

## Article

# ONTOLOGICAL MODELLING AND CONCEPTUAL ARCHITECTURE OF SOCIAL COHESION

## Modelado ontológico y arquitectura conceptual de la cohesión social

OLENA MYKHAILOVSKA<sup>1</sup> & OKSANA LIASHENKO<sup>2</sup>

**Abstract:** Research on tolerance, education, and social cohesion is characterised by conceptual richness but structural fragmentation. Different disciplinary traditions operationalise these constructs at distinct levels of analysis and according to divergent normative and methodological priorities. As a result, theoretical pathways are often implied rather than explicitly specified. This study proposes an ontology-based conceptual model that formalises the relationships between education, diversity, contact, trust, identity, tolerance, social cohesion, and policy models within a unified semantic framework. The model was developed through structured concept extraction from peer-reviewed European literature, hierarchical organisation of core classes, and specification of object properties representing admissible relations between constructs. The ontology was implemented in OWL using Protégé and logically verified with a description-logic reasoner. The resulting ontology clarifies the conceptual relationships between education, diversity, trust, identity, tolerance and social cohesion and demonstrates how these constructs can be organised into a coherent multi-level semantic architecture. The study discusses the implications of ontology-based modelling for integrating fragmented research traditions and for supporting future empirical operationalisation in European comparative studies.

**Keywords:** Ontology-based modelling, Cultural diversity, Education, Tolerance toward immigrants, Social cohesion, Trust, Identity formation, Conceptual integration, Europe.

**Resumen:** La investigación sobre educación, tolerancia hacia los inmigrantes y cohesión social en Europa se caracteriza por una gran riqueza conceptual, pero también por una notable fragmentación estructural. Las distintas tradiciones disciplinares operacionalizan estos conceptos en niveles de análisis diferentes y según prioridades normativas y metodológicas divergentes. Como resultado, las relaciones teóricas suelen quedar implícitas en lugar de estar formalmente especificadas. Este estudio propone un modelo conceptual basado en ontología que formaliza las relaciones entre educación, diversidad, contacto, confianza, identidad, tolerancia, cohesión social y modelos de política pública dentro de un marco semántico unificado. El modelo se desarrolló mediante un proceso estructurado de extracción conceptual a partir de literatura científica europea revisada por pares, organización jerárquica de clases centrales y especificación de propiedades relacionales entre los constructos. La ontología fue implementada en OWL utilizando Protégé y verificada mediante un razonador de lógica descriptiva. La ontología resultante clarifica las relaciones conceptuales entre educación, diversidad, confianza, identidad, tolerancia y cohesión social, y demuestra cómo estos constructos pueden organizarse en una arquitectura semántica coherente de múltiples niveles. El estudio analiza además

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<sup>1</sup> Research and Educational Innovation Center of Social Transformations. Main contact: [M-olena@ukr.net](mailto:M-olena@ukr.net)

<sup>2</sup> Lesya Ukrainka Volyn National University.



las implicaciones del modelado ontológico para integrar tradiciones de investigación fragmentadas y para apoyar futuras operacionalizaciones empíricas en estudios comparativos europeos.

**Palabras clave:** Modelado basado en ontologías, Diversidad cultural, Educación, Tolerancia hacia los inmigrantes, Cohesión social, Confianza, Formación de la identidad, Integración conceptual, Europa.

## 1. Introduction.

Research on tolerance toward immigrants, social cohesion, and the role of education in Europe has expanded considerably over the past decades. These concepts are central to contemporary debates on migration governance, democratic resilience, and integration policy. Empirical studies have examined the determinants of anti-immigrant attitudes (Dražanová & Gonnot, 2023; Gorodzeisky & Semyonov, 2016, 2019; Schmidt, 2021), the dynamics of social trust (Mitchell, 2021; Wu, 2021), and the multidimensional character of social cohesion (Davis & Davies, 2025; Langer et al., 2017; Laurence, 2011).

Despite this growing body of research, the conceptual foundations of tolerance and social cohesion remain fragmented. Tolerance has been approached from multiple theoretical traditions. Classical intergroup contact theory emphasises structured contact as a mechanism for reducing prejudice (Allport, 1954; Pettigrew, 1998). Subsequent research has investigated competitive threat and racial prejudice as drivers of anti-immigrant attitudes (Gorodzeisky & Semyonov, 2016), as well as identity-based predictors of support or opposition to immigration (Visintin et al., 2018). At the same time, efforts to operationalise tolerance have produced diverse measurement instruments and behavioural indicators (Costantini et al., 2024; Liberati et al., 2020). These strands reveal conceptual richness but also definitional divergence regarding what tolerance precisely entails.

The concept of social cohesion displays similar heterogeneity. Some studies conceptualise cohesion in terms of social capital, interethnic relations, and community-level trust (Laurence, 2011). Others construct perception-based indices that integrate belonging, participation, and shared norms (Langer et al., 2017). Recent reviews highlight its multidimensional structure and measurement variability (Davis & Davies, 2025). Trust, identity, and perceived diversity are repeatedly identified as key components (Mitchell, 2021; Van Assche et al., 2023), yet these dimensions are not consistently integrated into a unified theoretical architecture.

Education is frequently positioned as a mediating mechanism linking diversity to attitudinal and societal outcomes. Research on intercultural and multicultural education emphasises communication competence and inclusive pedagogical practices (Giavrimis & Dimitriadou, 2023; Roux, 2002). Normative debates on multiculturalism and interculturalism

further shape the policy framing of integration (Levrau & Loobuyck, 2018; Sealy et al., 2024; Zapata-Barrero, 2017;). However, educational research often focuses on sector-specific outcomes without explicitly connecting micro-level classroom processes to macro-level cohesion indicators.

Recent developments in ontology-based modelling offer methodological tools for addressing such conceptual fragmentation. Ontological approaches enable explicit specification of classes, hierarchical relations, and admissible object properties, thereby reducing semantic ambiguity (Guizzardi, 2005; Verdonck et al., 2019). Applications in behavioural science and social systems demonstrate the potential of formalised ontologies for integrating heterogeneous theoretical constructs (Adamo & Willis, 2022; Hastings et al., 2020, 2024). The Protégé platform and OWL formalisation provide a machine-readable environment for implementing logically structured conceptual architectures (Musen, 2015; Rubin et al., 2005).

In the context of contemporary globalisation processes, cultural diversity increasingly interacts with questions of identity formation and social sustainability. Recent interdisciplinary debates emphasise that societies must balance plural cultural identities with shared democratic norms and inclusive institutional frameworks. Understanding how diversity, identity and education interact therefore becomes crucial not only for analysing tolerance toward immigrants but also for supporting sustainable forms of social cohesion in multicultural societies.

Building on this foundation, the present study develops an integrated ontological model that systematises the core constructs of Education, Diversity, Contact, Trust, Identity, Tolerance, Social Cohesion, and Policy Model in the European context. Rather than introducing new empirical findings, the article seeks to formalise conceptual relationships, clarify levels of abstraction, and provide a structured semantic architecture capable of linking previously disconnected theoretical strands. By doing so, it contributes to conceptual clarity and establishes a foundation for future empirical operationalisation and cross-sectoral integration.

## **2. Theoretical Foundations of Tolerance, Social Cohesion and Education.**

### **2.1. Tolerance Toward Immigrants.**

Tolerance toward immigrants is a multidimensional construct that has been widely examined in European research. Although often treated as a single attitudinal outcome, empirical studies demonstrate that tolerance encompasses political, cultural, social, and

emotional dimensions. The predictors of tolerant and anti-immigrant attitudes operate at individual, contextual, and structural levels.

In European research, the distinction between political and social tolerance is fundamental.

- Political Dimension (Support for Equal Rights): Authors framing tolerance primarily through this lens emphasize the belief that immigrants should have identical legal and educational access as the native population. This perspective is often rooted in the liberal principle of equality of opportunity and institutional accommodation, where multiculturalist theorists argue that equal treatment requires the formal recognition of minority rights and anti-discrimination measures. In the context of this study, this approach is reflected in the works of Levrau & Loobuyck (2018) and Sealy, Dupont, & Modood (2024), who map the normative foundations of multiculturalism as a framework for legal equality.
- Social Dimension (Everyday Social Acceptance): Conversely, scholars emphasizing social tolerance focus on the reduction of "social distance" and the quality of intergroup relations. From this perspective, tolerance is achieved through "equal status contact" and meaningful interpersonal dialogue in shared public spheres. This direction is represented by the foundational contact theory of Allport (1954) and Pettigrew (1998). Furthermore, interculturalist approaches, such as those discussed by Zapata-Barrero (2017), prioritize the management of face-to-face encounters and everyday interactions as the central axis for cultivating social acceptance and mutual understanding. Recent research by Kreienkamp et al. (2023) further supports this by highlighting that the psychological quality of these everyday contacts is a crucial determinant of tolerant outcomes.

Recent European studies consistently identify several stable predictors of immigrant tolerance. One of the most robust factors is inclusive identity. Strong identification with Europe, particularly in countries with inclusive integration policies, is positively associated with more tolerant attitudes toward immigrants (Visintin, Green, & Sarrasin, 2018). Inclusive normative climates reinforce the relationship between European identification and pro-immigrant orientations.

Social trust is another key predictor. Higher levels of generalized trust are consistently associated with more positive attitudes toward immigrants, even when controlling for socio-economic variables (Mitchell, 2021). Trust functions as a stabilizing mechanism that reduces perceived threat and fosters openness toward out-groups.

Cultural values also play a central role. Individuals socialized in contexts emphasizing tolerance and universalism tend to express more supportive attitudes toward immigrants. Conversely, strong religiosity in certain contexts has been associated with lower tolerance, although research suggests that this effect is linked more to intensity of religiosity than to religious identity per se (Berggren, Ljunge, & Nilsson, 2022).

Social globalization and spatial mobility further contribute to tolerance. Exposure to global communication flows, cultural openness, and cross-border experiences reduce social distance and enhance acceptance of immigrants (Tsai & Tzeng, 2022). Individuals with experience of living abroad or relocating across regions demonstrate higher levels of tolerance, independent of other demographic factors (Bjarnason et al., 2019).

At the same time, anti-immigrant attitudes are shaped by distinct mechanisms. Economic competition remains an important explanatory factor, particularly among individuals with lower socio-economic status or in regions experiencing economic instability. Perceived competition over jobs, welfare benefits, and public resources intensifies negative attitudes, especially during periods of rapid immigration increase (Dražanová & Gonnot, 2023; Gorodzeisky & Semyonov, 2019).

Racial prejudice constitutes an independent source of opposition to immigrants. Studies show that negative attitudes toward non-European or racialised minorities are not reducible to economic concerns and may be amplified in societies with larger visible minority populations (Gorodzeisky & Semyonov, 2016, 2019).

Cross-country variation further complicates the picture. Tolerance levels differ substantially across European societies depending on psychological orientations, socio-economic inequalities, crisis experiences, and institutional contexts. Events such as Brexit or the refugee crisis have intensified polarisation in certain countries, particularly among economically vulnerable groups (Kromczyk, Khattab, & Abbas, 2021). Cohort effects are also observed, with younger generations generally displaying more favourable attitudes toward immigrants, although this tendency may stabilise over time (Schmidt, 2021).

Overall, research indicates that tolerance toward immigrants is more consistently influenced by identity, trust, cultural orientations, exposure to globalisation, and mobility experiences than by purely economic considerations. However, the conceptualisation of tolerance varies across studies, ranging from political rights support to broader social acceptance, which contributes to the broader issue of conceptual fragmentation identified in this article.

## 2.2. Social Cohesion.

In multicultural European societies, social cohesion is conceptualised as a complex, multidimensional construct that reflects the strength of social bonds and the level of solidarity among members of society. It is commonly operationalised through indicators such as trust, belonging, inclusion, equality, and the quality of intergroup relations. Social cohesion is understood not merely as the absence of conflict, but as an active process of integration that recognises and accepts diversity within and between social groups.

Theoretically, social cohesion encompasses both social-associative and cultural-moral dimensions. It integrates elements of social capital, perceived inequality, institutional trust, shared values, and national identity, which can be analysed at the individual, community, and national levels (Chuang, Chuang, & Yang, 2013). Its multidimensional nature makes it particularly sensitive to variations in measurement strategies and policy contexts.

Survey-based research often uses indicators such as generalised trust — measured by respondents' belief that most people can be trusted — as a central dimension of cohesion. Feelings of belonging to a local community or nation, perceptions of shared norms and goals, and participation in civic or voluntary activities are also widely used indicators. In addition, measures of inclusion and equality assess perceived fairness, equal opportunities, and the absence of discrimination.

Ethnic and cultural diversity plays a complex and often contested role in shaping perceived social cohesion. Empirical studies suggest that subjective perceptions of diversity and segregation, rather than objective demographic composition alone, are crucial in explaining variations in trust and cohesion (Van Assche et al., 2023). Perceived segregation combined with high diversity tends to produce lower levels of intergroup trust.

However, diversity does not uniformly undermine cohesion. Research shows that in contexts where “bridging” social ties are cultivated, ethnic diversity can improve interethnic relations (Laurence, 2011). Historical legacies and political conditions also matter: countries with colonial pasts or inclusive integration policies often show weaker negative effects of diversity on cohesion (Ponce, 2019).

Measurement approaches further illustrate conceptual diversity. At the macro level, composite indices such as the Social Cohesion Index (SCI) combine trust, perceived inequalities, and national identity to capture broader societal integration (Langer et al., 2017). In other strands, cohesion is framed more narrowly around belonging and shared values,

excluding structural dimensions such as inequality. These differences reflect distinct theoretical emphases and policy priorities.

Overall, social cohesion is consistently treated as a multidimensional construct, yet its operationalisation varies widely across disciplines. Some models emphasise emotional belonging and shared norms, while others prioritise institutional trust and structural equality. This variability contributes to the broader conceptual fragmentation that motivates the present study.

### **2.3. Education as Normative and Cognitive Mechanism.**

Education is widely recognised in European research as a key mechanism shaping attitudes towards immigrants and broader patterns of social cohesion. However, its role is conceptualised differently across subfields. In general terms, education operates as both a normative mechanism — transmitting democratic values and social norms — and a cognitive mechanism — developing critical thinking, empathy, and intercultural literacy.

Civic education research shows that higher levels of civic knowledge and an open classroom climate are linked to more tolerant attitudes towards immigrants. Teacher fairness, opportunities for discussion, and participatory learning environments foster political tolerance and inclusive democratic orientations among adolescents (Javornik, 2023). In this strand, education is understood to strengthen support for equal rights and democratic inclusion.

Intercultural education, in turn, emphasises direct engagement with diversity. It promotes multilingualism, intercultural dialogue, and the deconstruction of cultural stereotypes. Research indicates that intercultural practices in schools foster more positive attitudes towards immigrants and refugees, though their effectiveness depends heavily on teachers' orientations and institutional contexts (Giavrimis & Dimitriadou, 2023). Educators' competence in culturally sensitive communication is identified as a crucial factor in reducing potential intergroup tensions (Roux, 2002).

Beyond formal classroom practices, intercultural literacy is cultivated through both curricular and extracurricular activities. Artistic and community-based initiatives provide authentic intercultural experiences that enhance empathy and reduce prejudice (Matos & Melo-Pfeifer, 2020).

Across these strands, education is repeatedly positioned as a solution to distinct policy challenges — democratic participation, the prevention of social tensions, inequality reduction, and European integration. Yet the underlying conceptualisation of how education relates to tolerance and social cohesion varies. Some approaches emphasise cognitive

development and empathy, others focus on institutional fairness and access, while still others highlight identity formation.

Taken together, education functions as both a normative and a cognitive mechanism that shapes tolerance and cohesion, yet the absence of a unified conceptual framework limits the integration of findings across sectors and levels of analysis.

### **3. Relational and Policy Mechanisms Linking the Core Constructs.**

#### **3.1. Contact Theory as Relational Mechanism.**

Intergroup contact theory offers a relational mechanism linking education, tolerance, and social cohesion. Formulated by Allport (1954), the theory holds that positive, cooperative interaction between members of different social groups can reduce prejudice and improve intergroup relations, particularly when specific conditions are met: equal status, common goals, intergroup cooperation, and institutional support.

Subsequent theoretical developments expanded the model beyond direct contact to include indirect and extended forms of contact, as well as mediating psychological processes such as reduced anxiety, increased empathy, and perspective-taking (Pettigrew, 1998). In contemporary European research, contact theory has been empirically examined in diverse contexts, including schools, neighbourhoods, and workplaces.

Recent studies show that not only the frequency but also the quality of contact matters. Need fulfilment during intergroup interaction — such as feeling respected or understood — strengthens positive attitudinal outcomes (Kreienkamp et al., 2023).

From a conceptual perspective, contact theory serves as a bridge between micro-level attitudes and macro-level cohesion. At the micro level, meaningful contact fosters empathy, trust, and reduced prejudice. At the meso level, educational institutions structure opportunities for such contact through classroom climate, curricular design, and intercultural programmes. At the macro level, sustained positive intergroup interactions contribute to broader patterns of social trust and cohesion.

Importantly, contact theory clarifies how education functions not merely as a transmitter of norms but as a relational space where intergroup attitudes are formed and transformed. Schools and universities create structured environments in which institutional support and cooperative goals can be embedded in everyday interaction.

Thus, within the integrated framework proposed in this study, contact theory serves as a core relational mechanism linking diversity, educational environments, trust formation, and tolerance outcomes. It provides a theoretical bridge between individual-level cognitive

and emotional processes and broader patterns of social cohesion, and therefore forms a central component of the ontological model developed below.

### **3.2. Multiculturalism vs Interculturalism as Policy Frames.**

While contact theory explains relational dynamics at the interactional level, broader policy frameworks shape the normative context in which education, tolerance, and social cohesion are defined. In European discourse, multiculturalism and interculturalism are two dominant yet distinct approaches to managing diversity.

Multiculturalism traditionally emphasises recognition, the protection of minority rights, and institutional accommodation of cultural differences. It frames diversity primarily in legal and political terms, focusing on equality, anti-discrimination measures, and group-based rights (Levrau & Loobuyck, 2018). Within this model, tolerance is often conceptualised as support for equal rights and fair institutional treatment, while social cohesion is associated with peaceful coexistence within a shared legal framework.

Interculturalism, by contrast, shifts the emphasis from recognition to interaction. It foregrounds dialogue, everyday encounters, and the active construction of shared civic space (Zapata-Barrero, 2017). Rather than merely protecting difference, interculturalism seeks to foster contact, mutual understanding, and relational integration. In this approach, tolerance is not limited to rights-based acceptance but includes openness, empathy, and engagement.

Recent scholarship suggests that interculturalism should not be understood as a radical departure from multiculturalism but as its evolution or complement (Sealy, Dupont, & Modood, 2024). Multiculturalism provides the normative foundation of equality and recognition, whereas interculturalism operationalises integration at the level of interaction and everyday practice.

These policy frames directly shape educational discourses. In civic education, multicultural principles underpin equal participation and democratic inclusion. In religious education, cohesion may be framed around shared moral values and the prevention of social tensions. In higher education policy, multicultural logics support access and equality, while intercultural perspectives highlight mobility, exchange, and transnational identity formation.

From an integrative perspective, multiculturalism and interculturalism serve as macro-level normative structures that shape expectations of how education should influence tolerance and cohesion. They define the policy goals within which educational institutions operate and determine whether emphasis is placed on rights, dialogue, prevention, identity formation, or structural equality.

Within the ontological framework proposed in this study, these policy models are conceptualised as contextual layers that moderate and structure the relationships between education, contact, trust, identity, tolerance, and social cohesion. They provide the normative environment in which relational mechanisms unfold and institutional practices are embedded.

### **3.3. Trust and Identity as Intertwined Mediating Mechanisms.**

In European research, diversity, education, and tolerance are increasingly conceptualised as linked through mediating layers of trust and identity. Rather than functioning as isolated predictors, these constructs serve as intervening mechanisms between structural conditions (migration, inequality, institutional quality) and individual attitudes towards immigrants.

#### **Diversity, Institutional Context, and Trust.**

Regional European analyses conceptualise social trust as a generalised expectation that others and institutions will act fairly and non-harmfully under conditions of uncertainty. In this sense, trust is not merely an interpersonal sentiment but a cognitive orientation shaped by institutional performance and perceived fairness.

The literature distinguishes these constructs by analyzing their specific targets and temporal stability. Generalised trust (or social trust) is directed toward "unfamiliar others" and is viewed as a stable cultural trait that persists even during economic shocks (Mitchell, 2021). In contrast, institutional trust (political trust) is directed at formal structures like the legal system or government and is more volatile, reflecting current events (Wu, 2021). This conceptual distinction is critical for building a multi-level semantic architecture, as it allows for the differentiation between interpersonal orientations and perceptions of institutional performance.

Similarly, identity is modeled as a multi-layered construct within European research. Personal identity relates to the individual's foundational self-concept, while social identity (affiliations with ethnic or religious groups) acts as a mediating bridge to national or civic identity (Ahmadi & Tabar, 2025). In this framework, a shared civic identity—such as identification with Europe—serves as the "social glue" that accommodates diverse personal and social attachments and fosters tolerance (Visintin et al., 2018). Identifying these hierarchical layers of identity provides the necessary conceptual components for formalizing how inclusive identification supports broader social cohesion.

Diversity influences both contact opportunities and perceived risk. Empirical evidence suggests that higher levels of migrant presence in European regions are associated

with higher tolerance and inclusion, particularly when embedded within effective and impartial institutional frameworks (Peiró-Palomino et al., 2024). Where institutions are perceived as fair, effective, and low in corruption, trust is strengthened, and this trust sustains advanced aspects of social progress, including rights protection, tolerance, and educational access (Peiró-Palomino et al., 2024; Wu, 2021).

Cary Wu's micro–macro framework further specifies the role of education in shaping trust. In stable, low-conflict societies — characteristic of much of Europe — education socialises individuals into generalised trust. In contrast, under high instability or conflict, education may heighten awareness of risk and reduce trust (Wu, 2021). Conceptually, trust thus operates both as a mediator and a moderator between diversity, education, and tolerance.

### **Education, Identity Formation, and Tolerance.**

Identity-based models position education as a central arena for socialisation and identity formation. Structural identity frameworks conceptualise social identity (belonging to ethnic, religious, or civic groups) as mediating between personal identity and broader national cohesion. Inclusive social identities integrate diverse attachments within shared national or civic frameworks that support cohesion in multicultural societies (Ahmadi & Tabar, 2025).

Minority education research in Central and Eastern Europe further highlights schooling as a site for either identity reproduction or intercultural integration. Systems that combine equity with intercultural content are theorised to support inclusive national identities and, consequently, higher tolerance in diverse settings (Kiss & Toró, 2025).

Across these models, identity mediates the impact of diversity. Where educational institutions enable multi-layered identities — ethnic, religious, civic, and European — diversity is more likely to translate into tolerant and cohesive orientations. Where identity constructions remain exclusive or hierarchical, diversity may reinforce boundary-drawing and exclusion.

### **Trust and Identity as Mutually Reinforcing.**

Trust and identity function not as parallel but as intertwined mediators. Regional European models show that social trust underpins the quality of government, prosocial behaviour, and lifelong learning, which, in turn, sustain tolerance and inclusion (Peiró-Palomino et al., 2024). At the same time, identity models emphasise that inclusive narratives depend on institutional trust and perceptions of fairness. Institutional trust moderates the translation of identity into cohesion (Ahmadi & Tabar, 2025).

From a social identity perspective, generalised trust expands the moral community beyond narrow in-groups, making inclusive identities and tolerant practices more plausible in diverse settings (Kordi & Maung, 2025). Trust stabilises identity boundaries, while inclusive identity frameworks normalise trust toward out-groups.

Conceptually, the European pathway can therefore be summarised as follows:

Structural diversity and institutional context

→ Educational experiences (equity, curricula, intercultural contact)

→ Identity formation (personal, social, national/European) and generalised trust

→ Political and social tolerance, support for inclusive rights, and social cohesion

Where institutions are impartial, and education fosters inclusive identities, trust and identity jointly mediate diversity's effects toward higher tolerance and cohesion. Where institutional quality is weak or identity constructions are exclusionary, the same diversity may produce distrust and intolerance.

Within the ontological model proposed in this study, trust and identity are therefore conceptualised as central mediating classes that connect structural diversity, educational processes, and attitudinal outcomes. Their integration resolves the vertical misalignment between micro-level attitudes, meso-level institutional practices, and macro-level cohesion indicators identified in the introduction.

The conceptual pathways discussed above can be synthesised into a structured representation of mediating mechanisms linking diversity, education, tolerance, and social cohesion. Rather than treating trust and identity as isolated variables, the literature consistently positions them as intervening mechanisms that translate structural and institutional conditions into attitudinal and societal outcomes.

Table 1 systematises these mediating pathways, identifying the directional links, the specific mediating roles of trust and identity, and the core conceptual mechanisms proposed in recent European research.

**Table 1.**

*Schematic Representation of Mediating Mechanisms Linking Diversity, Education, Tolerance and Social Cohesion*

Link	Mediat or role	Conceptual mechanism	Citations
Diversity → Tolerance	Trust	Diversity plus good institutions raise social trust, supporting rights, inclusion	Peiró-Palomino et al., 2024; Wu, 2021
Education → Tolerance	Trust	Educational socialization fosters or undermines generalized trust depending on stability	Peiró-Palomino et al., 2024; Wu, 2021
Education → Cohesion	Identity	Social identity integrates personal and group identities into national cohesion	Ahmadi & Tabar, 2025; Kiss & Toró, 2025
Diversity → Cohesion	Identity & Trust	Inclusive identities and high trust convert diversity into tolerant, cohesive outcomes	Ahmadi & Tabar, 2025; Peiró-Palomino et al., 2024

Source: Compiled by the authors

## **4. Methodology: Ontology Development Process.**

### **4.1. Research Design and Ontological Rationale.**

This study adopts a conceptual-theoretical research design grounded in ontology-driven modelling. Rather than testing empirical hypotheses or estimating statistical relationships, the objective is to integrate fragmented theoretical constructs within a formally structured semantic framework. The research, therefore, follows a knowledge-structuring approach that combines systematic literature review with ontology engineering principles.

This methodological choice is particularly appropriate for research areas characterised by conceptual fragmentation, as ontology modelling allows explicit representation of conceptual relations and reduces semantic ambiguity across disciplinary traditions.

The central methodological premise is that conceptual fragmentation in the social sciences can be addressed by explicitly formalising entities and relations. Constructs such as tolerance, trust, identity, diversity, and social cohesion are frequently defined differently across disciplines and policy domains. Without formal specification, these variations remain implicit, making theoretical integration difficult. Ontology-based modelling provides a structured mechanism for clarifying such constructs and specifying admissible relations among them.

Ontology-driven approaches require the explicit definition of classes, hierarchical relations (is-a), and object properties that link conceptual domains. Unlike narrative conceptual frameworks, ontologies impose semantic discipline: entities must be clearly distinguished, levels of abstraction must be specified, and relational pathways must be formally encoded. This requirement reduces ambiguity and prevents category overlap, thereby enhancing conceptual rigour (Guizzardi, 2005; Verdonck et al., 2019).

In the social and behavioural sciences, ontology-based modelling has increasingly been used to integrate heterogeneous theoretical systems and reduce fragmentation (Adamo & Willis, 2022; Hastings et al., 2020, 2024). By providing a shared semantic backbone, ontologies enable partially overlapping constructs from different traditions to be compared, aligned, or differentiated within a unified representational structure. This supports cumulative theorising and reduces conceptual inflation arising from synonymous or loosely defined terms (Pekrun, 2024).

Another key advantage is formal interoperability. Ontologies are machine-readable representations implemented in languages such as OWL, enabling logical consistency checking and computational reasoning (Musen, 2015; Rubin et al., 2005). Although the

present study does not aim at automated large-scale reasoning, the use of a formal ontology ensures internal coherence and prepares the model for potential future computational extensions.

In light of these methodological advantages, ontology-based modelling is particularly suitable for integrating fragmented theories of education, tolerance toward immigrants, trust, identity, diversity, and social cohesion in the European context. The approach enables cross-level structuring of micro-level attitudes, meso-level institutional mechanisms, and macro-level societal outcomes within a single coherent conceptual architecture.

#### **4.2. Literature Corpus and Conceptual Data Sources.**

The ontological model is constructed on the basis of a structured review of contemporary peer-reviewed literature in political science, sociology, education research, social psychology, and interdisciplinary European studies. Rather than serving as empirical data, the literature corpus functions as a source of candidate conceptual entities and relational mechanisms.

The literature corpus was selected using targeted searches in Scopus and Web of Science databases, focusing on peer-reviewed publications addressing tolerance toward immigrants, social cohesion, education and identity in European contexts. The corpus under review includes several thematic clusters. First, research on tolerance toward immigrants and minority groups provides differentiated conceptualisations of prejudice, political tolerance, social acceptance, perceived threat, and intergroup contact (Allport, 1954; Costantini et al., 2024; Gorodzeisky & Semyonov, 2016, 2019; Liberati et al., 2020; Pettigrew, 1998). Second, studies on social cohesion offer multidimensional operationalisations that include trust, belonging, participation, inequality, and perceived diversity (Davis & Davies, 2025; Laurence, 2011; Langer et al., 2017; Van Assche et al., 2023). Third, literature on trust and identity informs distinctions between generalised and institutional trust (Mitchell, 2021; Wu, 2021) and between personal, social, national, or civic forms of identification (Visintin et al., 2018).

Educational research constitutes an additional conceptual source. Studies of intercultural and multicultural education address communication competence, inclusive classroom climate, and normative integration models (Giavrimis & Dimitriadou, 2023; Levrau & Loobuyck, 2018; Roux, 2002; Sealy et al., 2024; Zapata-Barrero, 2017;). These strands provide distinctions among civic, intercultural, religious, and higher education perspectives, which are relevant for structuring the educational domain within the ontology.

The literature corpus, therefore, reflects theoretical diversity across disciplines and policy contexts. Importantly, the objective is not to privilege a single theoretical tradition but

to extract recurring conceptual dimensions and structurally central constructs that appear across domains. Where multiple terminological labels refer to closely related phenomena, harmonisation is applied to prevent redundant conceptual inflation.

Through this structured engagement with peer-reviewed European research, a stabilised conceptual inventory is derived. This inventory serves as the basis for subsequent class hierarchy construction and relational specification within the ontological framework.

### **4.3. Concept Extraction Procedure.**

Concept extraction followed a literature-based, iterative procedure consistent with established ontology-construction methodologies in the information and social sciences. The aim of this stage was to identify structurally central constructs recurring across disciplinary strands and to transform them into a stabilised set of candidate ontological classes.

In ontology engineering, concept extraction commonly combines systematic literature analysis with terminological normalisation (Zulkipli et al., 2022). Rather than relying solely on automated pipelines, domain-oriented social science ontologies typically require theoretically informed selection and refinement. Accordingly, the present study employed a structured qualitative extraction process grounded in repeated reading and comparative synthesis of the selected corpus of literature.

The extraction procedure included four interrelated steps:

1. Identification of recurrent core constructs. Concepts appearing consistently across tolerance, cohesion, trust, identity, diversity, and education research were marked as candidate upper-level entities. These included, among others, Tolerance, Social Cohesion, Trust, Identity, Diversity, Contact, Education, and Policy Model.
2. Differentiation of theoretically grounded subtypes. Where the literature systematically distinguishes dimensions within a construct, subclasses were identified. For example, tolerance research distinguishes between political and social tolerance; trust research distinguishes between generalised and institutional trust; and identity scholarship distinguishes between personal, social, national, and civic identity. Such distinctions were preserved as lower-level classes to avoid conceptual conflation.
3. Elimination of redundant or synonymous labels. Terminological harmonisation was undertaken to prevent conceptual inflation. Where different strands used alternative labels for closely related phenomena, conceptual equivalence was assessed and, where appropriate, unified under a single class label. This step reduces semantic ambiguity and ensures internal coherence.

4. Standardisation of abstraction levels. Concepts were evaluated according to their level of abstraction (attitudinal, institutional, structural, or normative). Constructs referring to distinct analytical levels were not merged; instead, they were positioned hierarchically to preserve cross-level clarity.

This iterative refinement process aligns with domain-oriented ontology development approaches that emphasise conceptual normalisation before hierarchical structuring (Liu et al., 2011; Zhao et al., 2024). Rather than mechanically importing disciplinary vocabularies, the procedure aimed to construct a theoretically coherent conceptual inventory capable of supporting cross-domain integration.

The result of this stage is a structured list of candidate classes and subclasses, forming the basis for taxonomic organisation and relational modelling in the subsequent phase.

To illustrate this process, the concept of "Generalised Trust" was extracted from sociological literature where it is defined as a belief in the benevolence of others. In the ontology, this was translated into the class *GeneralisedTrust*, positioned as a subclass of *Trust*. It was then linked via the object property *influences* to the class *Tolerance*, reflecting the theoretical argument that foundational social trust reduces perceived threat and fosters openness toward out-groups.

#### **4.4. Class Hierarchy Construction.**

Following concept extraction and normalisation, the candidate constructs were organised into a structured taxonomic hierarchy. The objective of this stage was to establish clear superclass–subclass (is-a) relations and prevent conceptual overlap across levels of abstraction.

In ontology development, hierarchy construction may rely on clustering techniques, hypernym detection, or formal concept analysis (Hwang et al., 2005; Ríos-Alvarado et al., 2013). However, in theoretically dense social-science domains, hierarchical structuring typically requires iterative literature-based validation to ensure conceptual coherence and alignment with disciplinary distinctions (Kumazawa et al., 2014; Zulkipli et al., 2022).

In the present study, the class hierarchy was constructed through an iterative refinement process guided by theoretical differentiation identified in the literature. Core conceptual domains were defined as upper-level classes: Education, Diversity, Contact, Trust, Identity, Tolerance, Social Cohesion, and Policy Model.

These upper-level classes represent analytically distinct domains rather than empirical variables. Their separation reflects recurring structural divisions within the corpus of literature.

Subclasses were introduced where theoretical traditions consistently distinguish dimensions within a domain. For example:

- Tolerance was subdivided into *PoliticalTolerance* and *SocialTolerance*, reflecting the distinction between support for equal rights and everyday social acceptance.
- Trust was subdivided into *GeneralisedTrust* and *InstitutionalTrust*, corresponding to the differentiation between interpersonal and system-level trust.
- Identity was structured into *PersonalIdentity*, *SocialIdentity*, and *CivicIdentity*, capturing individual, group-based, and institutional attachment dimensions.
- Education was differentiated into forms such as *Civic Education*, *Intercultural Education*, *Religious Education*, and *Higher Education*, in line with sectoral distinctions in the literature.

Hierarchical relations were implemented strictly according to taxonomic logic: subclasses inherit the properties of their respective superclasses but represent more specific conceptual instantiations. This prevents the mixing of dimensions across domains (e.g., avoiding treating trust as a subtype of cohesion or identity as a subtype of education).

Particular attention was given to preserving cross-level coherence. Attitudinal constructs (e.g., tolerance, trust) were not conflated with institutional mechanisms (e.g., policy models, educational forms) or structural conditions (e.g., diversity). Instead, these domains were kept distinct yet relationally connectable, enabling subsequent specification of object properties without compromising hierarchical clarity.

Through this structured taxonomic organisation, the ontology establishes a formally coherent conceptual backbone that reflects theoretical differentiation while enabling integration across levels of analysis.

#### **4.5. Object Property Specification.**

While class hierarchy construction establishes taxonomic clarity, conceptual integration requires specifying the relational mechanisms between domains. In ontology-based modelling, these mechanisms are encoded through object properties that define admissible relations between classes.

In the present model, relational pathways identified in the literature were formalised as object properties linking distinct conceptual domains. The specification of these properties followed two guiding principles: (1) theoretical grounding in the reviewed literature and (2) semantic coherence, ensured by explicit domain and range constraints.

The following core object properties were implemented:

- Influences – representing directional theoretical effects between conceptual domains (e.g., Education influences Tolerance; Diversity influences Trust);
- Mediates – capturing the intermediary mechanisms through which one domain affects another (e.g., Identity mediates the relationship between Education and Tolerance);
- Moderates – encoding conditional relationships (e.g., PolicyModel moderates the effect of Diversity on SocialCohesion);
- Enhances – indicating reinforcing relationships (e.g., Trust enhances SocialCohesion);
- Reduces – representing theoretically grounded negative associations (e.g., Contact reduces Segregation or Prejudice);
- AssociatedWith – used where literature indicates systematic correlation without directional specification.

Each object property was defined with explicit domain and range restrictions to prevent semantically inconsistent relations. For example, attitudinal constructs were not permitted to act as superclasses of institutional domains, and structural conditions were not modelled as subclasses of psychological states. This constraint-based approach enhances internal coherence and reduces category errors (Guizzardi, 2005).

Importantly, the object properties encode theoretical directionality, not statistical causality. The ontology does not assert empirical effect sizes or probabilistic relationships. Instead, it formalises conceptually admissible pathways recurrently identified in the literature, thereby creating a structured map of relational possibilities across domains.

Through this relational specification, the ontology moves beyond static taxonomic representation and captures the dynamic interplay between education, diversity, trust, identity, tolerance, and social cohesion. The resulting structure allows multi-level integration without collapsing analytically distinct constructs.

#### **4.6. Object Property Specification.**

The ontological model was implemented using Protégé, an open-source ontology engineering platform that supports OWL 2–based formal modelling (Musen, 2015). Protégé enables the structured definition of classes, subclass relationships, and object properties within a description logic framework. The Web Ontology Language (OWL) was used to encode the class hierarchy and relational specifications in a machine-readable format (Rubin et al., 2005).

Within the implementation environment, upper-level classes and their respective subclasses were created in accordance with the hierarchy defined in the previous sections. Object properties were then specified with explicit domain and range constraints to ensure the semantic admissibility of relations. This step prevents structurally inconsistent connections (e.g., modelling an institutional category as a subtype of an attitudinal construct) and reinforces taxonomic clarity.

The ontology's logical consistency was verified using an integrated description logic reasoner. The reasoning process was applied to:

- detect unsatisfiable classes,
- identify unintended equivalences between distinct classes,
- verify inheritance structures within the hierarchy,
- confirm compliance of object properties with specified domain and range restrictions.

No logical contradictions or unsatisfiable classes were identified in the final version of the model. The reasoning procedure, therefore, confirmed internal semantic coherence and structural consistency of the ontology.

It is important to emphasise that logical validation in this context refers to formal consistency within the OWL framework. It does not constitute empirical validation of theoretical pathways. Instead, it ensures that the conceptual architecture is structurally sound and free from internal contradictions.

The use of a formal ontology engineering environment strengthens the methodological transparency of the study. By encoding conceptual distinctions in a machine-readable and logically testable format, the model moves beyond narrative theorisation and provides a reproducible semantic structure that may support future empirical annotation and theoretical extension.

The ontology developed in this study is designed as a conceptual integration framework rather than an empirical causal model. Its primary function is to formalise relationships among theoretically grounded constructs and to provide a structured semantic architecture that links previously fragmented research strands.

Validation in this context refers to semantic and structural consistency, not statistical verification. Logical coherence was ensured through formal reasoning within the OWL framework. However, the ontology does not assert empirically tested effect sizes, nor does it claim predictive power. Object properties encode theoretically admissible directional

relationships derived from the literature, but they do not represent quantified causal estimates.

The model is also selective in scope. While it integrates central domains recurrent in European research on tolerance towards immigrants and social cohesion, it does not aim to exhaustively represent all possible subdimensions. For example, specific forms of prejudice, detailed policy instruments, or highly granular institutional indicators may be incorporated in future extensions. The present version prioritises conceptual integration and cross-level coherence over maximal granularity.

Moreover, the ontology reflects the current state of peer-reviewed European scholarship included in the literature corpus. As theoretical debates evolve and new constructs emerge, iterative refinement may be required to maintain conceptual relevance.

Despite these limitations, the ontology provides a structured foundation for future empirical operationalisation. Researchers may map survey indicators, policy variables, or qualitative findings onto formally defined classes, thereby facilitating cross-dataset alignment and cumulative knowledge building. In this sense, the model serves as a semantic infrastructure that supports interdisciplinary dialogue and systematic theoretical development.

## **5. Resulting Ontological Structure and Visual Representation.**

The ontology developed in this study provides a formally structured representation of the relationships between education, diversity, mediating mechanisms, tolerance toward immigrants, and social cohesion. Building on the methodological procedures described in Section 4, the resulting model integrates structural, institutional, attitudinal, and societal domains within a unified semantic architecture.

At its highest level, the ontology is organised around eight core classes: Education, Diversity, Contact, Trust, Identity, Tolerance, Social Cohesion, and Policy Model. These classes represent analytically distinct but relationally connected domains recurrent in European theoretical literature. Their separation ensures conceptual clarity, while object properties formally encode admissible pathways between them.

Education is positioned as a central institutional domain. It connects to Trust, Identity, Contact, and Tolerance through directional relations reflecting theoretically grounded mechanisms. Diversity functions as a structural context and links primarily to Contact, Trust, and Identity. Trust and Identity operate as mediating constructs translating structural and institutional conditions into attitudinal orientations. Tolerance represents the attitudinal domain toward immigrants and minority groups, while SocialCohesion constitutes

the broader societal outcome. PolicyModel introduces a normative layer that distinguishes between Multiculturalism and Interculturalism and moderates institutional pathways.

The relational structure enables representation of cross-level conceptual chains such as:

Diversity → Contact → Trust → Tolerance → SocialCohesion

and

Education → Identity → Trust → Tolerance → SocialCohesion

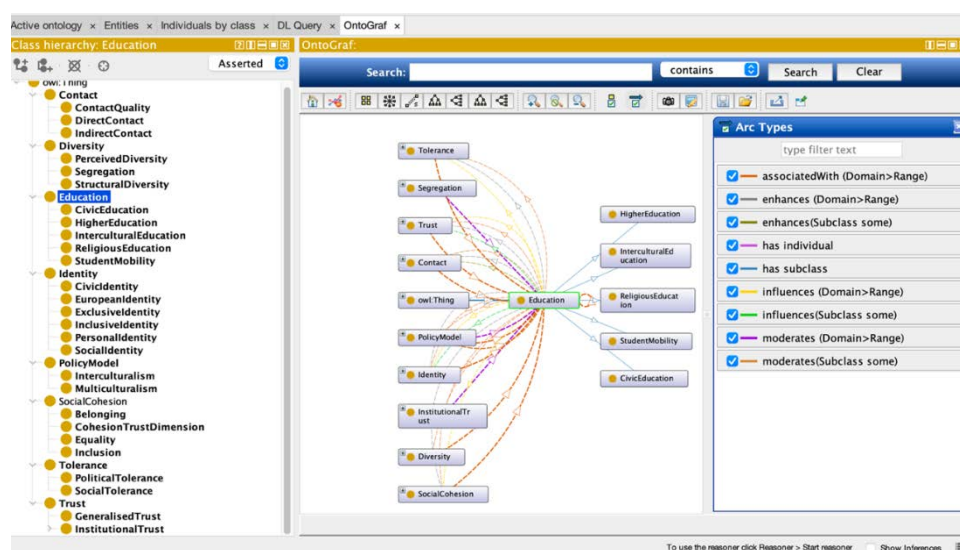
These pathways are not encoded as deterministic causal laws but as theoretically admissible relational structures. The ontology preserves analytical distinctions between domains while making cross-level linkages explicit.

Figure 1 presents an OntoGraf visualisation focused on the education-related segment of the ontology. This domain-specific view illustrates how Education is formally connected to Identity, Trust, Contact, and Tolerance through directional object properties. The figure also displays relevant subclass relations and restrictions, demonstrating how institutional mechanisms are semantically encoded within the OWL structure. This focused representation improves interpretability by isolating a key institutional pathway within the broader model.

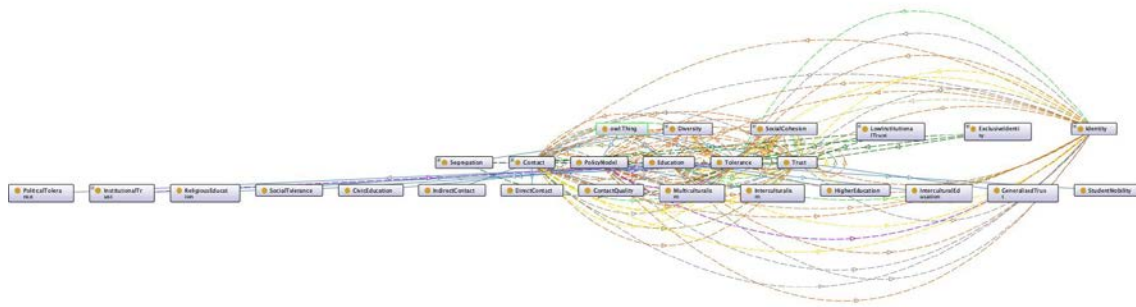
Figure 2 displays the fully expanded OntoGraf network with all core classes and their relational connections simultaneously visible. Both hierarchical (subclass) and relational object properties are shown. This dense network representation demonstrates the ontology's semantic richness and its capacity to encode multiple theoretical pathways within a single integrated framework.

**Figure 1.**

*Education-focused OntoGraf representation of the ontology*



Source: Constructed by the authors

**Figure 2.***Fully expanded OntoGraf network of the implemented ontology*

Source: Constructed by the authors

Together, these visualisations show how fragmented theoretical strands concerning education, diversity, trust, identity, tolerance, and cohesion are formally integrated into a coherent ontological system. The model does not collapse distinct constructs into a single composite index but preserves their differentiation while encoding structured relations among them.

## 6. Discussion.

This study set out to explore whether ontology-based modelling could help structure the fragmented theoretical strands in European research on education, tolerance towards immigrants, and social cohesion. The objective was to translate recurrent conceptual patterns from the literature into a formally specified ontological framework.

At the theoretical level, the model clarifies distinctions often blurred in empirical debates, such as the difference between political and social tolerance, between generalised and institutional trust, and between multiple layers of identity. It also makes explicit the multi-level nature of the research field, in which structural conditions (diversity, policy models), institutional mechanisms (education), mediating constructs (trust, identity, contact), and societal outcomes (tolerance, cohesion) interact.

However, the main contribution of the study lies in its methodological implementation. The ontology was constructed through a structured process of concept extraction, hierarchical organisation, and relational specification, and was implemented in Protégé using OWL-based formalisation. Logical consistency was verified using a description logic reasoner, ensuring that the model does not contain internal contradictions or unintended class equivalences.

By encoding conceptual domains and their admissible relations in a machine-readable format, the study demonstrates how fragmented theoretical constructs can be represented

within a coherent semantic architecture. The model does not replace empirical research, nor does it claim to establish causal relationships. Instead, it provides a structured conceptual framework that may support clearer operationalisation and comparison in future empirical studies.

In addition, the proposed ontology may facilitate future empirical research by enabling researchers to map survey indicators, policy variables or qualitative findings onto formally defined conceptual classes. Such semantic alignment may help overcome the fragmentation of indicators across datasets and support more consistent comparative analysis of tolerance and cohesion across European contexts.

The ontology should therefore be understood as an attempt at formal integration rather than a definitive theoretical solution. Its scope is limited to the constructs and distinctions identified in the reviewed literature, and it remains open to further refinement and extension.

A challenge in this modeling process is the interaction between formal semantic structures and the inherent fluidity of social concepts. Formal ontologies address the "False Agreement Problem" —where different traditions use the same term for incompatible concepts— by imposing strict constraints and explicit definitions. However, it is important to recognize that constructing such an ontology is itself a social process of meaning negotiation. While the model provides a machine-readable "semantic backbone," its adequacy depends on its ability to capture a shared, psychologically grounded understanding of social reality among researchers. Future extensions could incorporate "anti-rigid" roles to better model how individuals transition between different social identities (e.g., "Student" or "Citizen") within specific policy contexts.

## **7. Conclusion.**

Research on tolerance toward immigrants, social cohesion, and education in Europe is characterised by conceptual richness but structural fragmentation. Different subfields operationalise these constructs according to their own methodological constraints and policy agendas, often without shared definitions or cross-level integration. As a result, cumulative theorising remains limited, and theoretical pathways are frequently implied rather than explicitly specified.

This study proposed an ontology-based conceptual model to address this fragmentation. By formalising core classes—Education, Diversity, Contact, Trust, Identity, Tolerance, SocialCohesion, and PolicyModel—and explicitly specifying admissible relations among them, the model provides a structured semantic architecture capable of integrating

heterogeneous theoretical traditions. Implemented in Protégé using OWL (Web Ontology Language), the model ensures that the conceptual integration is not merely narrative but formally structured, logically consistent, and machine-readable.

The ontology clarifies several key theoretical insights. First, tolerance and social cohesion are distinct but structurally connected constructs. Second, trust and identity operate as central mediating mechanisms translating diversity and educational experiences into attitudinal and societal outcomes. Third, educational processes function as both normative and cognitive mechanisms, with effects that depend on institutional context and policy framing. Fourth, diversity does not produce cohesion or conflict directly; its effects are conditional on intervening relational and identity-based layers.

The ontological framework provides a structured conceptual foundation for future operationalisation. It enables researchers to map empirical indicators onto formally defined classes, compare competing theoretical pathways, and extend the model using computational reasoning tools. In a European context characterised by growing diversity and ongoing debates about integration, education, and democratic resilience, conceptual clarity is not merely an academic concern. It is a precondition for coherent research, informed policy design, and cumulative knowledge production. Ontology-based modelling offers one pathway towards such clarity by transforming fragmented narratives into an integrated conceptual system.

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