allowing for multiple configurations depending on organizational and interactional settings (Hurtado-Cardona et al., 2023). However, empirical support for the DART framework remains limited, and applications in higher education WIL ecosystems are scarce. This gap is significant, as university-industry collaborations differ structurally from commercial innovation scenarios, particularly in terms of pedagogical mediation, assessment regimes, and shared accountability for learning outcomes (Mackaway & Winchester-Seeto, 2018; Vallo Hult et al., 2025). On the other hand, recent WIL studies have identified time, trust, and territory as “facilitating factors” that encourage collaborative learning across organizational boundaries (Gankhuyag et al., 2025). Trust, especially in cross-boundary collaborations, is often characterized as the willingness to embrace vulnerability in interdependent relationships, which correlates with improved collaboration and communication in university-society engagement studies (Law & Le, 2023). These relational dynamics align closely with the concept of psychological safety – the extent to which participants feel free to express ideas, questions, and concerns without fear of relational harm (Edmondson, 2018). In increasingly multidisciplinary and multicultural WIL ecosystems, fostering psychological safety is crucial for maintaining meaningful communication and enabling collaborative experimentation. Moreover, WIL ecosystems function within larger stakeholder governance frameworks. Stakeholder theory conceptualizes organizations as embedded within networks of relationships that require balanced value creation among various actors (Freeman et al., 2020). In education, this implies that the quality of WIL should not be evaluated solely on student outcomes but also on how external stakeholders, institutions, and society perceive its value. Governance perspectives emphasize coordination mechanisms that enable distributed actors to align objectives, share responsibility, and manage interdependencies (Jacobides et al., 2018).

From these theoretical vantage points, tools that can account for relational quality from stakeholder perspectives are necessary to assess the effectiveness of WIL. However, quantifying such relational constructs poses significant methodological challenges. Measurement theory highlights the importance of establishing construct validity and measurement invariance, as dimensional structures may become unstable if transferred from one context to another (Henseler et al., 2016). Instruments not designed for a specific environment may need empirical re-evaluation before being applied in different relational contexts. Tensions in scale validation are evident in the debate between empirically grounded and empirically derived approaches, such as Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). While CFA assumes a predefined dimensional structure, EFA allows latent dimensions to emerge inductively from context-specific data, especially in newly established empirical settings (Howard, 2016). If the DART framework is applied to WIL, it remains theoretically uncertain whether the original four dimensions will retain their distinctiveness or adapt to the relational dynamics of higher education ecosystems.

This study aims to address these conceptual and methodological gaps by translating and empirically assessing a Portuguese adaptation of the DART scale within the WE: Working and Envisioning Community of Practice at Bragança Polytechnic University (Instituto Politécnico de Bragança, IPB). The WE program employs Complex Challenge-Based Learning approaches, in which interdisciplinary and multicultural student teams collaborate with community-based stakeholders for 8-12 weeks to develop solutions to real-world issues. This structured yet relationally rich environment provides a relevant empirical context for exploring how external partners perceive co-creation processes in WIL. By

offering empirical insights into the dimensional construction of the DART framework, this study seeks to contribute to the WIL literature in three interconnected ways. First, by investigating whether existing co-creation constructs remain valid in educational contexts. Second, by extending quality establishment by examining how a diagnostic tool can enhance stakeholder engagement in WIL activities. Third, by responding to calls for a stronger theoretical and empirical foundation for WIL as a field capable of addressing complex societal challenges through collaborative knowledge generation (Lundh Snis et al., 2025). Ultimately, this paper positions WIL not merely as a pedagogical strategy but as a governance-driven, stakeholder-oriented ecosystem that requires robust theoretical foundations and empirically based tools to thrive in the future.

Conceptual framing

Work-Integrated Learning (WIL) is increasingly being recognized as a significant area of research and practice that transcends traditional pedagogical frameworks. It encompasses the dynamic nature of learning that occurs across institutional, professional, and societal boundaries. Current scholarship emphasizes the importance of viewing WIL not merely as a model for placements or a tool for enhancing employability, but as an intricate, governance-driven process through which knowledge, responsibility, and agency are collaboratively constructed among various stakeholders (Sunnemark et al., 2024; Björck & Willermark, 2025; Lundh Snis et al., 2025). This evolving perspective responds to the growing concern over the instrumentalization of WIL, which may reduce it to a mere means of meeting labour market demands or a shortcut to applied competence (Björck & Willermark, 2025). Instead, contemporary literature positions WIL as a relational learning framework where universities, students, organizations, and communities collaboratively engage in problem identification and value creation within complex ecosystems (Gankhuyag et al., 2025; Vallo Hult et al., 2025).

In alignment with the introduction, WIL ecosystems are conceptualized as governance-mediated learning constellations characterized by interdependence and boundary-spanning value production. From this perspective, WIL is not a straightforward transfer of knowledge from academia to practice (or vice versa), but rather the emergence of diverse knowledge configurations resulting from mutual interactions across boundaries. Sunnemark et al. (2024) stress that WIL must be theoretically grounded to avoid “practice-over-theory reductionism,” advocating for a structured approach that connects pedagogical design, stakeholder engagement, and governance mechanisms to ensure conceptual coherence. This insistence on academic rigor is echoed by Björck and Willermark (2025), who identify a common issue of under-theorization within the “WIL” component itself, leading to conceptual dilution.

These critiques underscore the urgency of recognizing WIL as a multidimensional phenomenon in which pedagogical, relational, and institutional dimensions coexist. Viewed through this lens, collaboration is not an adjunct to learning; rather, it serves as its foundational mechanism. Gankhuyag et al. (2025) regard WIL ecosystems as collaborative spaces for social sustainability, where stakeholders negotiate meanings, responsibilities, and expectations over time. In this sense, collaboration within WIL becomes a vital learning tool that enables diverse actors to co-construct their understanding of complex challenges. This aligns with contemporary views of higher education ecosystems, which position universities as integral nodes within innovation networks characterized by interdependence and co-specialization (Jacobides et al., 2018). Value in such ecosystems is not the result of individual contributions but emerges through organized interactions. To view WIL as collaborative learning, it is essential to define the structural conditions that foster generative collaboration rather than mere coordination. Boundary-crossing experiences create these structural conditions. Current WIL research recognizes that learning between academia and the workplace involves negotiating discontinuities in epistemic norms, institutional logics, and professional identities (Sunnemark et al., 2024). Boundary crossing does not imply seamless integration; instead, it introduces productive tensions that turn differences into assets for knowledge creation. However, boundary crossing is not self-sufficient; it relies on mediating artifacts that facilitate interaction and coordination. In WIL contexts, these artifacts may include project briefs, prototypes, assessment rubrics, design documents, and evaluation tools. These artifacts ground dialogue, shape expectations, and transform abstract collaboration into tangible outcomes.

Omeland et al. (2025), through their systematic review of co-creation in higher education, illustrate that co-creation occurs interactively through positioning, voice, and negotiated meaning. Artifacts provide the space for such positioning, enabling actors to express interests, challenge interpretations, and redefine obligations. Consequently, boundary objects serve as mediators in the interplay between institutional expectations and emergent learning forms. This perspective allows

for a more nuanced understanding of how value is generated within WIL ecosystems. Wenger-Trayner and Wenger-Trayner (2020) theorize value production within social learning spaces, where participants engage in collective meaning-making. Value arises not from isolated contributions but from reasoned engagement in shared practices. In a WIL context, social learning spaces are facilitated by boundary objects that support collaboration while allowing for interpretive flexibility. Rather than relying solely on transactional exchanges, universities, students, and external stakeholders integrate resources and create value through active participation in these learning environments.

Through this framework, the relational dynamics of co-creation can be analytically examined using the DART model, which articulates Dialogue, Access, Risk Assessment, and Transparency as interrelated conditions shaping collaborative value creation (Pralhad & Ramaswamy, 2004). Rather than reiterating its foundational premises, previously asserted in the Introduction, it is important to emphasise that DART functions as a relational structuring device, enabling the analysis of how interaction quality, resource accessibility, shared responsibility, and informational openness collectively configure co-creation processes. Building on service-dominant logic, these dimensions do not operate in isolation; instead, they are enacted through ongoing exchanges among actors who integrate resources within networked environments (Vargo & Lusch, 2004; Nagarethenam et al., 2018). From this perspective, the relevance of DART lies in its capacity to translate abstract notions of co-creation into observable relational conditions. Dialogue supports reciprocal engagement and meaning-making; access structures participation through the availability of resources and information; risk assessment reflects the distribution and negotiation of responsibility; and transparency underpins trust by reducing informational asymmetries. Contemporary literature positions the model as a flexible analytical framework capable of capturing co-creation dynamics across varied organisational settings, while also recognising that its empirical validation remains context-dependent and evolving (Hurtado-Cardona et al., 2023). As such, DART should be understood not as a fixed dimensional structure, but as a conceptual lens whose configuration may shift in response to the relational and governance characteristics of the context in which it is applied.

As such, its application within WIL ecosystems necessitates theoretical refinement. University-industry collaboration involves pedagogical mediation, institutional accountability, and shared ownership of learning outcomes, which differ significantly from commercial innovation contexts. When applied to WIL, the relational dimensions captured by DART may require reconfiguration. In this context, the relationship between compliance and capacity building becomes critical. In governance-intensive WIL ecosystems, particularly those driven by regulatory frameworks, external partners are often entangled in compliance structures, institutional accountability measures, and performance benchmarks. Compliance can thus serve as a primary organizing principle. Nevertheless, contemporary WIL theory posits that true capacity building occurs when organizations internalize compliance structures within social learning processes, rather than merely imposing external compliance (Gankhuyag et al., 2025; Sunnemark et al., 2024). When integrated into boundary-mediated collaboration, compliance mechanisms can foster shared responsibility and clarify expectations, thus promoting capacity building rather than perpetuating a restrictive status quo.

This aligns with Emerson and Nabatchi's (2015) collaborative governance model, which asserts that principled engagement, shared motivation, and the capacity for joint action are mutually reinforcing elements of successful collaborative systems. Compliance frameworks may stabilize WIL systems while social learning spaces cultivate adaptive capabilities. Recent studies on collaborative performance management indicate that challenges in collaborative governance regimes – such as substantive problem-solving, processual accountability, and goal alignment – are contingent on structured integration among overarching objectives, formal dialogue mechanisms, and evaluative practices. Waardenburg et al. (2025) emphasize that performance management in collaborative settings is not merely a technical issue but also involves interpersonal and iterative processes. Applied to WIL ecosystems, this implies that co-creation instruments must encompass more than transactional exchanges; they should also reflect the quality of relational processes that support learning. In this light, trust emerges as a crucial relational condition. Law and Le's (2023) systematic review highlights that trust is consistently linked to vulnerability acceptance in interdependent interactions. Trust fosters openness, information sharing, and long-term collaboration. In WIL ecosystems characterized by multidisciplinary and multicultural teams, trust is essential for facilitating authentic dialogue and addressing organizational ambiguities. Trust is closely linked to psychological safety, which is the feeling that it is safe to express ideas and concerns. Psychological safety fosters experimentation and adaptive reflexivity within governance-intensive learning environments.

However, trust alone cannot fully capture the relational prerequisites for co-creation. The concept of territory adds another analytical dimension to WIL theory. Territory can be understood not merely as protective boundaries but as a

means of asserting ownership within social learning spaces. According to Wenger-Trayner and Wenger-Trayner (2020), value creation hinges on participants recognizing their legitimate stake in the learning process. As a principle, territory signifies ownership and acknowledges individuals' value and agency in achieving outcomes. Without this ownership, positioning and voice remain superficial. Empirical studies of immersive, challenge-based WIL initiatives reveal that when participants claim collective artifacts as “our solution” or “our project,” ownership becomes discursively evident, marking a transition from mere participation to active agency (Barroso et al., 2025). This discourse of appropriation signifies the activation of territory as a recognized stake within the social learning space, whereby territory serves as a recognition condition that elevates dialogue from procedural interactions to consequential positioning. Omland et al. (2025) present a more interactional perspective, showing that co-creation occurs through positioning practices in which actors assert, negotiate, or redistribute agency. In this sense, territory becomes the condition for recognition that activates positioning. When participants are granted ownership in the learning environment, they are more likely to engage substantively, articulate their views, and share in the associated risks. Thus, territory connects structural value creation with interactional co-creation, elucidating why dialogue becomes meaningful rather than merely procedural.

Langley et al. (2019) define boundary work as the process through which actors negotiate identities and jurisdictions within organizational contexts. While their analysis sheds valuable light on how boundaries are enacted and transformed, framing territory solely as boundary work may overemphasize identity negotiation at the expense of collective ownership. Boundary work does occur within WIL ecosystems, yet emphasizing territory as ownership underscores the necessary recognition and acknowledgment for sustainable engagement. Boundary work elucidates how positions evolve, while territory explains the rationale behind actors' investments in these shifts. These relational dynamics are further influenced by time. Gankhuyag et al. (2025) argue that collaborative learning for social sustainability is inherently a long-term endeavour that unfolds over time. Short-term interactions rarely yield deep alignment; instead, ongoing iterations enable participants to recalibrate expectations and foster a shared understanding. Time interconnects with trust and territory, reinforcing relationships and fostering stability. The temporal design of WIL programs, typically structured around 8- to 12-week collaborative cycles, can determine whether ownership develops or remains superficial.

Additionally, ecosystem complexity emphasizes the necessity for relational anchoring. Jacobides et al. (2018) indicate that ecosystems are defined by distributed agency and interdependence. Governance mechanisms must coordinate functions while allowing for flexibility. In WIL contexts, universities align learning objectives, while private or public organizations contribute domain expertise, and students navigate both. Dialogue, resource accessibility, risk sharing, and transparency do not operate in isolation; instead, they are embedded within the ecosystem's governance infrastructure. In this conceptual framework, the DART model evolves from a prescriptive tool to a diagnostic lens. Dialogue reflects the quality of boundary-mediated interactions; Access evaluates the availability of resources within social learning contexts; Risk Assessment captures the collective evaluation of vulnerability during collaborative exploration; and Transparency pertains to the visibility of expectations and accountability structures. In WIL settings, these dimensions may empirically shift due to the interdependencies of relational constructs within governance-intensive environments. Therefore, measurement should adapt responsively to contextual variations.

In conclusion, this study defines WIL as a multidimensional learning ecosystem that emerges from boundary-crossing interactions centred on artifacts. Collaboration functions as the generative mechanism for co-creating value, while boundary objects facilitate interaction and stabilize expectations. Interpersonal factors such as trust, time, and territory enhance productive discussions and mutual agency. Territory, understood as ownership in social learning spaces, links structural value creation with interactional co-creation by activating positioning and voice. Collaborative governance frameworks create the macro-architectural conditions that align compliance and capacity building rather than allowing them to conflict. By situating empirical explorations within this theoretically robust framework, we can not only deepen the discussion around measurement in WIL but also contribute valuable insights toward solidifying its theoretical foundations as a distinct field of study.

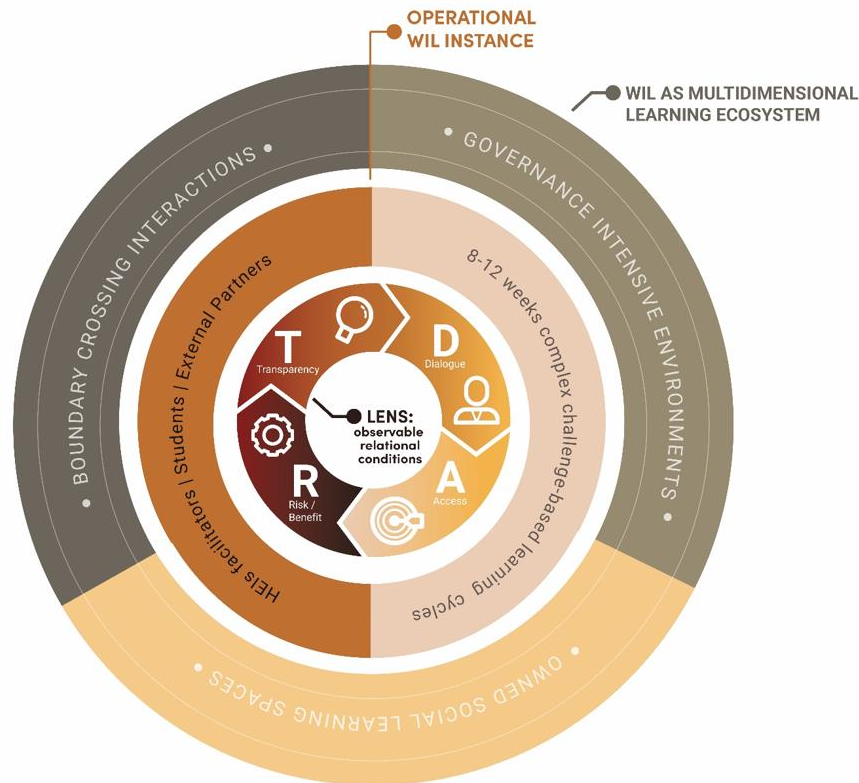


Figure 1: WIL as a governance-mediated ecosystem in which the co-creation context functions as a structured, boundary-crossing environment, with interaction through boundary objects, while the DART framework operates as a relational lens. Source: Developed by the authors.

Aim and research questions

The present study aims to examine whether the relational architecture of value co-creation, as operationalised through the DART framework (Prahalad & Ramaswamy, 2004; Taghizadeh et al., 2016), retains structural validity when situated within a governance-intensive WIL ecosystem. Rather than treating DART as a universally stable measurement instrument, this study positions its empirical validation as a theoretically informed test of dimensional robustness within a multidimensional learning phenomenon characterised by boundary crossing, stakeholder interdependence, and artefact-mediated collaboration. In this study, DART is used as an analytical starting point rather than a fixed explanatory framework, enabling the empirical assessment of its dimensional stability in context.

As articulated in the Conceptual Framing, WIL is conceptualised here as a governance-structured ecosystem in which universities, students, and external partners co-produce knowledge through boundary-mediated interaction around artefacts. Within such ecosystems, collaboration is not merely coordinative but generative. Value emerges in social learning spaces (Wenger-Trayner & Wenger-Trayner, 2020) through dialogue, positioning, negotiated responsibility, and shared ownership (Omeland et al., 2025). These dynamics are sustained by relational preconditions such as trust, time, and territory (Gankhuyag et al., 2025) and are embedded within broader collaborative governance regimes (Emerson & Nabatchi, 2015; Waardenburg et al., 2025).

In this context, the DART framework offers a structured representation of relational conditions for co-creation – Dialogue, Access, Risk Assessment, and Transparency. However, because DART was initially developed in commercial innovation environments, its dimensional distinctiveness cannot be assumed to remain stable when transferred to a WIL ecosystem characterised by pedagogical mediation, distributed accountability, and temporally bounded collaboration cycles. The present study, therefore, investigates whether DART’s theoretical building blocks reorganise empirically in

response to the structural and relational conditions specific to WIL.

The empirical setting for this examination is the WE: Working and Envisioning Community of Practice at Bragança Polytechnic University (Instituto Politécnico de Bragança, IPB), where multidisciplinary student teams and external stakeholders engage in 8–12-week challenge-based collaboration. This ecosystem provides a structured yet relationally intensive environment in which compliance frameworks, capacity-building dynamics, and shared responsibility intersect. Within such a governance-intensive learning architecture, co-creation may not manifest as four discrete dimensions; however, it may be reconfigured as relational constellations reflecting how stakeholders experience interaction, ownership, transparency, and shared risk.

Accordingly, the study pursues the following research questions:

RQ1. To what extent does the original four-dimensional structure of the DART model (Dialogue, Access, Risk Assessment, and Transparency) replicate within a governance-intensive WIL ecosystem?

RQ2. If such replication is not observed, what alternative dimensional configurations emerge when the DART scale is applied to external stakeholders participating in boundary-mediated, artefact-centred co-creation processes?

RQ3. What are the psychometric properties – factor structure, reliability, and internal consistency – of the Portuguese adaptation of the DART scale in this WIL context?

RQ4. How can any observed dimensional restructuring be theoretically interpreted in relation to ecosystem governance complexity, social learning spaces, relational trust dynamics, and ownership (territory) within WIL?

By addressing these questions, the study intends to contribute to both measurement theory and WIL scholarship. Empirically, it examines whether established co-creation constructs preserve structural coherence outside their original commercial domain. Theoretically, it tests whether relational mechanisms of dialogue, access, risk, and transparency manifest differently when embedded within governance-intensive learning ecosystems characterised by boundary crossing and shared responsibility. In doing so, the study contributes to efforts to consolidate WIL as a theoretically grounded field rather than a practice-led aggregation of partnership arrangements.

Research design and methodological positioning

The present study adopts a quantitative, instrument validation research design situated within a post-positivist tradition of construct measurement. The primary objective is not merely statistical replication of an existing scale, but contextual validation of a relational measurement framework within a governance-intensive WIL ecosystem. As articulated in the Aim and Research Questions, the study investigates whether the relational architecture operationalised through the DART framework – Dialogue, Access, Risk Assessment, and Transparency – retains dimensional distinctiveness when transferred from commercial innovation contexts to a boundary-mediated university-industry learning ecosystem.

In measurement theory, the contextual transfer of instruments across domains raises questions about construct stability and dimensional invariance. Constructs validated in one institutional or sectoral configuration cannot be assumed to function identically in another, particularly where governance logics, accountability structures, and relational expectations differ. This is especially pertinent in WIL ecosystems, where co-creation unfolds within pedagogically mediated and temporally bounded collaboration cycles embedded in institutional governance frameworks. The present design, therefore, positions instrument validation not as a purely technical procedure but as a theoretically informed inquiry into the contextual robustness of relational constructs.

Methodologically, the study employs a cross-sectional survey design combined with Exploratory Factor Analysis (EFA). This design is appropriate given the research questions, which seek to examine replication (RQ1), identify emergent dimensional configurations (RQ2), assess reliability (RQ3), and interpret structural shifts theoretically (RQ4). The use of EFA reflects an epistemological recognition that dimensional structures may reorganise in response to contextual conditions. Rather than imposing confirmatory constraints based on the original four-factor DART structure, the analytic strategy allows latent relational dimensions to emerge inductively from stakeholder perceptions within the WIL ecosystem under study.

Contextual setting: The WE community of practice

The empirical setting for this research is the WE: Working and Envisioning Community of Practice at Bragança Polytechnic

University (Instituto Politécnico de Bragança, IPB). Since 2017, the WE ecosystem has fostered sustained regional engagement through the coordination of over 100 co-creation initiatives, including research outputs, prototypes, professional internships, and patents. These initiatives, reportedly 115 across different formats, reflect an on-going pattern of collaboration between the university, industry, and broader societal actors. This sustained activity provides contextual evidence of the ecosystem's maturity and its capacity to generate applied outcomes at both national and international levels.

The WE programme operates as a structured WIL ecosystem implementing Complex Challenge-Based Learning cycles lasting between eight and twelve weeks. In each cycle, diverse and multidisciplinary student teams co-create solutions with external stakeholders, such as companies, public organisations, and non-profit entities, typically represented by a designated individual, to address real-world challenges. Teaching staff act as facilitators, ensuring alignment with pedagogical objectives, maintaining consistency in the process, and mediating boundary crossings between academic and professional domains.

Rather than functioning as an ad hoc collaboration model, the WE programme is organised as a deliberately designed co-creation cycle integrating stakeholder mapping, iterative challenge formulation, and structured validation processes (Rodrigues et al., 2025). This design reflects a governance-intensive learning architecture characterised by distributed agency and coordinated interaction. External stakeholders provide access to data, facilities, and domain expertise, while students contribute analytical capacity, creativity, and iterative prototyping. Facilitators ensure alignment between learning objectives, institutional accountability requirements, and stakeholder expectations throughout successive feedback loops. Collaboration unfolds around artefacts such as project briefs, design documents, interim presentations, and final prototypes, which function as boundary objects stabilising interaction across institutional logics.

From an analytical perspective, this configuration exhibits key characteristics of collaborative governance regimes as conceptualised by Emerson and Nabatchi (2015), particularly the interplay between principled engagement, shared motivation, and capacity for joint action. Structured dialogue and iterative alignment institutionalise principled engagement; role clarification and expectation management cultivate shared motivation; and coordinated artefact production scaffolds capacity for joint action. While remaining pedagogically grounded, the WE ecosystem can therefore be situated within a collaborative governance architecture that structures interdependence without reducing learning to compliance.

This governance-structured configuration renders boundary crossing observable and methodologically traceable. The temporally bounded collaboration cycles and distributed responsibilities differentiate the setting from commercial innovation environments, where the DART framework has typically been validated. As such, the WE ecosystem provides an analytically appropriate context to examine whether relational dimensions of dialogue, access, risk, and transparency preserve structural distinctiveness when embedded within a governance-intensive, artefact-centred WIL environment.

Instrument selection, theoretical alignment, translation, and cultural adaptation procedure

The study employs the DART scale developed by Taghizadeh et al. (2016), originally designed to operationalise Prahalad and Ramaswamy's (2004) conceptualisation of value co-creation within business innovation contexts. The instrument comprises 28 items distributed across four theoretical dimensions: Dialogue, Access, Risk Assessment, and Transparency. Its use in this study is not intended to assume direct transferability, but rather to examine whether these relational building blocks retain structural coherence when applied beyond their original domain, notably in WIL ecosystems. Specifically, within the WE – Working & Envisioning Community of Practice, co-creation unfolds through structured interaction among students and facilitators, both from different academic fields and geographical origins, and external stakeholders, represented by one or more designated individuals, who collaboratively address complex real-world challenges. Rather than assuming a direct equivalence with the commercial roles pertaining to the origins of the DART model, these actors are conceptualised as occupying functionally analogous positions within a co-creation system: external stakeholders contribute domain-specific needs and contextual constraints; students act as active contributors to solution research and development; and facilitators support coordination, mediation, and alignment processes. This configuration reflects the interactional logic underpinning the DART model, in which value emerges through reciprocal engagement, access to shared resources, negotiated responsibility, and transparency in decision-making processes (Taghizadeh et al., 2016; Nagarethenam et al., 2018).

Recent research further suggests that DART dimensions may operate as structuring conditions shaping how actors engage in co-creation under varying constraints. In particular, Anshu et al. (2022) demonstrate that Dialogue, Access, Risk

Assessment, and Transparency moderate the relationship between barriers to co-creation and behavioural outcomes, highlighting their influence on interaction quality and participation dynamics. Although developed in a business-to-consumer context, this perspective supports interpreting DART as a relational framework that informs how co-creation processes unfold across different environments. This interpretation is consistent with applications of the DART model in multi-stakeholder contexts beyond traditional firm – customer settings, such as megaproject ecosystems, where interactional conditions influence collaborative outcomes and shared understanding (Xu et al., 2022). In parallel, emerging work in higher education frames co-creation as a multi-actor process characterised by distributed agency and collaborative knowledge production (Rodrigues et al., 2025). Students are increasingly conceptualised as active contributors who integrate resources and participate in value generation within institutional ecosystems (Lu & Zhang, 2024). Taken together, these perspectives support the use of DART as a relational lens for analysing co-creation processes in broader ecosystems. At the same time, they underscore the need for empirical validation and context-sensitive interpretation when applying the framework to WIL settings. Dialogue reflects the quality and reciprocity of communication. Access captures the availability of resources and information. Risk Assessment addresses perceptions of shared vulnerability and responsibility. Transparency concerns the clarity of expectations and decision-making processes. Within governance-intensive WIL contexts, these dimensions may overlap or reorganise due to the interplay between pedagogical mediation, institutional accountability, and stakeholder interdependence. Consequently, the instrument is treated as a theoretically grounded but contextually open measurement tool.

To ensure linguistic and contextual validity within the Portuguese higher education environment, the scale underwent a structured translation and adaptation process. The procedure followed established cross-cultural adaptation principles to preserve construct intent while ensuring contextual appropriateness. First, the original English items were translated into Portuguese by bilingual subject-matter experts familiar with both innovation management and higher education collaboration contexts. Second, semantic refinements were introduced to replace market-oriented terminology with language reflecting university-industry collaboration. References to “customers” or “market exchanges” were reformulated to “external stakeholders” and “collaborative challenge-based projects.” These modifications preserved theoretical meaning while aligning items with WIL ecosystem terminology. Third, the adapted instrument underwent pre-testing with a small group of academic staff and external partners who had previously participated in the WE cycle. The pre-test aimed to verify clarity, eliminate ambiguous phrasing, and confirm contextual resonance. Minor wording adjustments were made where necessary. This stage enhanced face validity and strengthened the alignment of DART dimensions with WIL relational dynamics.

Ethical considerations, sampling strategy, and data collection

The study adhered to established ethical research guidelines applicable to non-interventional survey research in higher education contexts. Participation was voluntary, and respondents were informed of the study’s academic purpose prior to completing the survey. No sensitive personal data was collected beyond general organisational affiliation and role context. Responses were anonymised to prevent identification of individuals or organisations.

Data was stored securely and used exclusively for research purposes. The study did not involve vulnerable populations or experimental interventions. Institutional guidelines for ethical conduct in social science research were followed throughout. Although formal ethics committee approval was not required under applicable institutional policies for anonymous perception-based surveys, the research adhered to principles of informed consent, confidentiality, and research integrity.

From this standpoint, data was collected from individual participants affiliated with companies and organisations that had participated in at least one WE Complex Challenge-Based Learning cycle, acting as external stakeholder representatives in the process. In fact, inclusion criteria required direct involvement in collaboration with student teams and active engagement in co-creation processes, ensuring that respondents had first-hand experience of the interaction dynamics under study. For each organisation within a given WE cycle, a single respondent was included, ensuring that there was no overlap of responses from the same organisation within the same cycle. The external stakeholders encompass a broad range of profiles, including private companies, public institutions, and non-profit entities engaged in collaborative challenge-based projects within the WE ecosystem, providing a heterogeneous set of perspectives that enrich the understanding of co-creation dynamics.

An online survey questionnaire was distributed electronically following project completion, thereby reducing potential social desirability bias and role-related pressures during active collaboration. Respondents rated each item on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), consistent with the original DART measurement format. A total of 46 valid responses were obtained. While this sample size is modest for psychometric analysis, the study adopts an exploratory validation perspective. In early-stage contextual adaptation studies, smaller samples can be acceptable when communalities are adequate, and factor loadings are strong. The study does not aim to confirm a pre-established model but to explore dimensional robustness within a specific ecosystem context.

Data analysis strategy

The analytic strategy was designed to address the study's research questions directly. Given that the primary objective is to examine whether the original four-dimensional DART structure replicates within a governance-intensive WIL ecosystem, imposing a confirmatory factor model would have risked constraining the data to a predetermined structure. Therefore, Exploratory Factor Analysis (EFA) was selected as the most appropriate technique.

EFA is particularly suitable when instruments are applied in new empirical contexts and dimensional stability cannot be assumed. In this case, contextual transfer from commercial innovation settings to boundary-mediated educational ecosystems introduces structural differences in governance logic, accountability frameworks, and stakeholder interdependence. EFA allows latent dimensions to emerge inductively from the empirical data, thereby addressing RQ1 and RQ2 simultaneously. Crucially, the structural patterns revealed through EFA also provide the empirical basis for addressing RQ4. Any observed convergence, overlap, or reconfiguration of the original DART dimensions is analytically examined, considering the conceptual framing of WIL as a governance-intensive ecosystem embedded in social learning spaces. In this sense, EFA does not merely test dimensional replication; it generates structural evidence that enables theoretical interpretation of governance complexity, relational interdependence, and territorial ownership.

Prior to factor extraction, the adequacy of the data was assessed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity. These diagnostics determine whether inter-item correlations are sufficiently strong to justify factor analysis. Principal component extraction was employed to identify latent dimensions. Although principal axis factoring could also be justified, principal component analysis is commonly used in early-stage scale purification to explore variance structure. Both Varimax (orthogonal) and Oblimin (oblique) rotations were applied. The use of orthogonal rotation allows examination of structural independence between dimensions, while oblique rotation permits correlated factors to emerge. Given theoretical expectations that co-creation dimensions may be conceptually related but empirically distinct, applying both rotations provided a comprehensive examination of structural configuration.

Items were removed iteratively based on established psychometric criteria. Removal thresholds included communalities below 0.40, high cross-loadings, or lack of theoretical coherence within emergent factor groupings. This iterative purification process ensured that the final factor structure retained only statistically robust and theoretically interpretable items. This procedure directly addresses RQ3 by refining the scale to capture relational dimensions as experienced within the WIL ecosystem. It also informs RQ4, as any dimensional restructuring is subsequently interpreted considering the conceptual framing developed in this study. Such interpretation does not imply direct empirical measurement of governance mechanisms, trust dynamics, or territorial ownership as standalone constructs. Instead, structural patterns observed in the factor configuration are analytically examined in relation to the governance-intensive architecture of WIL, social learning space theory, and ecosystem interdependence. In this sense, theoretical interpretation constitutes a context-sensitive reading of structural relationships rather than a causal inference about underlying relational processes.

Internal consistency was assessed using Cronbach's alpha. A threshold of $\alpha > 0.80$ was considered acceptable for early-stage validation. High reliability coefficients indicate that items within each emergent factor coherently measure an underlying latent construct. Reliability testing strengthens confidence in the structural validity of the adapted instrument and supports subsequent theoretical interpretation.

Methodological coherence with research questions and limitations

The methodological design is explicitly aligned with the research questions. Replication of the original DART structure is examined through exploratory extraction. Emergent alternative configurations are identified inductively. Psychometric

robustness is assessed through reliability and factor diagnostics. The theoretical interpretation of structural shifts is grounded in the conceptual framing of WIL as a governance-intensive ecosystem characterised by boundary crossing and relational preconditions of trust, time, and territory, while recognising that this interpretation remains inferential and structurally rather than behaviourally derived. Thus, the methodology does not merely validate a translated scale. It operationalises a theoretically situated inquiry into how relational co-creation constructs manifest within a multidimensional learning phenomenon.

Nevertheless, several limitations must be acknowledged. The sample size is modest and limited to a single institutional ecosystem. The study employs EFA without subsequent confirmatory testing in an independent sample. Data reflects perceptions of external stakeholders only; inclusion of student and facilitator perspectives would provide multi-actor triangulation, but was not considered within the scope of this study. Furthermore, the cross-sectional design captures perceptions at a single time point, limiting longitudinal analysis of relational dynamics. These limitations frame the findings as context-sensitive contributions requiring replication across diverse WIL ecosystems and cultural contexts.

Findings

This section presents the empirical results, structured to align directly with the research questions. The findings are organised into four parts: (1) assessment of factorability and data adequacy; (2) replication analysis of the original four-factor DART structure (RQ1); (3) identification of emergent dimensional configurations and psychometric properties (RQ2–RQ3); and (4) theoretically grounded interpretation of dimensional restructuring within a governance-intensive WIL ecosystem (RQ4). Throughout, results are reported with attention to methodological rigour, construct validity, and contextual coherence.

Prior to factor extraction, diagnostic tests were conducted to assess the dataset's suitability for exploratory factor analysis. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy indicated satisfactory adequacy ($KMO = 0.83$), exceeding the commonly accepted threshold of 0.60. Bartlett's Test of Sphericity was statistically significant ($\chi^2, p < .001$), confirming that inter-item correlations were sufficiently strong to justify factor extraction.

Inspection of the correlation matrix revealed multiple coefficients above 0.30, indicating meaningful shared variance among items. Communality values after initial extraction were generally above 0.50 for retained items, suggesting that the factors accounted for a substantial proportion of item variance. No extreme multicollinearity issues were observed.

Although the sample size ($n = 46$) is modest, the analysis was conducted within an exploratory validation logic, and factor loadings were strong and well above minimum interpretive thresholds. Given the high communalities and clear loading patterns, the factor solution can be considered statistically interpretable within the scope of this contextual study. These diagnostics support proceeding to dimensional analysis.

RQ1: Replication of the original four-dimensional DART structure

The first research question examined whether the original four-dimensional structure of the DART framework – Dialogue, Access, Risk Assessment, and Transparency – replicates within a governance-intensive WIL ecosystem. Initial extraction using eigenvalues greater than 1 suggested a two-factor solution rather than a four-factor configuration. Inspection of the scree plot confirmed a precise inflection after the second component, indicating that two dominant factors accounted for most of the systematic variance. Extraction constrained to four factors yielded unstable loadings and conceptual overlap across dimensions, with several items cross-loading or failing to meet adequate communalities. Specifically, items originally belonging to Dialogue and Access did not load on separate factors. Instead, they demonstrated consistent co-loading patterns. Similarly, items from Risk Assessment and Transparency clustered together rather than forming distinct latent constructs. Attempts to force a four-factor structure resulted in reduced internal consistency and theoretically ambiguous groupings. These findings indicate that the original four-dimensional DART architecture does not replicate structurally within the WE WIL ecosystem. Instead, the factor structure demonstrates empirical integration of originally distinct dimensions into broader relational domains. This directly addresses RQ1: the dimensional distinctiveness observed in commercial innovation contexts is not preserved in this governance-intensive educational ecosystem.

RQ2: Emergent dimensional configuration

Following iterative purification based on communalities, cross-loadings, and theoretical coherence, a stable two-factor solution was retained. The final structure explained 72.91% of total variance, a substantial proportion for social science measurement instruments.

Factor 1: Interaction and communicative access

The first factor accounted for 59.79% of total variance and exhibited excellent internal consistency (Cronbach's $\alpha = 0.904$). This factor comprised seven items originally distributed across the Dialogue and Access dimensions. Items captured frequent communication, responsiveness, clarity in exchanges, openness of interaction, and practical accessibility to information and resources. Empirically, items originally belonging to the Dialogue and Access dimensions loaded onto a common factor, indicating that these constructs were not statistically distinguishable within this sample. Rather than supporting their dimensional independence, the factor structure indicates that communicative exchange and resource accessibility covaried systematically in this context. Within the present dataset, communicative quality and resource availability thus formed a unified latent domain reflecting the operational functioning of collaboration. Loadings for retained items were all above 0.60, with minimal cross-loadings. This clean loading pattern enhances construct clarity and supports interpreting this factor as a coherent, relational-operational dimension of co-creation within the WE ecosystem. The empirical configuration suggests that communicative processes and access to resources operated as structurally integrated components of collaboration rather than as separable relational dimensions.

Factor 2: Transparency and shared risk governance

The second factor explained an additional 13.12% of variance and demonstrated high internal consistency (Cronbach's $\alpha = 0.912$). It comprised three items reflecting clarity of expectations, shared understanding of responsibilities, transparency in decision-making, and mutual awareness of potential risks. Conceptualized initially as distinct dimensions – Risk Assessment and Transparency – these items loaded onto a single factor in the present analysis, indicating empirical convergence between the two constructs within this context. Rather than emerging as statistically independent domains, they co-varied in a configuration suggesting structural interrelation between risk-related and transparency-related items in the WE ecosystem. Factor loadings exceeded 0.65 for all retained items, and cross-loadings were minimal, reinforcing the structural coherence of this dimension. Analytically, this factor may be interpreted as reflecting a governance-assurance domain, capturing the extent to which collaborative processes are structured around clarity, accountability, and shared responsibility.

Item removal and scale purification

Several items were excluded during the iterative purification process due to low communalities (< 0.40), ambiguous wording, or theoretical misalignment within the emergent factor structure. Items originating from the Transparency and Risk subscales were more frequently removed, particularly where phrasing appeared overly market-oriented or abstract relative to the WIL context. The purification process improved the structural coherence and internal consistency of the retained solution. At the same time, the pattern of item removal indicates that some aspects of the original DART formulation may require contextual adaptation when transferred to educational or governance-intensive ecosystems.

RQ3: Psychometric Properties

Internal consistency for both emergent factors exceeded the recommended threshold of 0.80, indicating strong reliability. The two-factor structure demonstrated high explained variance (72.91%) and strong factor loadings with minimal cross-loadings, supporting acceptable construct validity in the present context. It must be emphasised, however, that this constitutes exploratory validation. Confirmatory testing in independent samples would be required to assess dimensional stability across diverse WIL ecosystems. In terms of procedural safeguards, participation was voluntary and anonymised, and data collection occurred after project completion to reduce social desirability and role pressure. Given the modest sample size and single-ecosystem design, broader generalisability remains limited. The instrument, therefore, demonstrates contextual adequacy for capturing external stakeholder perceptions in this setting, while its transferability to other WIL ecosystems warrants further empirical examination.

RQ4: Theoretical Interpretation of Dimensional Restructuring

The most theoretically significant finding concerns the empirical reorganisation of four DART dimensions into two structurally integrated domains.

Integration of dialogue and access

The empirical merging of Dialogue and Access indicates that, within this governance-intensive WIL ecosystem, communicative interaction and resource accessibility did not manifest as separable statistical dimensions. While the analysis does not permit direct inference about underlying cognitive processes, the structural convergence suggests that these constructs were configured as mutually integrated components of boundary-mediated collaboration in this setting. In artefact-centred social learning spaces, such convergence may reflect the procedural entanglement of communication and access, where resource availability is enacted through communicative coordination. This structural pattern is consistent with the conceptual framing that collaboration in governance-intensive WIL ecosystems is generative rather than transactional, in the sense that dialogue is intertwined with actionable participation rather than functioning as an isolated exchange. The observed convergence aligns with ecosystem perspectives (Jacobides et al., 2018), which emphasise coordinated interaction among distributed actors rather than discrete resource exchanges. It also resonates with social learning space theory (Wenger-Trayner & Wenger-Trayner, 2020), in which value emerges through participatory engagement rather than through segmented relational components.

Integration of risk and transparency

The convergence of Risk Assessment and Transparency may be interpreted in light of the governance-intensive configuration of the WE ecosystem. Empirically, risk-related and transparency-related items did not form separate dimensions but loaded onto a common factor. Within this structural configuration, these item clusters were statistically intertwined rather than analytically independent. Although this pattern does not independently confirm specific relational mechanisms, it is consistent with the proposition that vulnerability in collaborative settings may be articulated through shared accountability processes. This interpretation aligns with collaborative governance theory (Emerson & Nabatchi, 2015), which holds that principled engagement and shared motivation underpin the capacity for joint action. Within such frameworks, risk and transparency are conceptually interlinked through accountability structures. The empirical results, therefore, indicate that, in this ecosystem, the relational architecture of co-creation manifested as two interdependent domains rather than four statistically distinct building blocks: a relational-operational interaction domain and a governance-assurance alignment domain.

Territory and ownership

Territory and ownership were not directly measured in this study, so we cannot make any empirical claims about their independent construct validity. However, the observed convergence of relational constructs aligns with the idea that ownership in social learning environments may serve as a fundamental condition for co-creation processes. While the data do not explicitly measure territory, the convergence of factors such as dialogue, access, risk, and transparency into broader categories can be theoretically interpreted as consistent with models where perceived stake and shared responsibility enhance relational integration. This interpretation is still inferential and requires direct measurement and empirical testing in future research.

Application implications

The two-factor structure identified in this study offers preliminary diagnostic potential for evaluating governance-intensive WIL ecosystems. Rather than assuming that the four theoretically discrete DART dimensions will manifest uniformly across contexts, the present findings indicate that, within this artefact-centred and pedagogically mediated WIL environment, the relational architecture of co-creation manifested as two structurally integrated domains. Whether this configuration generalises beyond the present ecosystem remains an open empirical question. Within similar governance-intensive WIL contexts, practitioners may consider assessing relational processes at the level of (a) interactional-operational quality and (b) governance-assurance alignment. These broader domains may provide a context-sensitive representation of co-creation dynamics in artefact-centred collaboration cycles.

Summary of findings

The emergent two-factor configuration identified in this study suggests potential implications for the evaluative design of governance-intensive WIL ecosystems. However, these implications must be interpreted cautiously, given the exploratory nature of the analysis and the single-ecosystem sample. Rather than applying the DART framework as four theoretically discrete relational dimensions, the present findings indicate that, within artefact-centred and pedagogically mediated WIL environments, stakeholders may experience co-creation through two structurally integrated domains: one reflecting interactional-operational quality (combining Dialogue and Access), and another reflecting governance-assurance alignment (integrating Risk Assessment and Transparency). From a diagnostic perspective, evaluative instruments in WIL contexts might benefit from assessing relational processes at this broader level of integration, particularly where collaboration unfolds within temporally bounded cycles and distributed accountability structures.

Importantly, this does not imply that the original DART dimensions lack conceptual relevance. Instead, the findings indicate that ecosystem governance arrangements, boundary mediation through artefacts, and the relational preconditions of trust and ownership may shape their empirical manifestation. In governance-intensive learning architectures, communicative exchange and resource accessibility may be enacted simultaneously through shared project artefacts. At the same time, risk perception and transparency may be co-experienced as elements of joint responsibility rather than independent evaluative domains. Accordingly, any practical adaptation of co-creation measurement tools within WIL should remain theoretically grounded and context sensitive. Replication across diverse institutional settings is necessary before drawing prescriptive conclusions. The present study, therefore, offers preliminary diagnostic insight rather than normative guidance, contributing to the incremental refinement of relational measurement within multidimensional WIL ecosystems.

Discussion

The present study examined whether the original four-dimensional DART framework, namely Dialogue, Access, Risk Assessment, and Transparency, replicates within a governance-intensive Work-Integrated Learning (WIL) ecosystem structured as an artefact-centred social learning space. The empirical results indicate that the original four-factor configuration did not replicate in this setting. Instead, exploratory factor analysis identified a two-factor structure integrating Dialogue with Access and Risk Assessment with Transparency. This discussion interprets these findings in relation to ecosystem complexity, collaborative governance architecture, and WIL as a multidimensional learning phenomenon, while maintaining caution regarding scope and generalisability.

Repositioning DART within Governance-Intensive WIL Ecosystems

The non-replication of the four-factor DART structure should not be interpreted as a failure of the framework itself. Instead, it suggests that relational constructs developed and validated in commercial innovation contexts may reorganise when embedded within governance-intensive educational ecosystems. In such environments, collaboration unfolds under structured pedagogical mediation, distributed accountability, and temporally bounded project cycles. These conditions differ substantively from market-based innovation exchanges in which DART has typically been operationalised.

Within the WE ecosystem examined in this study, collaboration is structured through iterative challenge-based cycles involving students, facilitators, and external stakeholders. Interaction is mediated through shared artefacts – project briefs, prototypes, design documents, and structured validation sessions – which function as boundary objects. Under such conditions, relational constructs may not manifest as analytically separable components but rather as structurally interdependent domains. This interpretation aligns with ecosystem perspectives that conceptualise value creation as emerging through coordinated interdependence among distributed actors rather than discrete dyadic exchanges.

Importantly, this finding does not invalidate the conceptual relevance of Dialogue, Access, Risk, or Transparency as theoretical categories. Instead, it indicates that their empirical manifestation may be shaped by governance architecture and artefact mediation. Dimensional stability, therefore, cannot be assumed when measurement instruments migrate across institutional logics. The present results contribute to an incremental understanding of how relational co-creation constructs behave under governance-intensive WIL conditions.

Dimensional convergence as ecosystem interdependence

The empirical convergence of Dialogue and Access into a unified relational-operational domain suggests that communicative exchange and resource accessibility were experienced as mutually constitutive within this ecosystem, rather than functioning as independent relational dimensions; communication and access co-varied systematically. In artefact-centred social learning spaces, communicative processes are often enacted through access to shared materials, information repositories, and structured feedback loops. Access, in this sense, is not merely the availability of resources but is operationalised through communicative coordination. Dialogue enables access, and access sustains dialogue. The structural integration observed in this study is therefore consistent with collaboration configured around shared artefacts rather than transactional exchange.

From an ecosystem perspective, actors rely on coordinated participation rather than discrete resource transfers. In such configurations, communication is inseparable from operational engagement. The empirical merging of Dialogue and Access may thus reflect the procedural entanglement of interaction and resource mobilisation characteristic of governance-intensive WIL environments. It should be emphasised, however, that the present analysis does not permit direct inference about cognitive or experiential processes. The convergence is structural and statistical. The interpretation offered here remains theoretically grounded but empirically bounded.

Furthermore, the convergence of Risk Assessment and Transparency into a governance-assurance domain similarly reflects the structured accountability environment of the WE ecosystem. In collaborative governance regimes, risk perception is mediated through visibility of roles, expectations, and decision-making processes. When responsibilities are clarified and engagement is structured, vulnerability may be experienced as distributed rather than unilateral. Within the WE programme, collaboration is scaffolded through formalised stakeholder mapping, iterative validation checkpoints, and explicit articulation of expectations. These governance mechanisms may render risk and transparency interdependent. Transparency mechanisms do not merely disclose information; they structure accountability and thereby shape how risk is perceived.

The empirical results indicate that stakeholders did not differentiate statistically between risk-related and transparency-related items. This suggests that, in this governance-intensive setting, perceptions of risk and transparency were configured as components of a shared accountability architecture. Again, this interpretation is consistent with collaborative governance theory but remains inferential. The data capture covariance patterns rather than underlying relational mechanisms. Taken together, the two-factor configuration suggests that co-creation in this WIL ecosystem manifested along two structurally integrated domains: interactional-operational quality and governance-assurance alignment. This reorganisation does not imply conceptual reduction but rather reflects ecosystem-specific relational structuring.

Implications for WIL theory consolidation

Beyond measurement considerations, the findings contribute to ongoing debates regarding the conceptual consolidation of WIL. Several scholars have cautioned against reducing WIL to placement-based or purely instrumental pedagogical arrangements. The governance-intensive framing adopted in this study conceptualises WIL as a multidimensional learning phenomenon emerging through boundary crossing around artefacts within structured collaborative architectures. The dimensional convergence observed here supports the proposition that relational co-creation processes in WIL are embedded within governance structures rather than operating as isolated relational exchanges. Interaction unfolds within pedagogically mediated cycles. Accountability is distributed across institutional actors. Artefacts stabilise participation across boundaries. Under these conditions, relational constructs may reorganise structurally. This interpretation reinforces the argument that WIL should be theorised as an ecosystem phenomenon rather than as a technique. It also aligns with calls for terminological precision and conceptual coherence in WIL research. The present findings do not redefine WIL; instead, they provide empirical support for treating relational measurement as context-sensitive within governance-intensive learning architectures.

Measurement and instrument transfer implications

The study also carries implications for measurement theory. The purification process removed several items whose wording was overly market-oriented or abstract for the WIL context. This pattern suggests that direct transfer of relational

instruments across domains may require contextual recalibration. Exploratory factor analysis demonstrated strong internal consistency and substantial explained variance. However, the modest sample size and single-ecosystem design necessitate caution. The present results represent exploratory validation rather than confirmatory testing. Dimensional stability across WIL ecosystems remains to be examined through multi-site studies and confirmatory factor modelling. Importantly, the observed two-factor structure does not imply dimensional collapse but rather dimensional integration under specific structural conditions. Future research should assess whether similar convergence patterns emerge in other governance-intensive or artefact-mediated learning environments, or whether alternative configurations appear under different ecosystem architectures.

Implications for practice and policy

From a practical standpoint, the findings offer preliminary diagnostic insight for governance-intensive WIL ecosystems. Rather than assuming that four theoretically discrete relational dimensions will manifest uniformly, evaluative frameworks may benefit from assessing relational processes at the level of integrated domains: interactional-operational quality and governance-assurance alignment. For practitioners designing WIL programmes, attention to the integration of communicative and operational dimensions may be particularly relevant in artefact-centred collaboration cycles. Similarly, explicit governance structures that clarify roles and distribute accountability may shape stakeholders' perceptions of transparency and risk. These implications should not be interpreted prescriptively. The present study does not provide normative guidance for restructuring WIL evaluation systems. Instead, it suggests that relational measurement tools may need to be adapted to reflect ecosystem-specific governance conditions. At a policy level, the results reinforce the importance of structured coordination mechanisms in sustaining principled engagement across institutional boundaries. Governance-intensive does not imply bureaucratic rigidity; rather, it denotes relational coordination architectures capable of maintaining shared responsibility within multi-actor collaboration. Evaluative instruments that ignore such structural conditions may fail to capture the relational dynamics of WIL ecosystems.

Territory and ownership as structuring conditions

Although territory and ownership were not operationalised in this study, their theoretical relevance warrants discussion. Social learning space theory conceptualises value creation as emerging through participation grounded in perceived stake and recognition. Within governance-intensive WIL ecosystems, ownership may function as a structuring condition that integrates relational dimensions. The convergence of Dialogue with Access and Risk with Transparency may be compatible with models in which perceived stake and shared responsibility facilitate relational integration. However, this interpretation remains inferential. Direct operationalisation of territory and ownership would be required to substantiate such claims. Future studies incorporating explicit measurement of perceived ownership could clarify whether territory functions as a mediating variable in relational co-creation processes.

Limitations

Several limitations must be acknowledged. First, the study is based on a single WIL ecosystem within a specific institutional context. Second, the sample size is modest and limited to external stakeholders. Third, the design is cross-sectional and does not capture longitudinal development of relational dynamics. Fourth, the analysis relies on exploratory factor analysis without confirmatory modelling. These limitations constrain generalisability and preclude strong causal inference. The interpretations offered remain bounded by the data and theoretical framing.

Future research directions

The present study does not resolve the dimensional status of co-creation constructs across contexts. Instead, it contributes to the incremental refinement of relational measurement within governance-intensive WIL ecosystems. The findings suggest that dimensional stability cannot be presumed when instruments migrate across institutional logics, and that relational constructs may reorganise structurally in artefact-mediated and accountability-structured environments. By situating DART within an ecosystem and governance architecture perspective, this study advances a context-sensitive understanding of co-creation measurement in WIL. Its contribution lies not in proposing a universal restructuring but in demonstrating the importance of aligning relational instruments with the structural realities of multidimensional learning

ecosystems. Therefore, future research should pursue multi-site validation across diverse WIL ecosystems to assess dimensional stability. Confirmatory factor analysis and measurement invariance testing would strengthen construct validation. Longitudinal designs could examine how relational domains evolve across collaboration cycles. Inclusion of student and facilitator perspectives would provide multi-actor triangulation. Finally, explicit operationalisation of territory and ownership would enable examination of their role in structuring relational integration.

Conclusions

The present study sets out to examine whether the relational architecture of value co-creation, as operationalised through the DART framework (Dialogue, Access, Risk Assessment, and Transparency), retains structural validity when transferred from commercial innovation contexts to a governance-intensive Work-Integrated Learning (WIL) ecosystem. Positioned within a multidimensional conceptualisation of WIL as a boundary-mediated and artefact-centred social learning space, the study did not assume dimensional stability but treated replication as an empirical question.

The findings provide a clear answer to the research questions, subject to appropriate methodological qualifications. Regarding RQ1, the original four-dimensional DART structure was not replicated within the WE governance-intensive WIL ecosystem. Exploratory factor analysis (EFA) revealed that the theoretically distinct dimensions did not yield four statistically independent latent constructs. Attempts to force a four-factor solution resulted in unstable loadings and reduced interpretability. This indicates that dimensional distinctiveness observed in commercial innovation settings is not structurally preserved under the governance and pedagogical conditions characterising the present WIL ecosystem.

Regarding RQ2, an alternative, statistically robust two-factor configuration emerged. Dialogue and Access were integrated into a coherent interactional-operational domain, while Risk Assessment and Transparency converged into a governance-assurance domain. These factors were not arbitrary statistical artefacts but demonstrated strong loadings, minimal cross-loadings, and conceptual interpretability consistent with the structural conditions of the ecosystem under study.

Regarding RQ3, the Portuguese adaptation of the DART scale demonstrated strong psychometric properties in this context. Internal consistency exceeded recommended thresholds ($\alpha > 0.80$ for both factors), communalities were adequate, and the two-factor solution explained a substantial proportion of variance (72.91%). These results support contextual reliability and preliminary construct adequacy. However, as emphasised throughout the manuscript, this constitutes exploratory validation within a single ecosystem. Confirmatory testing across independent samples and institutional contexts remains necessary before claims of dimensional stability can be advanced.

Finally, addressing RQ4, the observed dimensional restructuring was interpreted considering the conceptual framing of WIL as a governance-intensive, artefact-centred ecosystem embedded in social learning spaces. The empirical convergence of Dialogue and Access is theoretically consistent with boundary-mediated collaboration in which communicative exchange and resource accessibility are enacted simultaneously through shared artefacts. Similarly, the integration of Risk and Transparency aligns with collaborative governance theory, where vulnerability and accountability are structurally interlinked within principled engagement regimes. These interpretations remain inferential: the analysis reveals structural covariance patterns rather than directly measuring cognitive or behavioural mechanisms. Nevertheless, the observed structural patterns are theoretically coherent within the frameworks of ecosystem governance and social learning.

Taken together, the study substantiates the central proposition that co-creation mechanisms may reorganise when embedded within governance-intensive WIL ecosystems. Rather than invalidating the DART framework, the findings indicate that its relational building blocks may manifest differently when situated within pedagogically mediated, temporally bounded, and accountability-structured collaboration architectures. Importantly, the study does not claim universal dimensional restructuring. The two-factor configuration identified here is empirically bound to the WE ecosystem. The contribution lies not in proposing a replacement model, but in demonstrating that dimensional transferability cannot be assumed across institutional logics. Relational measurement instruments require contextual validation when migrating from commercial innovation environments to higher education ecosystems characterised by distributed responsibility and artefact-mediated interaction.

From a theoretical standpoint, the results reinforce the framing of WIL as a multidimensional learning phenomenon rather than a placement-based pedagogical technique. The convergence of relational constructs suggests that collaboration in governance-intensive WIL environments is structurally integrated rather than segmented. Dialogue and access co-function within operational engagement; transparency and risk co-function within accountability architectures. This supports ecosystem and collaborative governance perspectives in which value emerges through coordinated interdependence rather than isolated relational components. From a measurement perspective, the study contributes to construct validation debates by illustrating how exploratory factor analysis can reveal context-specific restructuring when instruments are transferred across domains. The findings underscore the importance of examining dimensional robustness before applying co-creation metrics within higher education ecosystems. From a practical standpoint, the study offers cautious diagnostic insight. In governance-intensive WIL settings similar to the WE programme, relational processes may be more accurately captured at the level of integrated domains – interactional-operational quality and governance-assurance alignment – rather than as four analytically discrete dimensions. However, this suggestion remains provisional and should not be interpreted as prescriptive guidance for instrument redesign without further validation.

Several limitations frame the scope of these conclusions. The study is based on a single institutional ecosystem and a modest sample size. The design is cross-sectional and limited to external stakeholder perceptions. The analysis is exploratory rather than confirmatory. Consequently, generalisability across WIL ecosystems, cultural contexts, and disciplinary domains cannot be assumed. As such, several concrete methodological extensions, including multi-site replication, confirmatory factor analysis, measurement invariance testing, longitudinal designs, and explicit operationalisation of territory and ownership, were outlined in the Future Research Directions section. Building on those proposals, the focus shifts to emphasise the broader research trajectory implied by the present findings.

Advancing the body of knowledge in this area requires moving from context-specific exploratory validation toward comparative and cumulative research. Multi-ecosystem studies can assess whether dimensional convergence is characteristic of governance-intensive WIL more broadly or contingent upon specific architectural features. Integrating student and facilitator perspectives can clarify whether relational restructuring is actor-dependent. A longitudinal investigation can determine whether dimensional integration strengthens or differentiates over time. Finally, explicit measurement of ownership (territory) and psychological safety may illuminate whether these relational preconditions mediate the integration of co-creation constructs.

In conclusion, this study contributes to the theoretical and empirical consolidation of WIL by demonstrating that relational measurement tools must be aligned with the structural realities of governance-intensive learning ecosystems. It advances a context-sensitive understanding of co-creation measurement without collapsing theoretical constructs into reductionist simplifications. By empirically examining dimensional robustness and theoretically situating structural restructuring within ecosystem governance and social learning perspectives, the study strengthens the dialogue between WIL scholarship and measurement theory. The future development of WIL as a field depends not only on innovative pedagogical designs but also on robust conceptual grounding and empirically validated relational instruments capable of capturing how value is co-created across institutional boundaries.

Declaration of interests

The authors declare that they have no known financial or non-financial competing interests that could have influenced the research, authorship, and/or publication of this article.

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