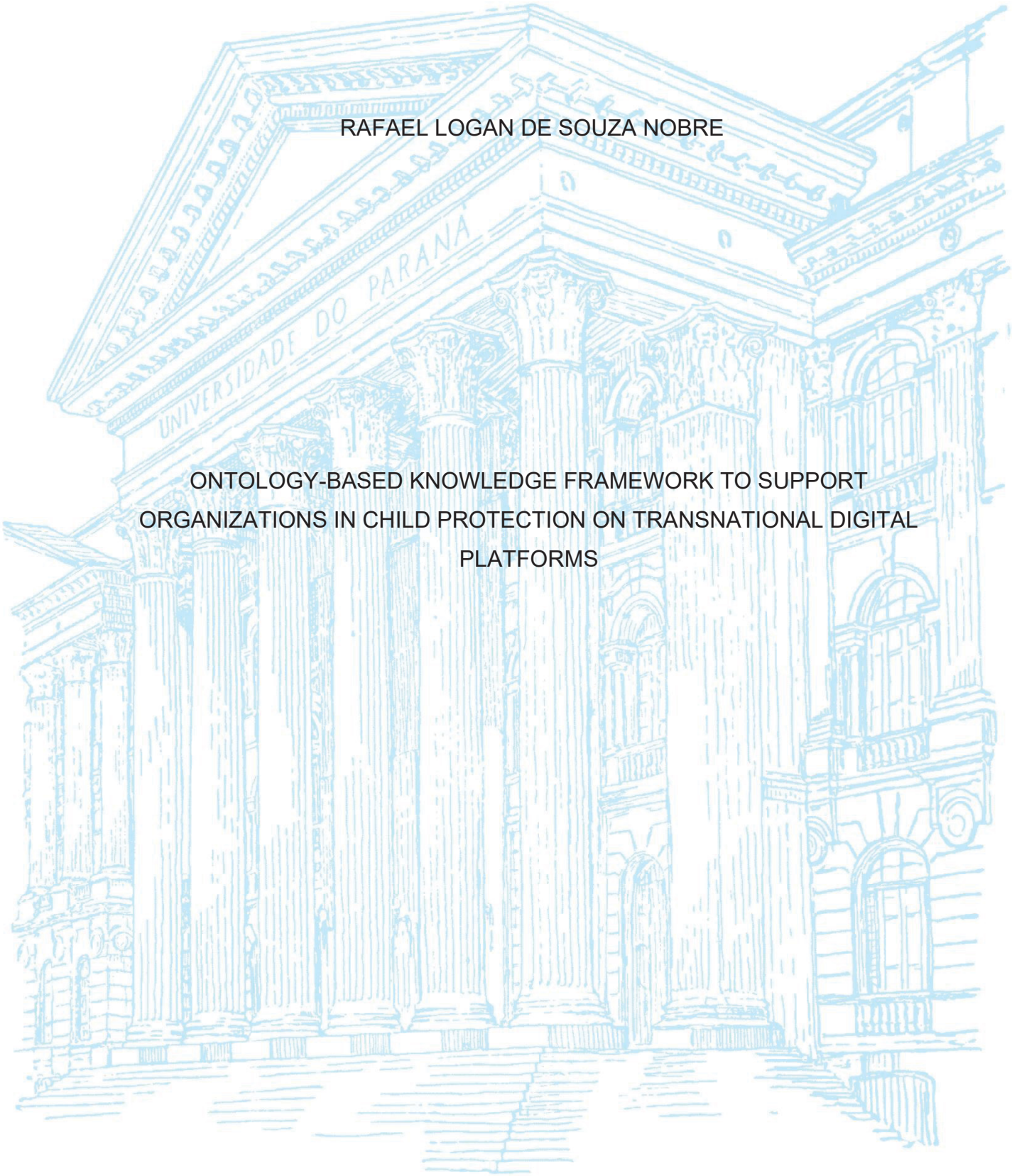
UNIVERSIDADE FEDERAL DO PARANÁ

RAFAEL LOGAN DE SOUZA NOBRE



ONTOLOGY-BASED KNOWLEDGE FRAMEWORK TO SUPPORT ORGANIZATIONS IN CHILD PROTECTION ON TRANSNATIONAL DIGITAL PLATFORMS

CURITIBA

2025

RAFAEL LOGAN DE SOUZA NOBRE

ONTOLOGY-BASED KNOWLEDGE FRAMEWORK TO SUPPORT ORGANIZATIONS IN CHILD PROTECTION ON TRANSNATIONAL DIGITAL PLATFORMS

Dissertação apresentada ao Programa de Pós-Graduação em Gestão da Informação, da Universidade Federal do Paraná, como requisito parcial à obtenção do título de Mestre em Gestão da Informação.

Orientador: Prof. Dr. Luciano Heitor Gallegos Marin.
Coorientadora: Profa. Dra. Rosilene Paiva Marinho de Souza.

CURITIBA
2025

DADOS INTERNACIONAIS DE CATALOGAÇÃO NA PUBLICAÇÃO (CIP)
UNIVERSIDADE FEDERAL DO PARANÁ
SISTEMA DE BIBLIOTECAS – BIBLIOTECA CIÊNCIAS SOCIAIS APLICADAS

Nobre, Rafael Logan de Souza
Ontology-based knowledge framework to support organizations in child protection on transnational digital platforms / Rafael Logan de Souza Nobre. – Curitiba, 2025.
1 recurso on-line : PDF.

Dissertação (Mestrado) – Universidade Federal do Paraná, Setor de Ciências Sociais Aplicadas, Programa de Pós-Graduação em Gestão da Informação.
Orientador: Prof. Dr. Luciano Heitor Gallegos Marin.
Coorientadora: Profa. Dra. Rosilene Paiva Marinho de Souza.

1. Gestão da Informação. 2. Plataformas digitais. 3. Ontologia. 4. Menores - Proteção. I. Marin, Luciano Heitor Gallegos. II. Souza, Rosilene Paiva Marinho de. III. Universidade Federal do Paraná. Programa de Pós-Graduação em Gestão da Informação. IV. Título.

Bibliotecário: Nilson Carlos Vieira Junior -- CRB-9/1797

MINISTÉRIO DA EDUCAÇÃO
SETOR DE CIÊNCIAS SOCIAIS E APLICADAS
UNIVERSIDADE FEDERAL DO PARANÁ
PRÓ-REITORIA DE PÓS-GRADUAÇÃO
PROGRAMA DE PÓS-GRADUAÇÃO GESTÃO DA INFORMAÇÃO - 40001016058P1

ATA Nº492025

ATA DE SESSÃO PÚBLICA DE DEFESA DE MESTRADO PARA A OBTENÇÃO DO GRAU DE MESTRE EM GESTÃO DA INFORMAÇÃO

No dia trinta e um de outubro de dois mil e vinte e cinco às 14:00 horas, na sala Microsoft Teams PPGGI, UFPR - Setor de Ciências Sociais Aplicadas, foram instaladas as atividades pertinentes ao rito de defesa de dissertação do mestrando **RAFAEL LOGAN DE SOUZA NOBRE**, intitulada: **ONTOLOGY-BASED KNOWLEDGE FRAMEWORK TO SUPPORT ORGANIZATIONS IN CHILD PROTECTION ON TRANSNATIONAL DIGITAL PLATFORMS**, sob orientação do Prof. Dr. LUCIANO HEITOR GALLEGOS MARIN. A Banca Examinadora, designada pelo Colegiado do Programa de Pós-Graduação GESTÃO DA INFORMAÇÃO da Universidade Federal do Paraná, foi constituída pelos seguintes Membros: LUCIANO HEITOR GALLEGOS MARIN (UNIVERSIDADE FEDERAL DO PARANÁ), JOSE MARIA PARENTE DE OLIVEIRA (INSTITUTO TECNOLÓGICO DE AERONÁUTICA), MATHIAS BROCHHAUSEN (UNIVERSITY OF ARKANSAS FOR MEDICAL SCIENCES), MARCIA REGINA MARTELOZO CASSITAS HINO (UNIVERSIDADE FEDERAL DO PARANÁ). A presidência iniciou os ritos definidos pelo Colegiado do Programa e, após exarados os pareceres dos membros do comitê examinador e da respectiva contra argumentação, ocorreu a leitura do parecer final da banca examinadora, que decidiu pela APROVAÇÃO. Este resultado deverá ser homologado pelo Colegiado do programa, mediante o atendimento de todas as indicações e correções solicitadas pela banca dentro dos prazos regimentais definidos pelo programa. A outorga de título de mestre está condicionada ao atendimento de todos os requisitos e prazos determinados no regimento do Programa de Pós-Graduação. Nada mais havendo a tratar a presidência deu por encerrada a sessão, da qual eu, LUCIANO HEITOR GALLEGOS MARIN, lavrei a presente ata, que vai assinada por mim e pelos demais membros da Comissão Examinadora.

CURITIBA, 31 de Outubro de 2025.

Documento assinado digitalmente
gov.br
LUCIANO HEITOR GALLEGOS MARIN
Data: 28/11/2025 09:58:01-0300
Verifique em https://validar.iti.gov.br

LUCIANO HEITOR GALLEGOS MARIN
Presidente da Banca Examinadora

Documento assinado digitalmente
gov.br
JOSE MARIA PARENTE DE OLIVEIRA
Data: 28/11/2025 10:46:43-0300
Verifique em https://validar.iti.gov.br

JOSE MARIA PARENTE DE OLIVEIRA
Avaliador Externo (INSTITUTO TECNOLÓGICO DE AERONÁUTICA)

Mathias Brochhausen
Mathias Brochhausen (Dec 5, 2025 15:13:30 CST)

MATHIAS BROCHHAUSEN
Avaliador Externo (UNIVERSITY OF ARKANSAS FOR MEDICAL SCIENCES)

Documento assinado digitalmente
gov.br
MARCIA REGINA MARTELOZO CASSITAS HINO
Data: 28/11/2025 10:58:28-0300
Verifique em https://validar.iti.gov.br

MARCIA REGINA MARTELOZO CASSITAS HINO
Avaliador Interno (UNIVERSIDADE FEDERAL DO PARANÁ)

TERMO DE APROVAÇÃO

Os membros da Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação GESTÃO DA INFORMAÇÃO da Universidade Federal do Paraná foram convocados para realizar a arguição da Dissertação de Mestrado de **RAFAEL LOGAN DE SOUZA NOBRE**, intitulada: **ONTOLOGY-BASED KNOWLEDGE FRAMEWORK TO SUPPORT ORGANIZATIONS IN CHILD PROTECTION ON TRANSNATIONAL DIGITAL PLATFORMS**, sob orientação do Prof. Dr. LUCIANO HEITOR GALLEGOS MARIN, que após terem inquirido o aluno e realizada a avaliação do trabalho, são de parecer pela sua APROVAÇÃO no rito de defesa.
A outorga do título de mestre está sujeita à homologação pelo colegiado, ao atendimento de todas as indicações e correções solicitadas pela banca e ao pleno atendimento das demandas regimentais do Programa de Pós-Graduação.

CURITIBA, 31 de Outubro de 2025.

gov.br Documento assinado digitalmente
LUCIANO HEITOR GALLEGOS MARIN
Data: 05/12/2025 08:11:46-0300
Verifique em https://validar.iti.gov.br

LUCIANO HEITOR GALLEGOS MARIN
Presidente da Banca Examinadora

gov.br Documento assinado digitalmente
JOSE MARIA PARENTE DE OLIVEIRA
Data: 03/12/2025 17:11:16-0300
Verifique em https://validar.iti.gov.br

JOSE MARIA PARENTE DE OLIVEIRA
Avaliador Externo (INSTITUTO TECNOLÓGICO DE AERONÁUTICA)

Mathias Brochhausen
Mathias Brochhausen (Dec 5, 2025 15:13:30 CST)

MATHIAS BROCHHAUSEN
Avaliador Externo (UNIVERSITY OF ARKANSAS FOR MEDICAL SCIENCES)

gov.br Documento assinado digitalmente
MARCIA REGINA MARTELOZO CASSITAS HINO
Data: 28/11/2025 10:56:18-0300
Verifique em https://validar.iti.gov.br

MARCIA REGINA MARTELOZO CASSITAS HINO
Avaliador Interno (UNIVERSIDADE FEDERAL DO PARANÁ)

ACKNOWLEDGMENTS

I express my profound gratitude to my advisor, Professor Luciano Heitor Gallegos Marin, from the Federal University of Paraná, and to my co-advisor, Professor Rosilene Paiva Marinho de Souza, from the Federal University of Paraíba. I am deeply indebted to them for their patience, assistance, and understanding. Their example as both researchers and human beings has been truly inspiring, and their guidance was fundamental not only to the completion of this work but also to the advancement of my doctoral studies.

Furthermore, I gratefully acknowledge the financial support provided by the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES), for 18 months.

"Nobody knows what the future holds. That's why its potential is infinite". – Rintarō Okabe, in episode 24 of Steins;Gate (directed by Hiroshi Hamasaki, 2011).

RESUMO

A proliferação de plataformas digitais transnacionais, embora ofereça vantagens, expõe crianças (indivíduos menores de 18 anos) a riscos significativos, estabelecendo a proteção infantil como um desafio global crítico. O principal obstáculo para uma resposta coordenada e eficaz a este desafio é a fragmentação sistêmica do conhecimento entre os principais grupos interessados, incluindo organizações privadas de tecnologia da informação e agências governamentais, que gera barreiras jurisdicionais, organizacionais e semânticas. Neste sentido, o estudo objetiva desenvolver um framework de conhecimento baseado em ontologia, projetado para auxiliar organizações na proteção de crianças contra ameaças online em plataformas digitais transnacionais. A pesquisa adotou uma abordagem metodológica dupla, utilizando a Design Science Research (DSR) para o desenvolvimento do framework, e a OntoForInfoScience (com suporte de Python e suas bibliotecas) para a criação da ontologia de domínio, que serve como núcleo do framework. Adicionalmente, uma revisão estruturada da literatura foi conduzida (com suporte de Python e suas bibliotecas) para estabelecer os fundamentos teóricos do estudo. O resultado é um artefato conceitual composto por três componentes: (1) uma ontologia de domínio para a proteção à criança em plataformas digitais transnacionais, nomeada Child Harm Identification in Large Digital-platforms Ontology (CHILD-Onto), parcialmente alinhada à Ontologia Formal Básica (BFO) para servir como um modelo semântico comum; (2) um framework de conhecimento, nomeado Ontology-Based Knowledge Framework on Child Protection (OBKF-CP); (3) e um guia de princípios norteadores que regem a aplicação do framework. Conclui-se que o framework proposto oferece um modelo para abordar a fragmentação do conhecimento, estabelecendo assim a base necessária para a futura interoperabilidade semântica e aplicação do framework no mundo real. Esta pesquisa contribui com um modelo teórico formal com implicações práticas para o avanço da proteção infantil na era digital.

Palavras-chave: framework de conhecimento; plataformas digitais transnacionais; ontologia aplicada; proteção à criança; interoperabilidade semântica.

ABSTRACT

The proliferation of transnational digital platforms, while offering advantages, exposes children (individuals under 18) to significant risks, positioning child protection as a critical global challenge. The primary obstacle to a coordinated and effective response to this challenge is the systemic fragmentation of knowledge among key stakeholders, including private technology companies and government agencies, which manifest jurisdictional, organizational, and semantic barriers. Accordingly, this study aims to develop an ontology-based knowledge framework designed to assist organizations in protecting children from online threats on transnational digital platforms. The research adopted a dual methodological approach, using Design Science Research (DSR) to develop the framework, and OntoForInfoScience (supported by Python and its libraries) to construct the domain ontology that serves as the framework's core. Additionally, a structured literature review was conducted (supported by Python and its libraries) to establish the theoretical foundations of the study. The resulting conceptual artifact comprises three components: (1) a domain ontology for child protection on transnational digital platforms, named Child Harm Identification in Large Digital-platforms Ontology (CHILD-Onto), partially aligned with the Basic Formal Ontology (BFO) as a common semantic model; (2) a knowledge framework, named Ontology-Based Knowledge Framework on Child Protection (OBKF-CP); (3) and a guiding principles governing the framework's application. This study concludes that the proposed framework provides a model to address knowledge fragmentation, thereby laying the groundwork for future semantic interoperability and real-world application. This research contributes a formal theoretical model with practical implications for advancing child protection in the digital age.

Keywords: knowledge framework; transnational digital platforms; applied ontology; child protection; semantic interoperability.

LIST OF FIGURES

LIST OF TABLES

LIST OF BOARDS

LIST OF ABBREVIATIONS OR ACRONYMS

AI	- Artificial Intelligence
BFO	- Basic Formal Ontology
CAPES	- Federal Agency for Support and Evaluation of Graduate Education
CHILD-Onto	- Child Harm Identification in Large Digital-platforms Ontology
CSAM	- Child Sexual Abuse Material
DL	- Deep Learning
DSR	- Design Science Research
EC	- Exclusion Criteria
GDPR	- General Data Protection Regulation
IBICT	- Brazilian Institute of Information in Science and Technology
IC	- Inclusion Criteria
INTERPOL	- International Criminal Police Organization
IWF	- Internet Watch Foundation
KM	- Knowledge Management
LISTA	- Library, Information Science and Technology Abstracts with Full Text
ML	- Machine Learning
MLATs	- Mutual Legal Assistance Treaties
NGOs	- Non-Governmental Organizations
OBKF-CP	- Ontology-Based Knowledge Framework on Child Protection
OCSEA	- Online Child Sexual Exploitation and Abuse
OKES	- Knowledge Management for Enterprise Systems
ONTOBRAS	- Seminar on Ontology Research in Brazil
SDG	- Sustainable Development Goal
SLR	- Structured Literature Review
SME	- Subject-Matter Expert
UFPR	- Federal University of Paraná

TABLE OF CONTENTS

1 INTRODUCTION

The 21st century has been defined by a profound paradigm shift, driven by the rise of a globally interconnected digital ecosystem. At the heart of this transformation lie transnational digital platforms – vast, complex socio-technical systems that have transcended geographical and political boundaries to become integral to the fabric of modern society (Van Dijck; Poell; Waal, 2018). These platforms, encompassing social media networks (or digital social platforms), messaging applications, online gaming environments, and content-sharing platforms, have catalyzed unprecedented opportunities. They function as dynamic arenas for identity formation and social exploration for young people, provide access to a wealth of educational resources, enable participation in civic discourse, and facilitate the maintenance of crucial social bonds across distances (Boyd, 2014). For billions of users, including a substantial and growing demographic of children and adolescents, these digital spaces represent a primary modality for learning, interaction, and self-expression, fundamentally altering the nature of childhood and adolescence in the modern era (Livingstone; Mascheroni; Staksrud, 2018).

Through this research, the term child (or children) is employed to collectively refer to both children and adolescents. This usage aligns with the definition from the United Nations (UNICEF, 1989), which classifies a child as any person under the age of eighteen. Therefore, for the remainder of this study, the term child (or children) will be used exclusively.

However, this digital revolution presents a stark, dual-use dilemma. The very architectural properties that foster open communication and global connectivity (anonymity, scalability, virality, and borderless infrastructure) simultaneously create a fertile ground for significant societal harms. For children, the risks are particularly insidious and acute. The digital environment exposes them to a spectrum of online threats that are often more pervasive, persistent, and complex than their offline equivalents.

The well-documented "online disinhibition effect" suggests that the perceived anonymity of the internet can lower psychological barriers, leading to behaviors ranging from extreme cyberbullying to predatory actions (Suler, 2004). Furthermore, the algorithmic systems designed to maximize user engagement can inadvertently

create "rabbit holes", amplifying harmful content and potentially leading vulnerable youth toward communities centered on self-harm, eating disorders, or extremist ideologies (Milano; Taddeo; Floridi, 2020). Consequently, the promise of digital empowerment is perpetually shadowed by the menace of digital endangerment.

This menace materializes in various forms of digital crime and harm targeting minors. One of the most severe of these is Online Child Sexual Exploitation and Abuse (OCSEA), a global crisis that includes the production, distribution, and consumption of Child Sexual Abuse Material (CSAM), as well as "sextortion", and live-streamed abuse. The scale of this problem is staggering. Organizations like the Internet Watch Foundation (IWF) report processing hundreds of thousands of Uniform Resource Locator (URL) containing CSAM annually, with the material becoming increasingly violent and the victims younger. To illustrate, their 2024 data provide quantifiable evidence of this volume: the foundation processed over 424,000 public reports, from which its highly trained analysts confirmed more than 291,000 as containing child sexual abuse imagery. This meticulous "eyes on" verification process led to the assessment of nearly 730,000 individual images and videos as criminal content.

Operating on a global scale that serves 53 countries, the IWF's primary function is to facilitate the removal of this material from the internet, a mission that has resulted in over 1.2 million webpages being taken down in the last five years. Their work involves a collaborative ecosystem, providing critical intelligence and technical services to law enforcement, technology companies, and governments to disrupt the storage and distribution of CSAM worldwide (Internet […], 2024).

Closely related is the phenomenon of online grooming, a deliberate and methodical process wherein perpetrators build trust with children to entice them into sexual activity or exploitation (Wolak; Finkelhor; Mitchell, 2008). Beyond sexual threats, cyberbullying and online harassment have become rampant, inflicting significant and lasting psychological trauma, with studies consistently showing high prevalence rates among adolescents worldwide (Li; Cross; Smith, 2011). The confluence of these threats creates a high-risk environment where the safety of children is constantly under siege.

Navigating this perilous landscape poses a challenge to the key stakeholders responsible for child protection. Public sector entities, including law enforcement, national Computer Emergency Response Teams, and child welfare agencies, grapple

with a persistent "legislative lag", where legal frameworks struggle to keep pace with rapid technological evolution. The transnational nature of these platforms creates a jurisdictional quagmire; a crime may be perpetrated from one country, hosted on servers in a second, monetized through a system in a third, and target a victim in a fourth, rendering traditional investigative and prosecutorial methods profoundly complex and often ineffective (UNODC, 2013). Concurrently, private enterprises (the technology companies that design and operate these platforms) face a challenge of unprecedented scale and complexity. Their trust and safety teams must moderate billions of pieces of user-generated content daily, a task that is impossible to perform manually. While they increasingly rely on sophisticated AI-driven content moderation systems, these tools are imperfect, often struggling with contextual nuance, cultural differences, and adversarial attacks from malicious actors seeking to evade detection (Gorwa; Binns; Katzenbach, 2020). This operational reality is further complicated by the inherent tension between their core business models, often predicated on maximizing engagement and data collection, and their corporate social responsibility to ensure user safety (Zuboff, 2019).

Ultimately, the central impediment to a coherent and effective response is the deep and systemic fragmentation of knowledge. Critical information regarding threats, offenders, victims, and effective interventions is locked away in disconnected silos. A platform may hold behavioral data indicating a grooming attempt, while a national law enforcement agency holds criminal intelligence on a suspect, and a non-governmental organization possesses case details from victim support services. These datasets rarely intersect due to technical barriers (incompatible data formats); legal transnational constraints – data protection laws like General Data Protection Regulation (GDPR) –; and semantic dissonance (the lack of a shared vocabulary to define and classify threats and harms).This fragmentation, as highlighted in global threat assessments, prevents the formation of a holistic, actionable intelligence picture and forces stakeholders into a reactive posture (Weprotect […], 2024). The need to bridge this gap through a shared, structured understanding across organizational and national borders establishes the foundational rationale for the present research.

1.1 RESEARCH PROBLEM CONTEXT

Flowing from the preceding contextual analysis, the central research problem addressed by this dissertation is the profound and systemic fragmentation of knowledge that critically undermines multi-stakeholder efforts to protect children on transnational digital platforms. This fragmentation manifests across jurisdictional, organizational, and, most critically, semantic dimensions. While legal and organizational hurdles are significant, it is the semantic fragmentation that represents the most fundamental barrier, as a shared understanding is a prerequisite for any meaningful legal or technical interoperability. Therefore, this dissertation formally defines its central research problem as: the challenge of overcoming semantic knowledge fragmentation to support organizations in protecting children from online threats within global digital platforms.

The problem's first layer is jurisdictional and legislative fragmentation. The global nature of digital platforms stands in stark contrast to the territorial nature of law. Legal frameworks governing child protection, data privacy, and cybercrime vary significantly from one country to another, creating complex and often contradictory regulatory patchwork. Definitions of what constitutes a "child", the age of digital consent, the specific elements of a "harm" or "crime", and the procedural requirements for lawful data access differ widely (Sekati, 2022). Along these lines, Sekati (2022) posits that a combination of internet fragmentation, disparate municipal laws, and inconsistent state-level regulatory actions hinders current frameworks designed to combat cross-border cybercrime (UNODC, 2013).

The challenges posed by transnational crime are not static; rather, they are evolving with increasing complexity and sophistication, a trend underscored by the International Criminal Police Organization (INTERPOL). Building on its 2022 analysis, INTERPOL's 2023 Global Crime Report highlights a significant escalation in the volume and intricacy of cyber-enabled crimes. The report specifically identifies Online Child Sexual Exploitation and Abuse (OCSEA) as one of eight crime areas experiencing notable growth. This expansion is driven by innovation within criminal syndicates, which now employ more complex, fragmented, and difficult-to-detect business models. A key factor in this evolution is the proliferation of "crime-as-a-service" models, which lower the barrier to entry for perpetrators and facilitate the convergence of different forms of crime, creating a deeply interdependent and resilient criminal ecosystem (INTERPOL […], 2023).

That legal heterogeneity creates a challenging environment for platforms striving for global compliance and for law enforcement agencies attempting to pursue cross-border investigations. An action deemed illegal and immediately actionable in one jurisdiction may not meet the criminal threshold in another, leading to what is often termed "jurisdiction shopping" by malicious actors and creating significant hurdles for international legal cooperation mechanisms like Mutual Legal Assistance Treaties (MLATs), which are notoriously slow and procedurally burdensome (Moskowitz, 2016; Funk, 2024).

The second layer is the prevalence of organizational and data silos. The ecosystem of child protection involves a diverse array of actors – including technology companies, national law enforcement, government regulators, and Non-Governmental Organizations (NGOs) – each collecting and managing valuable data within its own operational sphere. Technology companies possess vast repositories of behavioral data and content flags, while law enforcement holds criminal intelligence, and NGOs gather qualitative case data from victim support services. However, these datasets remain largely isolated due to commercial confidentiality, strict interpretations of data protection laws, a lack of mutual trust, and the absence of interoperable technical infrastructures for secure information exchange (Curtis; Edwards, 2019). The consequence is a fractured, incomplete view of the threat landscape, where no single entity possesses the holistic intelligence required for proactive and coordinated threat mitigation.

Thereby, an analysis of collaborative online child protection reveals that the effective sharing of information between public and private entities faces primary barriers that are fundamentally legal, technical, and trust-based in nature. From a legal standpoint, the creation of unified data-sharing frameworks is complicated by the fragmentation of privacy laws across different jurisdictions (Kalisz, 2023). This uncertainty is compounded by conflicting regulatory regimes, such as the EU's GDPR and Police Directive, which can discourage cooperation due to fears of legal liability and non-compliance (Purtova, 2018). Technically, these challenges are exacerbated by the absence of standardized, interoperable platforms for secure data exchange (Zibak; Simpson, 2019), a problem often magnified by the inadequate infrastructure within public services to manage real-time data flows (Curtis; Edwards, 2019). Compounding these issues is a significant deficit of trust; mutual distrust between

public authorities and private companies, rooted in fears of data misuse on one side and reputational or regulatory risk on the other, fundamentally hampers collaboration (Willis; Lester; Treverton, 2009). This complex dynamic is further complicated by widespread public and parental skepticism regarding the capacity of both government and corporations to handle children's data responsibly, thereby obstructing the necessary consent and support for collaborative initiatives (Keen, 2020).

The third and most fundamental layer is semantic fragmentation. Even if legal and organizational barriers to data sharing were removed, a core challenge would remain: the lack of a shared, machine-readable understanding of the domain itself. Different stakeholders use different languages, terminologies, taxonomies, and conceptual models to describe the same phenomena. For example, a platform's internal classifier might flag an image as policy-violating content, while a law enforcement agency would classify it as Child Sexual Abuse Material (CSAM) under a specific criminal statute, and a psychologist might describe the behavior involved as a particular stage of grooming. This semantic dissonance prevents meaningful data integration and automated reasoning. Without a common vocabulary and a formal set of defined relationships between concepts, it is impossible to aggregate and analyze data from disparate sources effectively. This necessitates a solution that can create semantic interoperability – a formally specified, shared conceptualization of the domain, which is the principal function of an applied ontology (Gruber, 1995; Noy; McGuinness, 2001).

1.2 RESEARCH QUESTION

In direct response to this multifaceted problem, this dissertation poses the following research question: how can semantic knowledge fragmentation be overcome to support organizations in protecting children from online threats within global digital platforms?

The formulation of this question is deliberate and precise. The "how can" framing signals a constructive, design-oriented research posture, aligned with the principles of Design Science Research (DSR), which focuses on creating innovative artifacts to solve real-world problems (Hevner *et al.*, 2004). The core challenge is pinpointed as "semantic knowledge fragmentation", referring to the problem of

disparate, non-interoperable data and terminologies existing in silos across different entities. The verb "overcome" emphasizes the goal of actively bridging these gaps, suggesting a solution focused on integration and shared understanding rather than mere co-existence. The focus on "support organizations" underscores the project's commitment to practical relevance and utility for all stakeholders. Finally, the scope is clearly bounded by the ultimate goal, "protecting children from online threats", and the specific operational context, "global digital platforms", highlighting the need for a solution that transcends national and systemic boundaries.

The significance and timeliness of this research are therefore profound. From a theoretical standpoint, it contributes to the fields of knowledge engineering and information systems by applying ontological modeling to a complex and socio-technical domain that has traditionally been approached from siloed legal, criminological, or policy perspectives. It seeks to develop a formal model that can structurally represent a domain characterized by nuanced human behaviors and evolving legal constructs. From a practical standpoint, the potential impact is substantial. A well-specified framework, as proposed in this research, provides the conceptual foundation for a new generation of shared safety tools. It establishes a formal blueprint that can enhance the accuracy of automated threat detection systems and lays the necessary groundwork for streamlining the exchange of actionable intelligence for law enforcement, and provide policymakers with a clearer, data-driven basis for regulatory oversight.

This research is particularly timely given the current global regulatory trajectory. Landmark legislation such as the Digital Statute of Children and Adolescents, in Brazil (Brasil, 2025); the European Union's Digital Services Act (European […], 2022); and the UK's Online Safety Act (United […], 2023) are moving beyond content moderation to impose systemic risk assessment and mitigation duties on platforms. These regulations explicitly call for greater transparency and data sharing with authorities and vetted researchers to understand and address systemic risks, including those to child safety. An ontology-based framework provides a direct and powerful technical mechanism to help organizations meet these complex compliance obligations by structuring the very knowledge required for such risk assessments and data exchanges. By tackling the root problem of knowledge fragmentation, this

research aims to provide a foundational contribution toward a more integrated and effective global response to protecting children in the digital age.

1.3 GENERAL OBJECTIVE

Addressing the research question, this dissertation pursues a general objective: develop an ontology-based knowledge framework designed to assist organizations in protecting children from online threats on transnational digital platforms.

1.4 SPECIFIC OBJECTIVES

Those components and their relationships, which form the conceptual layers of this research, are illustrated in Figure 1. To fulfill this general objective, the following specific objectives have been defined:

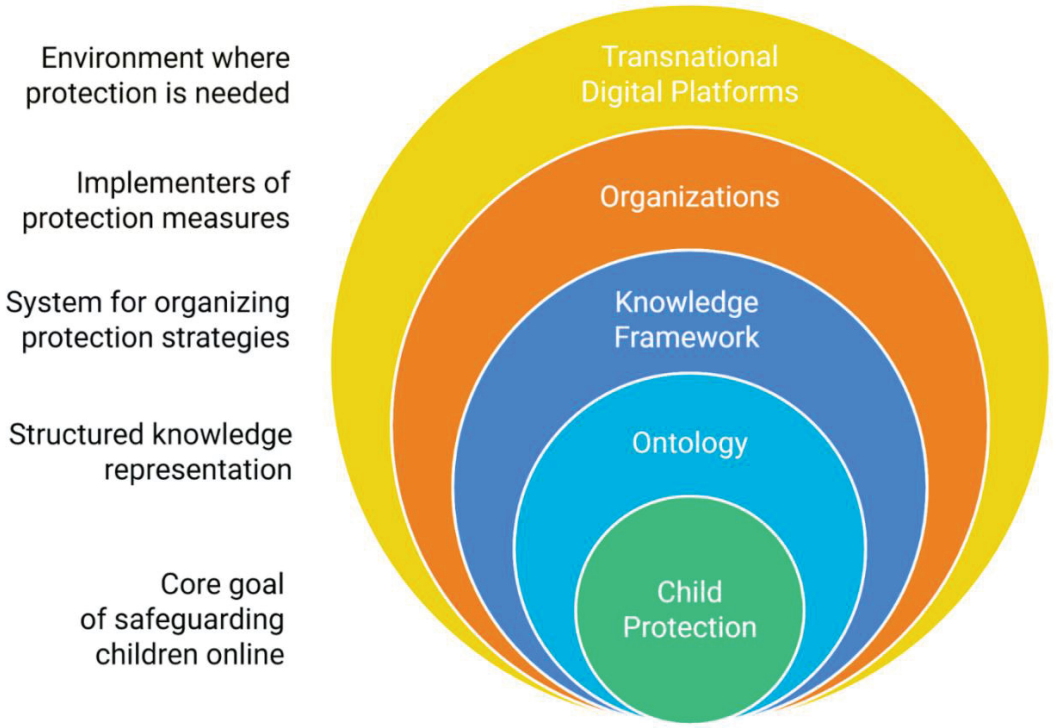
1. Investigate theoretical and practical underpinnings, best practices, and opportunities for contribution from existing literature on semantic information systems for child protection on transnational digital platforms.

   This initial objective ensures the research is grounded in established knowledge, identifying the theoretical foundations and gaps to be addressed.
2. Design a conceptual ontology-based model that integrates key concepts, relationships, and processes necessary for child protection on transnational digital platforms.

   This is the core constructive phase, where the insights from the literature review are synthesized into a formal, structured model – the ontology that serves as the heart of the framework.
3. Specify the architecture and components of the ontology-based knowledge framework by detailing the design of its core domain ontology and articulating the guiding principles for its application in promoting semantic interoperability among organizations.

This final objective focuses on formalizing the complete artifact, transforming the ontology into a usable framework by documenting its architecture and principles, thus providing a comprehensive conceptual solution.

FIGURE 1 - CONCEPTUAL LAYERS OF THE RESEARCH



SOURCE: Author (2025).

These objectives map a logical progression from theoretical investigation to design and, finally, to the detailed specification of the research artifact, demonstrating a coherent and feasible research plan (Board 1).

BOARD 1 - OVERVIEW OF KEY RESEARCH INFORMATION

Título	Ontology-based knowledge framework to support organizations in child protection on transnational digital platforms.
Research Question	How can semantic knowledge fragmentation be overcome to support organizations in protecting children from online threats within global digital platforms?
General Objective	Develop an ontology-based knowledge framework designed to assist organizations in protecting children from online threats on transnational digital platforms.
Specific Objectives	(1) Investigate theoretical and practical underpinnings, best practices, and opportunities for contribution from existing literature on semantic information systems for child protection on transnational digital platforms. (2) Design a conceptual ontology-based model that integrates key concepts, relationships, and processes necessary for child protection on transnational digital platforms. (3) Specify the architecture and components of the ontology-based knowledge framework by detailing the design of its core domain ontology and articulating the guiding principles for its application in promoting semantic interoperability among organizations.

SOURCE: Author (2025).

The methodology guiding this research is grounded in the principles of Design Science Research. The methods employed to achieve the specific objectives include a structured literature review to establish the theoretical foundations, complemented by an analysis of relevant legal instruments. Furthermore, an analysis of governance documents from digital platforms will be conducted, with a strategic focus on social media platforms. This decision is based on the empirical finding that these platforms, due to their operational reliance on user-generated content, are unique in providing robust and publicly accessible governance documents (e.g., Terms of Use, Privacy Policy) essential for this analysis, a level of transparency not consistently found in streaming or e-commerce platforms.

1.5 JUSTIFICATION

Hereafter, the justifications for the development of this dissertation are addressed, which are summarized for clarity in Board 2. The impetus for this research stems from a synthesis of academic training and practical experience in information and knowledge management, and semantic technologies. Foundational undergraduate studies in Information Management at the Federal University of Paraná

(UFPR)[1] provided a theoretical grounding in information systems and ontology engineering. This was complemented by professional experience at the Brazilian Institute of Information in Science and Technology (IBICT)[2], which offered firsthand insight into the complexities of managing large-scale national information ecosystems and underscored the need for semantic interoperability. Engagement with the scientific community, particularly at events like the Seminar on Ontology Research in Brazil (ONTOBRAS)[3], crystallized the decision to apply these principles to a domain of profound societal importance. This led to the selection of child protection on digital platforms – a field where the challenges of knowledge fragmentation are particularly acute, making it a fitting and urgent application for an ontology-based solution.

BOARD 2 - SUMMARY OF RESEARCH JUSTIFICATIONS

Personal Justification	The research leverages academic and professional expertise in information and knowledge management and ontologies to address the real-world challenge of child protection.
Economic Justification	The project aims to mitigate financial and operational costs for organizations by enhancing efficiency and risk management through a structured approach to knowledge.
Scientific Justification	The research contributes to the field by proposing a novel, interdisciplinary conceptual model that advances the application of ontological engineering to a complex socio-technical problem.
Social Justification	The framework addresses an urgent social need by facilitating public-private collaboration to prevent harm, protect children, and inform the development of more effective safety policies.

SOURCE: Author (2025).

From a resource and value perspective, the development of an ontology-based knowledge framework to support organizations in child protection on transnational digital platforms is justified by its potential to mitigate immense costs and deliver substantial operational efficiencies. The societal costs of online child exploitation – including long-term harm to victims and public health impacts – are staggering. For organizations, the operational costs of moderating content, investigating incidents, and collaborating with law enforcement are immense and growing. Furthermore, the financial and reputational risks associated with regulatory non-compliance and public trust failures are severe. The proposed framework, by promoting a structured and

---

[1] UFPR official website: https://ufpr.br/
[2] IBICT official website: https://www.gov.br/ibict/pt-br/
[3] ONTOBRAS official website: https://www.inf.ufrgs.br/ontobras/en/

semantically coherent approach to knowledge management, can contribute to several critical advantages. These include mitigating the financial risks of regulatory penalties, enhancing the operational efficiency of trust and safety teams through improved interoperability, and enabling a more effective allocation of limited resources toward proactive threat identification and prevention.

Scientifically, this study is relevant due to its potential to advance the frontiers of knowledge engineering in a highly complex, ethically charged, and multi-stakeholder domain. It addresses the real-world problem of child protection from the under-explored perspective of a holistic, ontology-based knowledge framework. The research is poised to contribute a novel conceptual model that integrates principles from ontology engineering, information systems, criminology, and victimology, thereby stimulating further academic discourse. The proposed framework can serve as a reference model for a safety by design approach, and the methodological insights from its development can inform other studies aiming to create similar conceptual artifacts for complex social problems.

The broader social relevance of this research is tied to modern society's urgent need to ensure digital environments are safe for their most vulnerable users. As digital interconnectedness deepens, the ability to manage and act upon safety-critical information across jurisdictional and organizational boundaries becomes paramount. This research, by aiming to enhance the collaborative underpinnings of child protection, contributes to the prevention of harm and the rescue of victims by facilitating more effective and timely data exchange between digital platforms, governments, and international law enforcement. It also supports the design of safer digital services and can contribute to enhanced public trust. The insights gained could directly inform the development of best practices, international standards, or policy related to transnational data governance for child protection.

Notably, this research is inherently interdisciplinary, drawing upon foundations from Information Science, Computer Science, and Legal Science. This multi-faceted approach is essential for effectively developing an ontology-based knowledge framework for child protection in the digital environment, as it navigates the complex and evolving nature of online child threats that transcend single disciplinary boundaries. Furthermore, this interdisciplinary alignment is consistent with the

researcher's educational background, and the guiding principles of the graduate program in which this research is set.

The present research directly and significantly aligns with the United Nations Sustainable Development Goal (SDG) 16: Peace, Justice, and Strong Institutions, specifically focusing on Target 16.2, which aims to terminate all forms of violence against children. The dissertation's general objective, to develop an ontology-based knowledge framework designed to support public and private organizations in protecting children from online threats on transnational digital platforms, directly addresses the diverse manifestations of harm encompassed by Target 16.2. Online threats frequently manifest as exploitation, abuse, and exposure to violence, thereby necessitating robust prevention and response mechanisms. By providing a structured and organized knowledge framework, this research empowers organizations – important components of 'strong institutions' – with enhanced capabilities to efficiently identify, categorize, and respond to these threats. Additionally, the emphasis on transnational digital platforms acknowledges the borderless nature of online risks, underscoring the vital role of strengthening institutional capacity across diverse jurisdictions to fulfill the global mandate of safeguarding children, as envisioned by SDG Target 16.2 (United […], 2025).

In conclusion, this research is positioned to make a significant contribution to both theory and practice. Theoretically, it contributes to the fields of knowledge engineering and information systems by applying ontological modeling to the complex socio-technical domain of child protection. Practically, the formally specified framework resulting from this research provides the foundational design for a new generation of tools for platforms, law enforcement, and policymakers, aimed at enabling more coordinated, data-driven, and effective protective actions across borders. The project is therefore not only academically rigorous but also possesses the potential for societal impact.

To contextualize the research problem and establish the theoretical foundation for the proposed framework, the following section provides a literature review. This analysis will examine the main concepts and existing works in the key domains underpinning this study: ontological engineering, knowledge frameworks, and the challenges of child protection on transnational digital platforms. The objective is to map the current practices and research, identify established contributions, and build the

theoretical foundation required to guide the development of the proposed ontology-based knowledge framework.

1.6 CHILD PROTECTION DIGITAL CONTEXT

In 2024 and 2025 the protection of children in online environments, especially within social media platforms, has entered a phase of heightened regulatory, technological, and societal activity. This phase is marked by three inter-related dimensions: rising empirical evidence of risk, intensifying regulatory intervention, and growing technological and cooperative responses. Together they form a dynamic backdrop against which this dissertation's ontology-based framework must be understood. This subsection summarizes key developments across Brazil, the United States, Europe and Asia, highlighting regulatory shifts, platform responses, and the persistent operational challenges associated with securing safe digital spaces for minors.

In Europe, the Digital Services Act (DSA) continues to underpin the regulatory architecture for platform accountability, especially regarding children's protections. For example, the European Commission published draft guidelines on the protection of minors under the DSA in May 2025 (European […], 2025a). In October 2025, the Commission further announced that it had sent information requests to major app stores and platforms (e.g., YouTube, Snapchat) to assess compliance with children's safety obligations under the DSA (European […], 2025b). In addition, a joint ministerial "Jutland Declaration" signed by 25 EU member states called for strengthened age-verification measures, and flagged that existing rules may not be sufficient (Kroet, 2025).

In the United Kingdom, the Online Safety Act took force on 25 July 2025, mandating that platforms deploy robust age-assurance and safer-feed mechanisms for under-18s – including secure age checks and algorithmic changes aimed at reducing exposure of minors to harmful content (United […], 2025).

In Brazil, a landmark statute, the Federal Law n. 15.211/2025 (Brazil, 2025), commonly "ECA Digital", was signed on 17 September 2025 to protect children and adolescents in digital environments. Key provisions include mandatory age verification, bans on behavioral profiling of minors, and requirements that online services offer

default high-privacy settings for users under 18. The law is scheduled to come into force in March 2026 (Human […], 2025).

In Asia, Indonesia adopted Government Regulation n. 17/2025 (PP Tunas) under which all digital platforms operating in Indonesia must provide parental-control features and age-based content classification: children under 13 may access only “safe” platforms; those aged 13-15 may access low/moderate risk platforms; those aged 16-17 may access “high risk” platforms only with parental supervision (Regulation […], 2025). Further, the Indonesian Ministry of Communication and Digital Affairs directed platforms to provide parental controls in August 2025 (GOVT […], 2025).

In the United States, while there is no comprehensive federal law exclusively dedicated to children’s online safety in social media, significant developments include the re-introduction of the Kids Online Safety Act (KOSA) in 2025. The bill would require platforms to implement safety and privacy measures for minors, though civil liberties groups have raised concerns about over-regulation (Feiner, 2025).

Major digital platforms are responding under pressure from regulators and civil society. For example, Meta Platforms announced in April 2025 that it would block livestreaming for users under 16 on Instagram unless parental consent is granted, and would blur suspected nudity in direct messages by default (Milmo, 2025). In October 2025, Meta announced a “PG-13”-style content moderation system for teen users under 18 across Instagram and other platforms, requiring default age-appropriate settings and parental opt-out only (Ortutay, 2025).

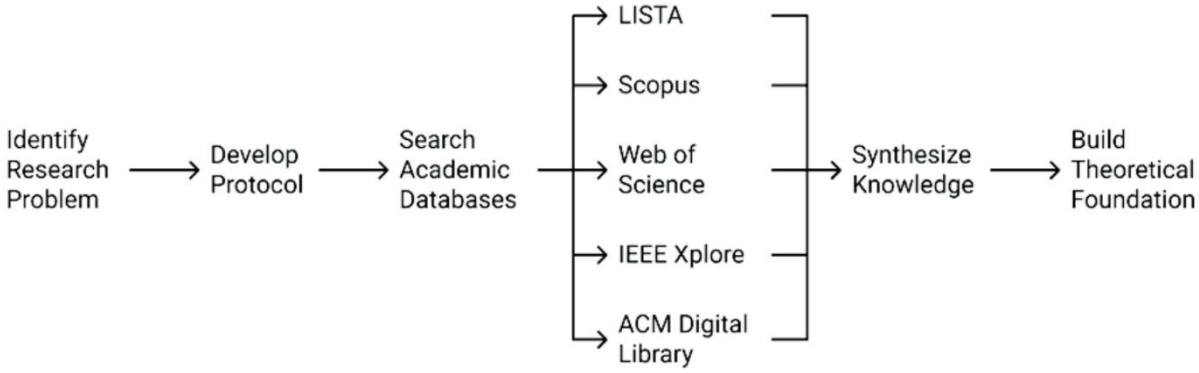
Emerging technology solutions are also being deployed: a recent industry survey reported a surge in demand for Artificial Intelligence (AI) systems and age-assurance technologies tailored to children’s online safety, driven by the regulatory momentum in the UK and US (Browne, 2025).

In the rapidly evolving digital ecosystem of 2025, safeguarding children online has moved from fringe policy issue to central regulatory priority in many regions. However, substantive implementation remains uneven. Ontological approach research proposes is timely and potentially impactful: by providing a structured, interoperable knowledge framework, it can support regulators, platforms, and researchers in translating legal mandates into real operational protections for children.

2 LITERATURE REVIEW

This chapter presents the literature review that provides the theoretical and conceptual foundation for this research. To construct this foundation comprehensively, the review was executed in two distinct and sequential phases, both conducted across the same five academic databases (Figure 2): Library, Information Science and Technology Abstracts with Full Text (LISTA)[4]; Scopus[5]; Web of Science (Core Collection)[6]; IEEE Xplore Digital Library[7]; and ACM Digital Library (publications from ACM and affiliated organizations)[8]. Each phase was guided by its own distinct protocol, tailored to a specific objective aligning with a Structured Literature Review (SLR) (Massaro; Dumay; Guthrie, 2016).

FIGURE 2 - LITERATURE REVIEW PROCESS



SOURCE: Author (2025).

To ensure a rigorous and objective foundation for this research, the SLR methodology was adopted, which, according to Massaro, Dumay, and Guthrie (2016), is "a method for examining a corpus of scholarly literature, to develop insights, critical reflections, future research paths and research questions" (2016, p. 767), and is "attractive to researchers because they offer a history, some critique and outline the future research potential of particular domains" (2016, p. 795).

---

[4] LISTA official website: https://www.ebsco.com/products/research-databases/library-information-science-technology-abstracts-full-text
[5] Scopus official website: https://www.elsevier.com/products/scopus
[6] Web of Science official website: https://clarivate.com/academia-government/scientific-and-academic-research/research-discovery-and-referencing/web-of-science/web-of-science-core-collection/
[7] IEEE Xplore Digital Library official website: https://ieeexplore.ieee.org/Xplore/home.jsp
[8] ACM Digital Library official website: https://dl.acm.org

While the SLR shares the core principles of rigor and transparency with the Systematic Literature Review – often considered the “gold standard” in medical science – it offers greater flexibility. This inherent adaptability makes the SLR particularly well-suited for fields such as management and information systems, which must often grapple with more heterogeneous or qualitative bodies of literature.

The first phase consisted of this literature review is a broad exploratory review. The objective was to map the general intellectual landscape of ontology-based frameworks. Guided by an exploratory protocol using general search terms, this initial analysis surveyed 834 valid documents, providing a panoramic understanding of the field's evolution, methodologies, and applications. The insights from this exploratory work, which will be summarized first, established the necessary context for the subsequent investigation. The second phase comprises a more in-depth analysis of specific terms related to the core of this research.

2.1 Exploratory Review (Phase 1)

The first phase of the literature review comprised a broad, exploratory analysis aimed at developing a comprehensive and initial understanding of the actual context in ontology-based frameworks. The goal was to map the field's evolution, methodological foundations, and prominent application domains over the last two and a half decades (from 2020 to 2024).

To manage the scale of this broad survey, a machine-assisted approach was adopted, utilizing custom Python scripts (Appendix A) for automating data filtering and preliminary thematic analysis across the target databases, with Pandas and Plotly libraries for data wrangling and image generation. This first review employed a flexible search strategy designed to survey the landscape broadly, considering publication years (2000 to 2024), document types (journal article, book chapter, book, and proceeding article), language (English, Spanish, and Portuguese), and search within title, abstract, and keywords. The process was operationalized through several searches:

- A primary search for the term "ontology-based framework" yielded 300 relevant documents.

- To broaden the scope, related concepts "semantic framework*" and "knowledge representation systems" were explored, identifying an additional 242 relevant documents.
- A search focusing on "application*" and “methodology* of ontology-based framework*" was conducted to capture diverse insights, resulting in 197 relevant documents.
- A final, more focused search for "ontology-based framework*" added 95 more relevant documents to the corpus.

This multi-pronged, machine-assisted approach yielded a total of 834 relevant scientific documents for analysis.

The analysis of the 834 documents reveals a clear evolutionary trajectory for ontology-based frameworks, which have matured from early semantic web integration prototypes in the 2000s to sophisticated, AI-aware systems in the 2010s to 2024. Key trends were identified across the field's development, methodological foundations, application domains, and future directions.

The development of ontology-based frameworks can be periodized into three main eras:

- Early Semantic Web Era (2000-2010): this period emphasized semantic annotation, text mining, and database integration. Landmark efforts included the CREAM/OntoMat framework for linguistic annotation (Cimiano; Handschuh, 2003) and the OTTO system for text mining (Bloehdorn *et al.*, 2005), as well as the OntoGrate prototypes for integrating relational databases with the Semantic Web (Dou, *et al.*, 2006).
- Application Expansion Period (2010-2015): the mid-2010s saw the application of frameworks to a wider range of specific domains, including e-learning systems (Zidi; Abed, 2013), content mining workflow management, and systems for sustainable factories (Gagliardo *et al.*, 2015).
- Modern Integration Era (2015-2024): recent work shows a convergence towards greater formalization and intelligence. This includes the adoption of formal upper-level ontologies like BFO and rule standards such as SWRL, alongside the integration of Machine Learning (ML) and

semantic embeddings to augment symbolic methods (Zhang; Tao, 2016). The NFDIcore 2.0 framework exemplifies this modern, modular, BFO-aligned design approach (Bruns *et al.*, 2024).

Across the literature, ontology-based frameworks are consistently built upon a set of core methodological pillars:

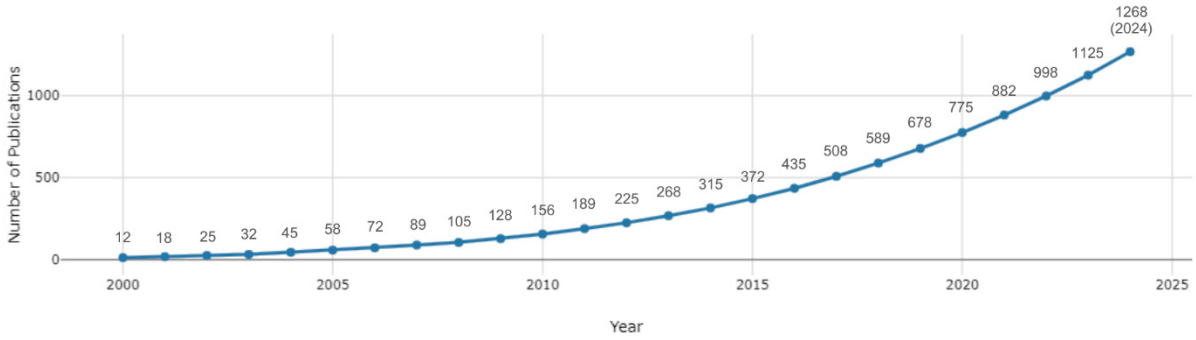
- Knowledge representation: most frameworks use RDF/OWL as the standard representational layer, employing domain or upper-level ontologies to mediate semantics (Dou et al, 2026; Zidi; Abed, 2014).
- Reasoning approaches: logical and rule-based reasoning is central, with systems adopting rule languages like SWRL or custom engines (e.g., OntoEngine) to perform inference and query translation (Lee, 2009).
- Mapping and matching: to address semantic heterogeneity, a variety of techniques are used, including similarity measures, evolutionary optimization (Huma; Rehman; Iftikhar, 2005), and hybrid ML approaches that use semantic embeddings to improve mapping beyond simple lexical overlap (Chandrashekar; Nagulapati; Lee, 2018; Bruns *et al.*, 2024).
- Artificial Intelligence (AI) integration: advanced frameworks incorporate AI planning for the automatic composition of scientific workflows, using ontologies to annotate capabilities and constraints (Buranarach *et al.*, 2016).

In summary, the phase one analysis reveals four pivotal insights into the evolving landscape of ontology-based solutions:

- Growth pattern: following its initial emergence with only 12 publications recorded in the year 2000, the field experienced a remarkable acceleration. The most significant inflection point occurred after 2010, when publications surpassed the mark of 150 per annum (reaching 156), thereby initiating an exponential growth trajectory. This trend culminated in an impressive 1,125 publications in 2023, with a projected figure of 1,268 publications in 2024 (Figure 3). This steep and sustained upward trend underscores an academic and industrial interest that is

not merely increasing, but dramatically intensifying in the capabilities of ontology-based solutions.

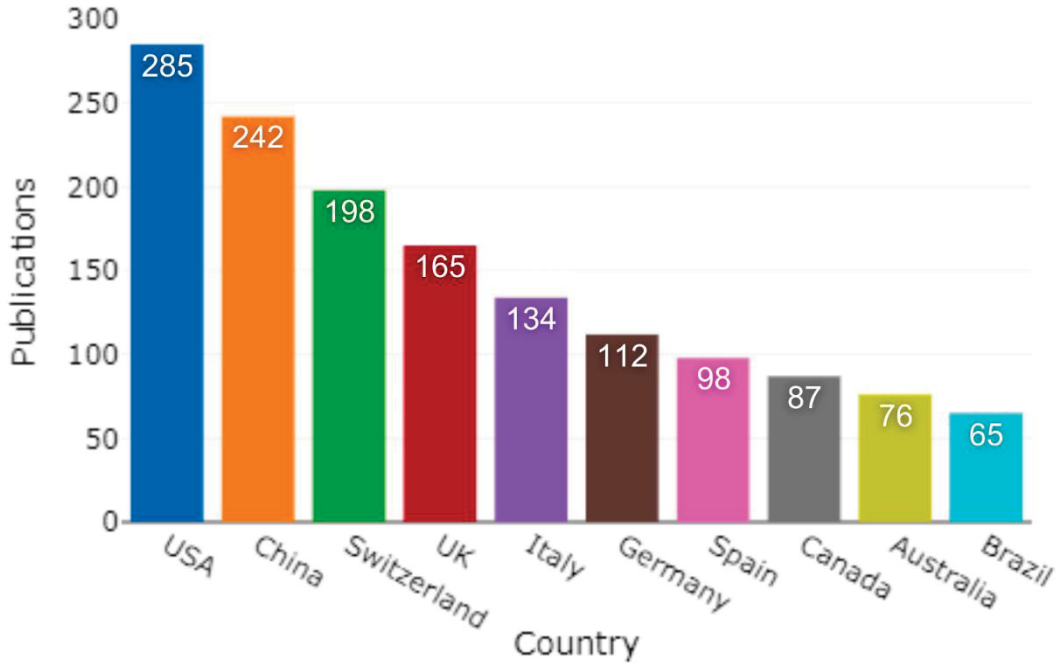
FIGURE 3 - ONTOLOGY PUBLICATIONS OVER TIME



SOURCE: Author (2025), based on literature review.

- Geographic distribution: it demonstrates a marked concentration of research output, with the USA leading decisively with 285 publications, followed closely by China (242) and Switzerland (198). Collectively, these three nations account for over one-third of the total analyzed publications, establishing them as the core contributors. Furthermore, the remaining top-ten list is predominantly comprised of European nations – including the UK (165), Italy (134), Germany (112), and Spain (98) – underscoring a clear historical and current center of gravity in North American and European institutions (Figure 4). While this concentration is evident, significant and emerging contributions are now being observed from multiple Asia-Pacific regions, signalling a globalization of expertise, notably including Australia (76) and Brazil (65) which complete the current top-ten list.

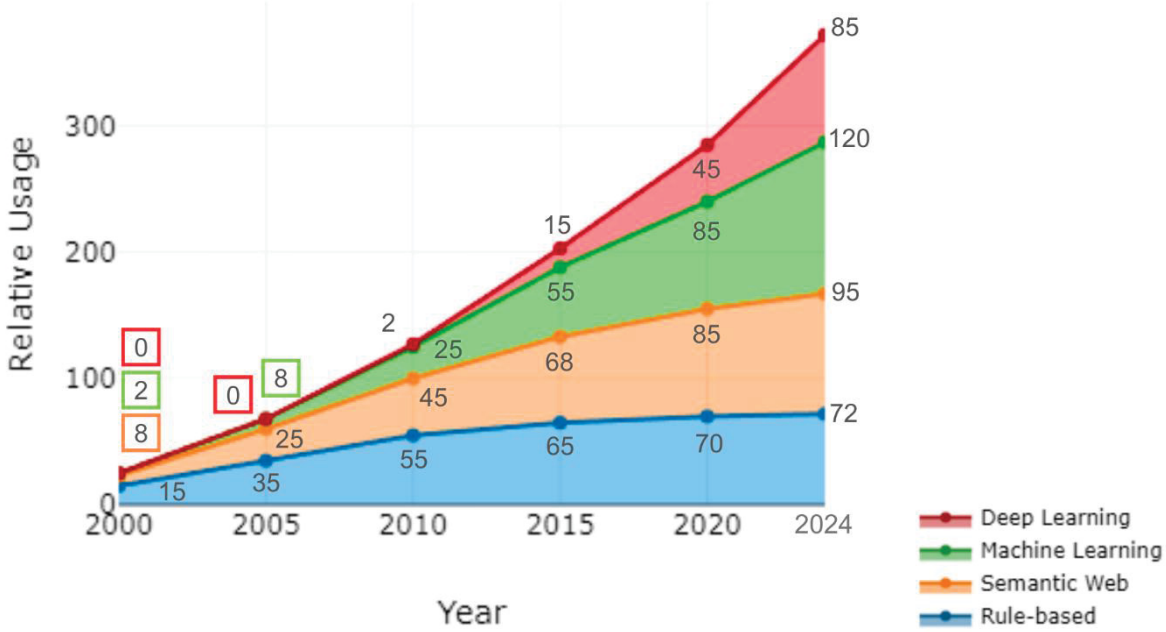
FIGURE 4 - TOP 10 COUNTRIES BY PUBLICATION COUNT



SOURCE: Author (2025), based on literature review.

- Methodology evolution: the field has demonstrably matured, shifting from its origins in Rule-based systems (which started with 15 occurrences in 2000 and stabilized at 72 instances by 2024) toward more dynamic, data-driven approaches (Figure 5). This transition is quantified by the rapid ascent of ML and Deep Learning (DL) methodologies. Machine Learning approaches, which had only 2 uses in 2000, grew to 120 uses by 2024, showcasing a sustained and high-velocity adoption. Even more pronounced is the emergence of DL, which appeared only after 2010 but escalated sharply to 85 uses in 2024. Concurrently, Semantic Web approaches maintained a consistent growth trajectory, rising from 8 uses in 2000 to 95 in 2024. The comparative trajectories thus confirm that hybrid methodologies, which combine the semantic rigor of established approaches with the predictive power of data-driven insights from ML and DL, are now gaining significant prominence, collectively representing the majority of contemporary research efforts.

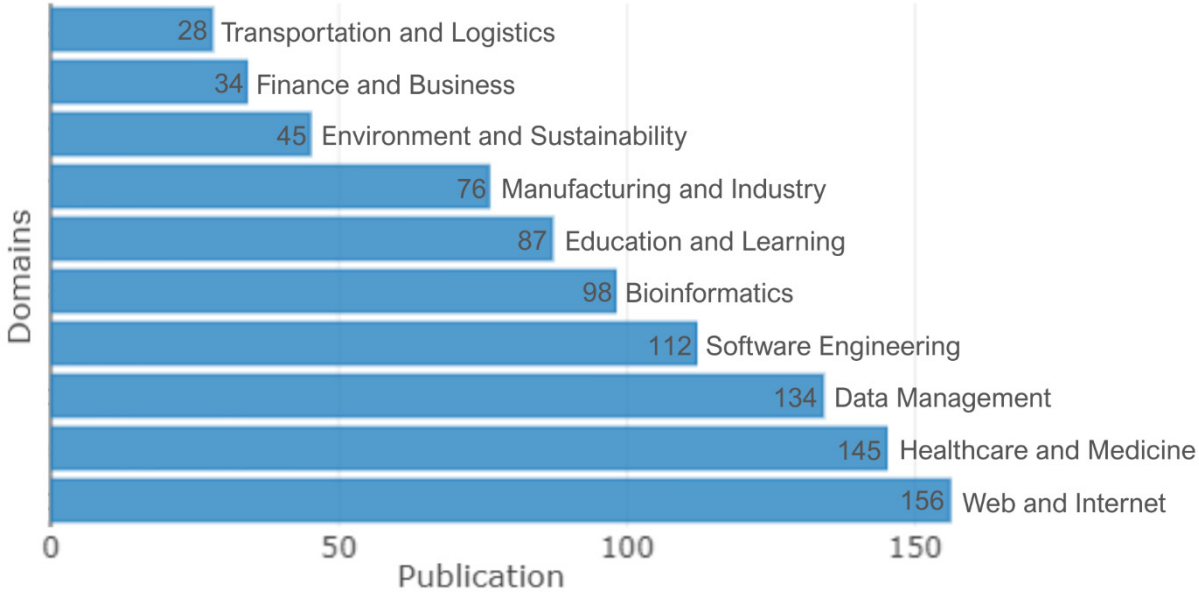
FIGURE 5 - EVOLUTION OF METHODOLOGICAL APPROACHES



SOURCE: Author (2025), based on literature review.

- Application expansion: the growing range of application domains demonstrates the profound versatility of these semantic frameworks (Figure 6). Once primarily associated with the semantic web, ontologies have successfully diversified into complex and critical sectors. Specifically, the top three application domains are Web and Internet (156 publications), Healthcare and Medicine (145 publications), and Data Management (134 publications), collectively representing a major focus of contemporary research efforts. Furthermore, the application breadth extends significantly into other critical areas, including Software Engineering (112), Bioinformatics (98), and Education and Learning (87). This distribution confirms the frameworks' successful deployment across diverse and high-impact industrial and academic settings.

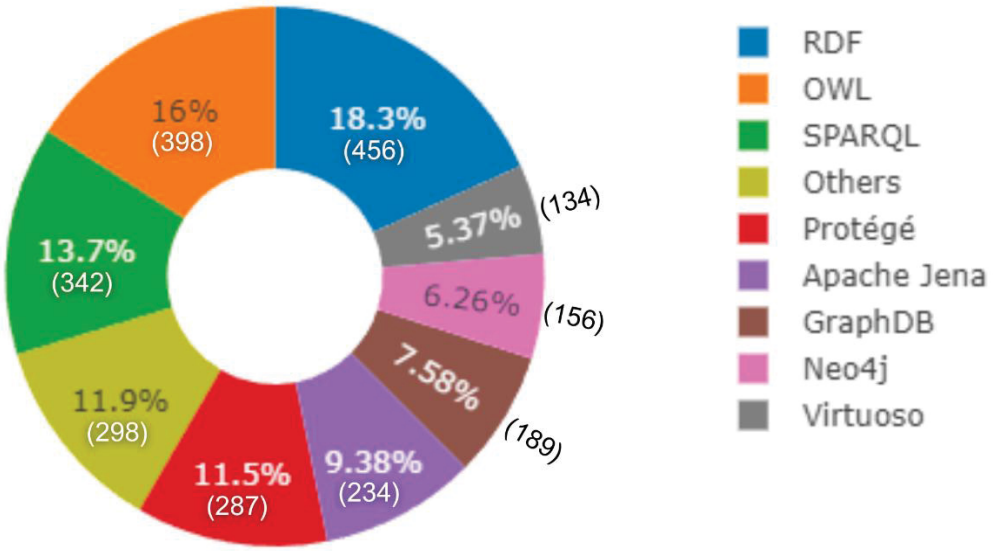
FIGURE 6 - APPLICATION DOMAINS BY PUBLICATION COUNT



SOURCE: Author (2025), based on literature review.

- Technological integration distribution: this widespread adoption is supported by a deep integration into diverse technological stacks (Figure 7). The foundational principles of the Semantic Web still account for a substantial portion of technology usage, evidenced by OWL (16%) and RDF (18.3%). However, the implementation infrastructure is highly heterogeneous. The primary query language, SPARQL, is leveraged in 13.7% of studies, and popular tools for development and management, such as Protégé (11.5%), Apache Jena (9.38%), and GraphDB (7.58%), confirm a robust and mature infrastructure for deploying ontology-based solutions. This indicates a strong ecosystem supporting the frameworks' successful transition from theoretical concept to practical, integrated technology.

FIGURE 7 - TECHNOLOGY INTEGRATION DISTRIBUTION



SOURCE: Author (2025), based on literature review.

The analysis of the evolving landscape of ontology-based solutions reveals four key characteristics: a pronounced exponential growth trajectory post-2010, resulting in over 1,000 annual publications (Figure 3); a concentrated, yet increasingly globalized, research effort predominantly anchored by the USA, China, and European nations (Figure 4); a fundamental methodological shift away from traditional rule-based systems toward hybrid AI and ML techniques, notably DL (Figure 5); and a successful application expansion into critical, complex sectors, such as Healthcare and Data Management, underpinned by diverse technological infrastructure featuring RDF, OWL, and development environments like Protégé (Figures 6 and 7). Collectively, these findings confirm the field's maturity, its established technological ecosystem, and its intensifying relevance across contemporary scientific and industrial domains.

2.2 Structured Literature Review (PHASE 2)

Building upon this foundational knowledge, the second phase was a focused, structured literature review. This phase aimed to methodically survey the body of knowledge directly pertinent to the dissertation's research problem. This targeted review was guided by a more rigorous, purpose-built protocol – detailed later in this chapter – that employed specific search strings to refine the results. This second

protocol, while not a formal systematic review, was designed to be simple and replicable, tailored to the dissertation's objective of creating an artifact.

For methodological transparency, it should be noted that access to the aforementioned databases was conducted through the CAPES Portal of Journals[9], a comprehensive digital library maintained by the Brazilian educational agency CAPES, which stands for Federal Agency for Support and Evaluation of Graduate Education. This access to CAPES Portal of Journals was provided by the Federal University of Paraná and authenticated via the Federated Academic Community Network.

This literature review pursues several interconnected objectives. First, it aimed to map the current intellectual landscape and synthesize foundational concepts, such as ontology-based knowledge frameworks, child protection, and transnational digital platforms. Second, it sought to investigate the theoretical underpinnings and established practices for developing ontology-based knowledge frameworks, particularly those designed to address complex problems involving transnational issues within digital platforms. Finally, the review worked to identify significant contributions from prior work, thereby confirming the research gap that the proposed framework was designed to address.

Following the definition of the research's scope and objectives, a structured approach was employed to survey the relevant scientific literature. After an initial phase of testing various keyword combinations to construct a search query, the decision was made to utilize three distinct, more focused search strings rather than a single, highly complex one. This multi-string strategy was adopted to allow for a more nuanced exploration of the literature at the intersection of the core conceptual pillars of this dissertation and to better manage the scope of results from each thematic area.

The search was therefore operationalized through the execution of three distinct search strings. Each string was designed to capture a specific thematic intersection, as follows:

- String 1 (Combines keywords related to ontology and frameworks with those of child protection): ("ontolog*" OR "ontology-based" OR "ontology based" OR "based on ontology" OR "ontology-driven" OR "ontology driven" OR "ontology framework" OR "knowledge framework"

---

[9] CAPES Portal of Journals official website: https://www.periodicos.capes.gov.br.

OR "knowledge management framework") AND ("protecting children" OR "child protection" OR "safeguarding children" OR "child online protection" OR "child online safety").

- String 2 (Combines keywords related to child protection with those of digital platforms): ("protecting children" OR "child protection" OR "safeguarding children" OR "child online protection" OR "child online safety") AND ("transnational digital platforms" OR "digital platform*" OR "online platform*" OR "social media" OR "online environment*" OR "transnational" OR "cross-border").
- String 3 (Combines keywords related to ontology and frameworks with those of digital platforms): ("ontolog*" OR "ontology-based" OR "ontology based" OR "based on ontology" OR "ontology-driven" OR "ontology driven" OR "ontology framework" OR "knowledge framework" OR "knowledge management framework") AND ("transnational digital platforms" OR "digital platform*" OR "online platform*" OR "social media" OR "online environment*" OR "transnational" OR "cross-border").

To refine the search results and ensure their relevance, timeliness, and academic rigor, a consistent set of filters was applied across all databases. These inclusion criteria were: publication years (2000 to 2024), document types (journal article, book chapter, book, and proceeding article), language (English, Spanish, and Portuguese), and search within title, abstract, and keywords.

Presented below (Table 1) are the preliminary quantitative results (1,517 records) yielded by each of the three search strings on all the aforementioned databases, reflecting the application of this defined search protocol. The breakdown of results per database was LISTA (58), Scopus (236), Web of Science (215), IEEE Xplore Digital Library (569), and ACM Digital Library (439).

TABLE 1 - PRELIMINARY SEARCH RESULTS PER DATABASE

	String 1	String 2	String 3	TOTAL
LISTA	11	19	28	58
Scopus	22	60	154	236
Web of Science	39	59	117	215
IEEE Xplore Digital Library	85	201	283	569
ACM Digital Library	68	142	229	439
TOTAL	225	481	811	**1,517**

SOURCE: Author (2025).

An initial analysis of the quantitative results across the five databases revealed significant differences in the volume of records retrieved by each search string. String 3, which combined keywords related to ontology/frameworks with digital platforms, consistently yielded the highest number of records across all databases. This outcome was anticipated, as the intersection of these two broad domains is naturally expansive, encompassing a wide range of technological and conceptual literature. Conversely, String 1, focusing on the intersection of ontology/frameworks and child protection, generated the fewest results. This suggested a more nascent or less extensively explored area within the scientific literature, aligning with the identified research gap this dissertation aims to address. String 2, combining child protection and digital platforms, produced an intermediate volume of results, indicating a more established but still developing field of study. The distinct yield of each string underscored the value of employing a multi-string strategy, allowing for a targeted exploration of specific thematic intersections.

To refine these initial results and make them more amenable to in-depth analysis, a systematic approach was employed using the web-based application Rayyan[10]. This tool was utilized for the initial screening and selection of results, primarily to eliminate duplicate entries based on title and/or DOI information. After the deduplication process, each document was then assessed for its relevance based on a defined set of revised inclusion and exclusion criteria within Rayyan. This initial screening, which was based on a review of each document's title, abstract, and keywords, served as a methodical filter to refine the large pool of initial results. The selection process was guided by a more inclusive approach to ensure both directly relevant and foundationally important literature was captured.

The selection process was guided by the following criteria (Figure 8):

- Inclusion Criteria (IC): to be considered for the next phase, a document had to meet at least one of the following primary conditions:
    - IC1 (Core thematic intersection): the study explicitly addresses the intersection of child protection/safety with either (a) ontology/knowledge frameworks or (b) transnational digital

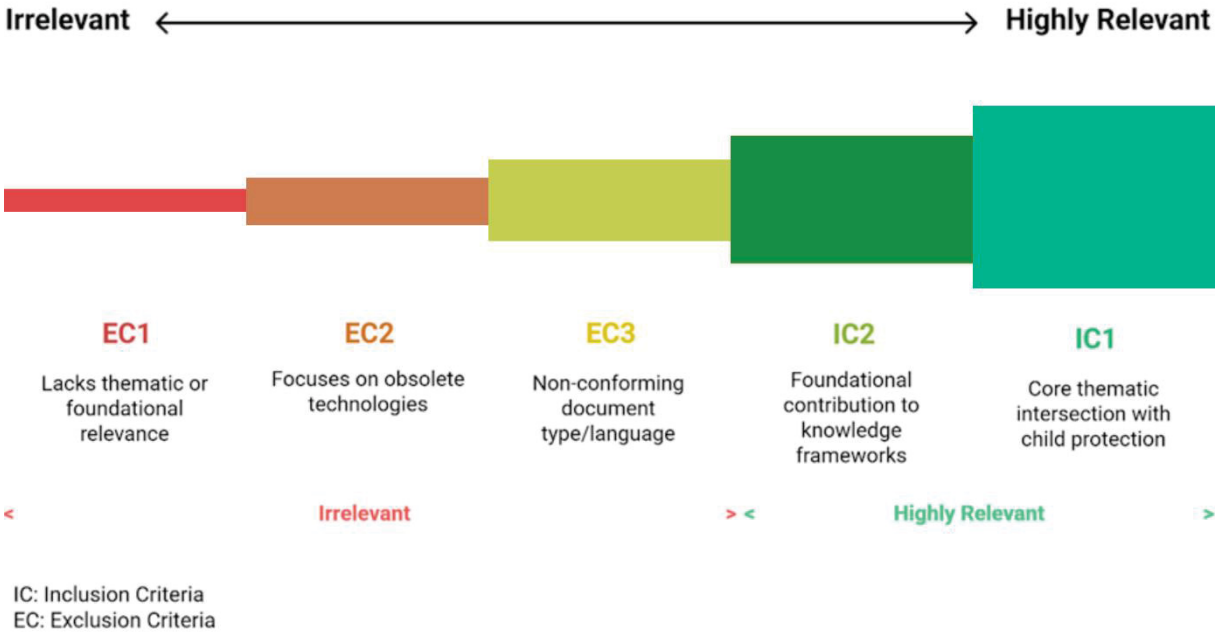
[10] Rayyan official website: https://www.rayyan.ai/

platforms or (c) digital realm. This captures a document directly within the dissertation's core domain.

- IC2 (Foundational contribution): the study provides a significant theoretical or methodological contribution to the design, structure, or application of ontology-based knowledge frameworks in complex digital environments, even if the specific application domain is not child protection (e.g., healthcare, e-learning, cybersecurity). This captures documents that are foundationally important for the proposed solution.

- Exclusion Criteria (EC): A document was excluded if it met any of the following conditions:
  - EC1 (Lack of thematic or foundational relevance): the study did not meet either IC1 or IC2.
  - EC2 (Technological obsolescence): the study focused on technologies or platforms that were demonstrably obsolete and not relevant to the current digital ecosystem.
  - EC3 (Non-conforming document type or language): despite initial search filters, some documents were identified as a type other than a journal article, book chapter, book, or proceeding article (e.g., editorial, pre-print article). Additionally, documents were excluded if, upon closer inspection, the full text was predominantly in a language other than English, Spanish, or Portuguese, even if the title, abstract, and keywords were presented in one of the filtered languages.

FIGURE 8 - DOCUMENT SELECTION PROCESS BASED ON RELEVANCE AND APPLICABILITY



SOURCE: Author (2025).

This structured application of inclusion and exclusion criteria ensured that the documents selected for in-depth analysis were precisely aligned with the research question and objectives of this dissertation. The second phase of the literature review involved the management and in-depth analysis of the selected documents. For this stage, the reference management software Zotero[11] was employed as the central tool to create a dedicated research library. The definitive cohort of documents identified as "included" during the Rayyan screening process was exported and subsequently imported into this Zotero library, establishing a focused and self-contained collection for the qualitative analysis.

Once the library was populated, the next step was to retrieve and attach the full-text document for each reference. This action transformed the Zotero library into a digital repository, allowing for efficient organization and offline access to the core scholarly materials. Within Zotero, functionalities such as collections and tags were used to categorize the literature according to sub-themes and research approaches, further structuring the analytical process. This organized repository then served as the foundation for the detailed qualitative analysis. Zotero's integrated PDF reader and

[11] Zotero official website: https://www.zotero.org.

annotation tools were utilized for a close reading of each article. This process included highlighting key passages, extracting significant quotes, adding analytical notes directly within the software, linking them to their specific sources. This methodical approach facilitated the identification of recurring themes, concepts, theories, significant findings, and methodological trends across the body of selected literature. Finally, Zotero assisted in the synthesis of these findings and the production of the scholarly output. The organized annotations and notes supported the composition of the literature review presented in this chapter. This two-tool approach, from Rayyan to Zotero, ensured an organized pathway from the initial broad search to the final, in-depth analysis.

Following the comprehensive screening process in Rayyan and subsequent management within Zotero, a refined cohort of 114 relevant items was ultimately identified for the literature review. This final selection was meticulously derived from the initial 1,517 records through the diligent application of the pre-defined inclusion and exclusion criteria.

This curated collection of literature served as the foundation for achieving the interconnected objectives of this review. Specifically, the subsequent subsections will examine into how this body of knowledge helped to map the current intellectual landscape and synthesize foundational concepts. Furthermore, these sections will investigate the theoretical underpinnings and established practices for developing ontology-based knowledge frameworks. Finally, the analysis will highlight significant contributions from prior work.

2.3 Conceptual Foundations

This subsection aims to map the current intellectual landscape and synthesize foundational concepts crucial to this dissertation. Specifically, it will explore key concepts such as ontology-based knowledge frameworks, child protection, and transnational digital platforms, providing the necessary theoretical groundwork for the subsequent discussions.

2.3.1 Knowledge framework

The literature on knowledge frameworks is diverse, encompassing various domains and approaches, as evidenced by the comprehensive reviews and analyses presented in the provided papers. Ontology-based frameworks in software engineering, for instance, are highlighted for their role in enhancing knowledge-sharing and decision-making, emphasizing the importance of precise domain definitions and the involvement of stakeholders in their development and utilization (Vecštejn *et al.*, 2024).

In the realm of enterprise financing, blockchain technology has been explored as a knowledge framework, with studies identifying its enabling mechanisms, such as improving information quality and trust mechanisms, while also noting challenges like technological uncertainty and data security (Song; Yang; Tao, 2023). Knowledge Management (KM) frameworks are further explored through various lenses, including their impact on individual and organizational capabilities, as well as their role in fostering organizational learning and perfor (Brahma; Mishra, 2015).

The interdisciplinary nature of KM is underscored by efforts to harmonize its diverse topics through the development of normative classification schemas, which aim to provide a common understanding and guide future research (Fteimi, 2015). Additionally, frameworks for building knowledge societies are proposed, focusing on dimensions such as cultural and technological aspects, which are crucial for decision-makers in different contexts (Lopes, 2021). The complexity and variety of KM models and frameworks are also discussed, with an emphasis on their application in organizational settings and the need for frameworks that are adaptable to specific organizational needs (Sensuse *et al.*, 2014; Yiu; Sankat; Pun, 2013).

Furthermore, the integration of business management and work psychology perspectives in KM frameworks highlights the importance of understanding the dimensions involved in knowledge management and transmission practices in workplaces (Pereira; Delgoulet; Santos, 2023). Finally, the development of KM implementation frameworks is addressed, with a focus on providing guiding principles and directions to overcome the challenges organizations face in realizing the full potential of KM (Wong; Aspinwall, 2004).

For research endeavors that aim to solve practical problems through the creation and evaluation of innovative artifacts, Design Science Research (DSR) stands as the preeminent methodology (Hevner *et al.*, 2004), including with applications in

industrial engineering (Goecks *et al.*, 2021). This approach is defined by its four core tenets: the development of a prescriptive artifact; a foundation in the relevance of a real-world problem; a requirement for scientific rigor; and a commitment to an iterative design and evaluation cycle (Peffers, 2007).

Figure 9 synthesizes this part of literature review by mapping the discussed frameworks along a conceptual spectrum, ranging from theoretical to applied. On the theoretical side, frameworks are utilized for purposes such as “harmonization” (Fteimi, 2015) and modeling domains like “software engineering” (Vecštejn *et al.*, 2024). As they move toward the applied end, they address “organizational settings” (Sensuse *et al.*, 2014) and “workplace practices” (Pereira; Delgoulet; Santos, 2023). At the most applied extreme, frameworks are directly employed for “problem solving” (Goecks *et al.*, 2021) and “overcoming challenges” (Wong; Aspinwall, 2004), aligning with the artifact-centric nature of DSR.

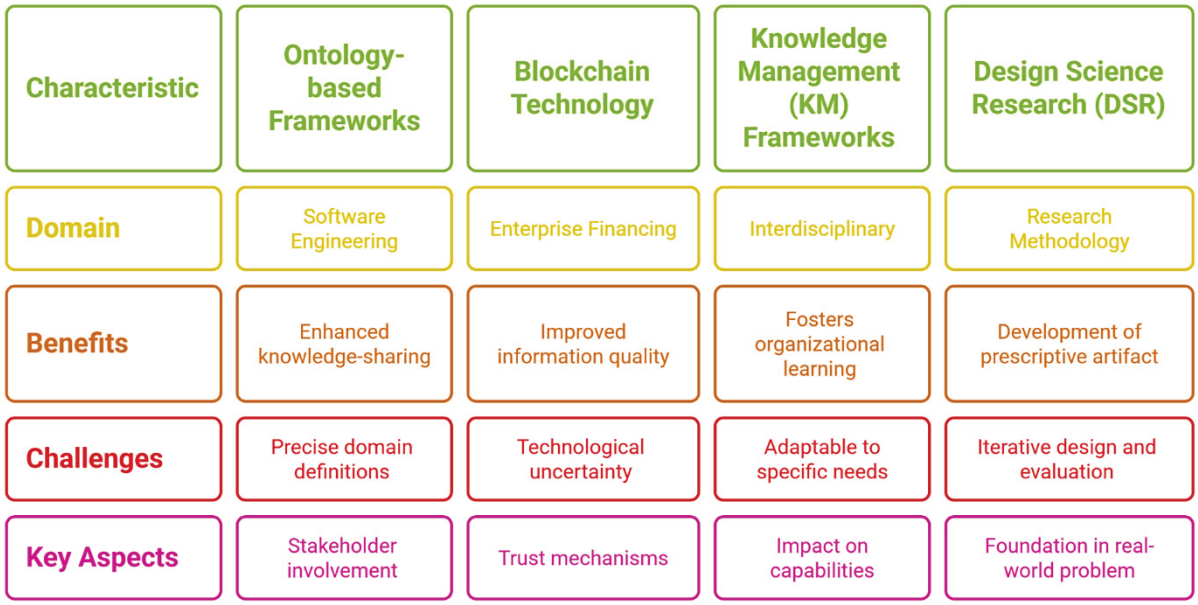
FIGURE 9 - KNOWLEDGE FRAMEWORK RANGE FROM THEORETICAL TO APPLIED

SOURCE: Author (2025), based on literature review.

Furthermore, Figure 10 offers a structured comparison of the key approaches identified in the literature. This matrix contrasts ontology-based frameworks; blockchain technology; Knowledge Management (KM) frameworks; and Design Science Research (DSR) across several dimensions. It summarizes their respective domains (e.g., software engineering vs. enterprise financing); benefits (e.g., enhanced knowledge-sharing vs. improved information quality); challenges (e.g., precise domain definitions vs. technological uncertainty); and key aspects (e.g., stakeholder

involvement vs. trust mechanisms). This comparison elucidates the distinct profiles and trade-offs of each framework strategy.

FIGURE 10 - KNOWLEDGE FRAMEWORK COMPARISON



SOURCE: Author (2025), based on literature review.

Collectively, these studies illustrate the multifaceted nature of knowledge frameworks and underscore the need for continued research to refine and adapt these frameworks to meet evolving organizational and technological demands.

As the literature indicates, the term "knowledge framework" is broad, and its precise meaning is context-dependent, varying across fields such as knowledge management and computer science. In the KM domain, for instance, it is often used synonymously with "knowledge management framework".

Such frameworks typically provide a model for how an organization handles knowledge. Wong (2005, p. 264), for example, conceptualizes a KM framework as "a conceptual model that illustrates the inter-relationships of all knowledge management functions and processes in an organization". Building on this concept and the many characteristics of knowledge frameworks cited throughout this research, the present study defines a knowledge framework as a conceptual model that specifies the components, categories, processes, and relationships within a specific body of knowledge.

2.3.2 Ontology-based knowledge framework

The concept of applied ontology and ontology itself has been extensively explored across various domains, each highlighting its unique applications and challenges. Ontologies serve as a formal representation of knowledge, enabling semantic interoperability and knowledge sharing across diverse fields. In software engineering, ontologies are utilized to enhance productivity and quality by facilitating higher abstraction levels and software reuse, particularly in automatic and generative programming (Strmečki; Magdalenić; Radošević, 2018).

In the realm of railway transport safety, ontologies and knowledge graphs are employed to formalize and structure domain knowledge, thereby improving decision-making processes and mitigating biases in AI systems (Hadj-Mabrouk, 2024). Cloud computing also benefits from ontologies, which aid in modeling knowledge to enhance cloud security, interoperability, and service discovery, although challenges remain in applying ontologies to business operations in multi-cloud environments (Agbaegbu *et al.*, 2021).

In organizational learning, ontologies, combined with IT, promote knowledge sharing and formalization, although their application remains limited (Valaski; Malucelli; Reinehr, 2012). Medical ontologies, particularly in liver disease representation, have proven effective in processing large data volumes and supporting decision systems, thus accelerating diagnosis processes (Messaoudi *et al.*, 2020). The sharing economy domain leverages ontologies to manage digital platforms and address data heterogeneity, although the development of comprehensive ontologies is hindered by a lack of standardization (Mohamad; Ahmad; Zakaria, 2022).

When it comes to smart cities, ontologies facilitate data interoperability and automated reasoning, addressing urban challenges through enhanced service integration (Nicola; Villani, 2021). A comprehensive review of ontology development aspects reveals its benefits, types, and application domains, underscoring its role in semantic web technologies and shared knowledge across fields like AI and Library Science (Law *et al.*, 2019). In distributed software development, ontologies simplify communication and information sharing among distributed teams, offering competitive advantages despite the challenges of remote collaboration (Junior *et al.*, 2012).

Finally, in collaborative design, ontologies are critical for application integration and knowledge sharing, with ongoing research focusing on improving ontology authoring languages and methodologies (Xie; Shen, 2006). Collectively, these studies underscore the versatility and critical role of ontologies in advancing knowledge representation and application across various sectors.

However, ontology-based knowledge frameworks have emerged as pivotal tools across various domains, facilitating enhanced knowledge management, interoperability, and decision-making processes. In software engineering, ontologies are instrumental in improving knowledge sharing, collaboration, and decision-making, with frameworks being crucial for defining precise domains and ensuring effective utilization of ontologies (Vecštejn *et al.*, 2024). Mokgetse *et al.* (2023) highlights innovative ontology-driven frameworks, emphasizing their role in integrating diverse knowledge bases and enhancing communication between human and machine agents.

In the context of supply chain management, ontology-based frameworks enable effective knowledge sharing, crucial for decision-making and establishing sustainable supply chains. These frameworks support activities such as buyer-supplier matchmaking and intelligent connectivity, thereby fostering long-term strategic collaborations (Hilal, 2020). In automatic programming, ontologies are used to achieve higher abstraction levels and software reuse, aiding in source code generation and product derivation, although challenges and gaps remain in their application (Strmečki; Magdalenić; Radošević, 2018).

The research by Osman, Mohd Noah, and Saad (2022) identifies trends and hotspots in ontology-based knowledge management, underscoring the need for further exploration of theoretical frameworks and practical applications. Ontology-based Knowledge Management for Enterprise Systems (OKES) supports the entire lifecycle of enterprise systems, facilitating knowledge repository, retrieval, sharing, and dissemination, with a taxonomy developed to understand OKES research.

This research by Sedera, Ahmad and Zakaria (2011) identifies that ontology-based knowledge management for enterprise systems supports the entire lifecycle of enterprise systems, facilitating knowledge repository, retrieval, sharing, and dissemination, with a taxonomy developed to understand OKES research.

Lastly, in software project management, ontologies are seen as tools to improve knowledge management and software reusability, though challenges such as lack of standardization and systematic domain modeling persist (Iatrellis; Fitsilis, 2021). Collectively, these studies illustrate the diverse applications and ongoing challenges in developing and implementing ontology-based knowledge frameworks across different fields.

According to Bermejo-Alonso *et al.* (2010), ontology-based knowledge frameworks are characterized by several key components that facilitate the management, integration, and retrieval of knowledge across various domains. A fundamental aspect of these frameworks is the establishment of a common conceptualization that can be shared among stakeholders, which is crucial for ensuring interoperability and effective communication within and across systems. Thus, in the context of knowledge management, ontologies help identify and characterize the basic components of knowledge management episodes, including the manipulation of knowledge resources and the influences affecting these processes (Holsapple; Joshi, 2004).

As the literature indicates, the term "ontology-based knowledge framework" is broad. Although its meaning is context-dependent, varying across fields such as engineering and product lifecycle management, authors often prioritize characterizing the framework's features over establishing a single, formal definition.

For example, Lee, and Suh (2008) characterize their framework by its features: it possesses a systematic lattice structure; is ontology-based to specify semantics explicitly; uses a uniform representation; is comprehensive; and ensures knowledge is managed without ambiguity or heterogeneity. Similarly, Zhang *et al.* (2015) describe their framework by its attributes, defining it as open, shared, and scalable; based on semantic web technology; providing a formal approach to knowledge representation; and structured upon a layered architecture.

Based on this literature review, the present study defines an ontology-based knowledge framework as a conceptual architecture or system model that utilizes an ontology – the formal, explicit specification of a domain's concepts, properties, and relationships – as its structural and semantic backbone. Transcending a traditional data model, an ontology-based knowledge framework not only defines the components, categories, and processes of a body of knowledge, but also renders

these relationships formally machine-readable. The primary objective of an ontology-based knowledge framework is to overcome ambiguity and heterogeneity, thereby enabling semantic interoperability, explicit knowledge management, and the facilitation of advanced services such as automated reasoning and new fact inference.

2.3.3 Child protection

The literature on child protection encompasses a wide array of concepts and frameworks aimed at safeguarding children's welfare and rights. A significant focus is placed on understanding risk and protective factors in child development, which are crucial for professionals working with children to effectively prevent behavioral problems and promote resilience (Maia; Williams, 2005).

Clinical supervision in child protection practice is another critical area, with various theoretical perspectives such as psychodynamic, managerialist, and systemic approaches influencing practice outcomes. However, the lack of a unified theoretical framework often leads to confusion in practice, highlighting the need for more robust theoretical and practical integration (Karpetis, 2021). Continuous quality improvement processes have shown potential in enhancing child protection services, although existing studies often lack validating data, suggesting a need for more comprehensive evaluations to confirm their effectiveness (Zuchowski *et al.*, 2019).

The intersection of disability, internet use, and child protection presents unique challenges and risks, necessitating a broadened conceptual understanding to effectively safeguard children in the digital age (Maher; Flynn; Byrne, 2023). Systematic assessment frameworks are essential in guiding information collection and decision-making in child protection investigations, ensuring that decisions are informed and consistent (Vis; Lauritzen; Fossum, 2019).

The role of child protection in fulfilling children's rights is underscored by legal frameworks such as Indonesia's Law Number 23 of 2002, which emphasizes the collective responsibility of various societal actors in protecting children's rights (Jayati, 2020). Decision-making in child protection is influenced by a complex interplay of case characteristics, caseworker attributes, organizational factors, and external elements, with organizational characteristics often playing a more significant role than individual caseworker traits (Lauritze, Vis; Fossum, 2018).

Child protection encompasses a multifaceted array of concepts aimed at safeguarding children from abuse, exploitation, and neglect, while ensuring their rights to survival, development, and participation are upheld. Central to these efforts is the recognition of children's vulnerability to various forms of harm, including commercial sexual exploitation, trafficking, and harmful traditional practices like child marriage (Bhandari, 2016). The concept of child protection is deeply intertwined with the social context of families, as highlighted by the inclusion of the German term "Kindeswohlgefährdung", which emphasizes the endangerment of a child's best interests (Widmer; Collins, 2024).

Internationally, child protection is challenged by issues such as natural disasters, political conflicts, and the exploitation facilitated by new technologies (Hackett, 2015). The Covid-19 pandemic has further underscored the importance of resilience-building, systems theory, and trauma-informed approaches in child protection, particularly for children with adverse childhood experiences (Flynn, 2022). Complexity theory also offers a valuable framework for understanding the unpredictable nature of child protection systems, advocating for adaptive and systemic approaches to decision-making (Gillen; Canavan, 2023).

Legal frameworks, such as the Child Abuse Prevention and Treatment Act of 1974 in the United States, play a crucial role in defining child abuse and guiding state intervention in the parent-child relationship (Katz, 2014). Moreover, the integration of child protection within broader human rights frameworks, such as the United Nations Convention on the Rights of the Child, emphasizes the need for preventive and protective strategies that align with global health and development goals (Wekerle, 2024). In practice, child protection involves a collaborative effort among various stakeholders, including government agencies, non-governmental organizations, and community-based initiatives, as exemplified by India's Integrated Child Protection Scheme (Bhandari, 2016). Despite these efforts, challenges remain, particularly in ensuring effective legal protection and addressing systemic issues within child welfare systems (Sulastri; Septania, 2022).

Overall, the literature underscores the need for integrated, evidence-based approaches that consider the diverse factors influencing child protection, from digital environments to legislative frameworks, to ensure the effective safeguarding of children globally.

Concerning child protection on digital environment, the key concepts and principles encompass a multifaceted approach that integrates legal, educational, and technological strategies to safeguard children's rights and well-being. Central to this is the recognition of children's rights to privacy and data protection, as highlighted by the implementation of the European Union General Data Protection Regulation, and the development of 'Children's Codes' in countries like the UK, Ireland, and the Netherlands, which emphasize fairness, transparency, and the best interests of the child (Milkaite, 2023). International frameworks, such as the Convention on the Rights of the Child and UN General Comment 25, provide a normative basis for adapting child protection to the digital age, though challenges remain in effectively implementing these standards (Mesias-Rodríguez, 2024). The digital environment presents unique risks, including cyberbullying, data exploitation, and privacy violations, necessitating a comprehensive policy approach that combines legislative measures, media literacy, and awareness initiatives (Mokhtar, 2024).

The involvement of multiple stakeholders, including governments, international organizations, industry, and civil society, is crucial in creating a safe online environment that respects children's rights and supports their development (Hradova; Zhytnyi; Tereshchuk, 2021). Additionally, the integration of child rights into digital product design remains a challenge, as designers often prioritize risk protection over ensuring children's rights to provision and participation, highlighting the need for a compelling rationale and practical means to implement these rights in commercial settings (Pothong *et al.*, 2024). Thus, a child rights-based approach to digital protection, aligned with the UN Sustainable Development Goals, is important for addressing the global nature of these challenges and ensuring that children and their caretakers are equipped to manage risks and leverage opportunities in the digital environment (Kovács-Szépvölgyi, 2023).

2.3.4 Transnational digital platforms

Transnational digital platforms are complex entities that integrate technology and organizational elements to facilitate economic and social interactions across borders. These platforms are characterized by their core-periphery architecture, which enables them to govern social orders through digital interfaces, thus playing a pivotal

role in modern economies (Ametowobla; Kirchner, 2023). The economic nature of digital platforms is defined by their ability to create value through network effects, where the interaction of economic agents leads to both positive and negative indirect effects. These platforms are categorized into various types, such as operational, innovative, investment, and integrated platforms, each with distinct income generation models (Bhargava; Wang; Zhang, 2022) The architecture of digital platforms can be dissected into four dimensions: infrastructure, core, ecosystem, and service, which help in understanding their configurations and functionalities (Blaschke *et al.*, 2019).

Global digital platforms or simply big techs, transnational digital platforms have emerged as new models for organizing cross-border economic activities, contributing to sustainable development and the creation of new goods and services for the global market (Karelina; Baykov, 2022). They operate as private legal orders with significant legislative, executive, and jurisdictional powers, influencing both national and international legal frameworks (Bassan, 2021). The economic principles governing these platforms are largely driven by network effects, which are crucial for their operation and strategic decision-making (Belleflamme; Peitz, 2021). Despite their benefits, digital platforms also pose risks, such as market concentration and the potential exacerbation of inequalities, necessitating state intervention at national and supranational levels to ensure fair competition and equitable development (Bonina *et al.*, 2021). Therefore, transnational digital platforms are reshaping global economic landscapes, offering both opportunities and challenges that require careful management and regulation.

Having established the foundational concepts, the subsequent section will elaborate on the theoretical underpinnings and established practices for developing ontology-based knowledge frameworks, particularly those designed to address complex problems involving transnational issues within digital platforms.

2.4 Theorical Foundations and Practices

This subsection aims to investigate the theoretical underpinnings and established practices for developing ontology-based knowledge frameworks. A particular focus will be placed on frameworks designed to address complex problems

involving transnational issues within digital platforms, building upon the foundational concepts previously discussed.

Developing a knowledge framework involves a variety of methodologies that cater to different domains and objectives, as evidenced by the diverse approaches outlined in the provided papers. A common theme across these methodologies is the integration of structured processes and tools to manage and utilize knowledge effectively.

In the realm of allied system engineering, Chen *et al.* (2004) describe a systematic approach that includes phases such as knowledge identification, analysis, modeling, and the development of a distributed knowledge management framework, emphasizing flexibility and dynamic configurability (Chen *et al.*, 2004).

Rosenberg's work on urban planning highlights the use of a knowledge framework to interpret territorial conditions and guide sustainable spatial development, organizing information into analytical and synthetic products (Rosenberg, 2023).

Niedderer, and Imani explore the use of knowledge management models, such as the SECI model, to manage tacit knowledge in creative disciplines, offering a flexible framework for integrating various research methodologies (Niedderer; Imani, 2009).

Taskin *et al.* (2013) propose a comprehensive lifecycle framework for knowledge management systems, addressing the complexity and interdisciplinary nature of the field. Tomé, and Neumann's framework supports knowledge-based development by benchmarking knowledge management maturity and providing strategic feedback (Tomé; Neumann, 2010).

Lastly, Smuts *et al.* (2009) enhance a 12-step process for implementing knowledge management systems, focusing on converting knowledge into actionable information for competitive advantage. These methodologies collectively underscore the importance of tailored frameworks that address specific needs and contexts, leveraging both structured processes and innovative tools to manage and develop knowledge effectively.

When selecting a suitable methodology for developing an ontology-based knowledge framework, several key considerations must be taken into account. First, the choice of methodology should align with the specific goals and domain of the ontology project. Different methodologies offer various strengths; for instance, the Simple Knowledge-Engineering Methodology is noted for its straightforward approach,

which was effectively applied in developing the TITO ontology for the University of Tabuk's Department of Information Technology (Alfaifi, 2022). Additionally, the integration and reuse of existing ontologies can significantly enhance efficiency and reduce costs, as highlighted by methodologies like MIOD, which focus on merging and integrating existing ontologies (Leung *et al.*, 2011).

The methodology should also support the systematic organization of steps, activities, and guidelines to ensure a structured development process (Leung; Lau; Tsang, 2013). Furthermore, the methodology should facilitate the minimization of ambiguity and imprecision in shared information, besides being adaptable to the specific requirements of the domain, as seen in the development of ontologies for medical domains, which require specialized knowledge representation and inference rules (Gawich *et al.*, 2012).

Finally, the potential for hybridization of methodologies to address gaps and enhance the correctness and robustness of ontology development is a critical consideration, as suggested by Aminu *et al.* (2020), who advocate for combining methodologies to strengthen ontology content and construction (Aminu *et al.*, 2020). Overall, the selection of an ontology development methodology should be guided by the specific needs of the project, the potential for reuse and integration, and the ability to support comprehensive and precise knowledge representation.

In light of these considerations, the choice of methodology for building a domain ontology, such one about child protection on transnational digital platforms, is influenced by many factors, including the nature of the domain, the intended application of the ontology, and the available resources and tools. One primary factor is the domain's complexity and specificity, which dictates whether a bottom-up or top-down approach is more suitable. Bottom-up methodologies, which start with specific domain descriptions and build up to a classification, are often used when detailed domain knowledge is available, while top-down approaches begin with an abstract view and are useful when such knowledge is less accessible (Cristani; Cuel, 2005).

The selection of information sources is another important aspect, as it impacts the quality and efficiency of the ontology. Techniques such as the AVRN method, which combines abstract analysis, vector space models, and neural networks, are employed to optimize source selection (Xing *et al.*, 2012). Additionally, the methodology must align with the ontology's intended use, whether for semantic web services, knowledge

sharing, or specific applications like medical ontologies, which may require specialized methodologies incorporating conceptualization and inference rules (Gawich *et al.*, 2012).

The choice is also influenced by the need for a lightweight or comprehensive approach, as seen in methodologies that utilize the entity relationship model for a more streamlined process (Raza *et al.*, 2019). Furthermore, the availability of tools and techniques for concept and relation classification, such as frequency-based and similarity-based approaches, also plays a role in methodology selection, ensuring that the ontology accurately reflects the domain's semantic structure (Yin; Gu; Hou, 2016). The potential for hybridization of methodologies to address gaps and improve correctness is a consideration, as it can lead to more robust ontology development across various domains (Aminu *et al.*, 2020).

While many ontology methodologies exist, their steps are often not well-explained, typically requiring experienced knowledge engineers with backgrounds in Computer Science, logic, and Philosophy. The methodology OntoForInfoScience aims to overcome these issues by using a simpler language, free of technical vocabulary, making it suitable for a variety of professionals, especially those in Information Science. The methodology, comprising nine phases, was developed by information scientists during the construction of an ontology for the human blood domain, named Hemonto (Mendonça; Almeida, 2016).

Consequently, the choice of methodology is a multifaceted decision that must consider these factors to effectively support the ontology's development and application.

Building upon the diverse factors influencing the choice of methodology for ontology construction, and recognizing the complexities inherent in detailing practical guidance for this process, the development of an expandable domain ontology for child protection on transnational digital platforms necessitates careful consideration of its foundational elements. Among these, selecting an appropriate top-level ontology is essential for ensuring comprehensive coverage and adaptability.

From the available top-level ontologies suitable for the framework proposed in this research, Basic Formal Ontology (BFO) stands out as a highly influential and widely adopted foundational ontology, known for its rigorous philosophical grounding

and its utility as a robust starting point for domain-specific knowledge representation (Arp; Smith; Spear, 2015; Otte; Beverley; Ruttenberg, 2022).

While BFO provides a strong basis, other candidates offer distinct advantages to meet the complex and dynamic requirements of child protection in digital environments. YAMATO ontology (Mizoguchi; Borgo, 2021), for instance, provides advanced features in quality description, representation, and process/event management, which are noted as improvements over existing ontologies like DOLCE and BFO.

The TUpper ontology offers a modular approach, beneficial for integrating various aspects such as time, process, and space (Grüninger; Ru; Thai., 2022), fostering adaptability for evolving threats. Similarly, while PROTON provides a domain-independent foundation aligned with popular standards, essential for semantic annotation and managing diverse data, BULO offers a foundational top-level ontology of very general concepts and relationships applicable across diverse domains (Terziev; Kiryakov; Manov, 2005).

The need for a robust and comprehensive ontology for child protection is further underscored by challenges in the literature, including gaps in specific regulations and the necessity for multisectoral collaboration (Mesias-Rodríguez, 2024), alongside the role of educational programs and parental controls (Oshodi *et al.*, 2024). Therefore, a strategic combination of foundational principles, potentially informed by BFO, with the specialized features and modularity offered by other ontologies, is crucial for developing a framework that effectively supports child protection on digital platforms.

With a clear understanding of the theoretical foundations and established practices, the subsequent section will focus on identifying significant contributions from prior work, thereby confirming the research gap that the proposed framework was designed to address.

2.5 Prior Contributions

This subsection aims to identify significant contributions from prior work, analyzing the existing body of knowledge. Through this analysis, this section will investigate research gaps that the proposed framework was designed to address.

Ontology-based knowledge frameworks have found diverse practical applications across various real-world industries, enhancing processes through improved data integration, interoperability, and decision-making capabilities. In the batch process automation industry, ontology-based models facilitate semantic data integration, allowing for more flexible software solutions that can adapt to changes in production infrastructure, thereby reducing engineering time and costs (Lepuschitz *et al.*, 2018). In the realm of supply chain management, ontology-based frameworks enable effective knowledge sharing, which is crucial for timely decision-making and establishing sustainable supply chains. These frameworks support buyer-supplier discovery systems, fostering intelligent connectivity and collaboration (Hilal, 2020). In the context of Industry 4.0, ontologies address the challenge of interoperability in digital manufacturing by formalizing and integrating production process information, as showed by the InPro ontology, which uses BFO and supports production planning and failure analysis (Yang *et al.*, 2023). High technology enterprises leverage ontology-based knowledge management systems to enhance strategic decision-making and maintain competitive advantages by effectively managing technological changes (Arman; Hodgson; Gindy, 2010). Furthermore, ontologies are integral to enterprise systems and knowledge management, influencing areas such as databases, information retrieval, and natural language processing, thereby facilitating a shared understanding across various domains (Ahmad; Colomb; Abdullah, 2013). In industrial process control, ontologies contribute to the cyber-physical integration required for Industry 4.0, enhancing vertical and horizontal integration and flexible operability (Sousa; Park, 2022). Additionally, in large manufacturing industries, ontologies support AI-based decision systems by structuring and organizing knowledge, which aids in interoperability and collaboration across different AI systems (D'Cruze *et al.*, 2023). The development of industry-relevant ontologies is guided by frameworks that ensure the ontologies are applicable to specific domains, as seen in compliance management (Abdullah; Sadiq; Indulska, 2011). These applications underscore the versatility and critical role of ontology-based frameworks in enhancing efficiency, adaptability, and strategic decision-making across various industrial sectors.

Within the scope defined by this dissertation's criteria, no ontology-based knowledge frameworks were found that applied to child protection, whether in the context of transnational digital platforms or more broadly.

Regarding ontologies that address child protection, these ontologies serve as structured to understand and address various aspects of child welfare, risk, and safety. One significant ontology is the phenomenological ontology of risk in child protection social work, which critiques the risk paradigm that often atomizes service users' experiences into discrete units of risk, rather than understanding them holistically within their familial and community contexts. This approach, rooted in phenomenology, emphasizes the lived experiences of individuals and challenges the clarity provided by traditional risk paradigms in the UK context (Smeeton, 2020).

Another ontology focuses on the ontological security of children, highlighting the complex interplay between children's vulnerabilities, existential concerns, and social relations, particularly emphasizing the role of home in providing both physical and ontological security (Fattore; Mason; Watson, 2016). In British Columbia, the ontologies of child welfare are examined through the lens of state interventions in Indigenous families, critiquing the historical and ongoing colonial logics that disrupt these communities (Leeuw, 2013).

In Brazil, the ONTOEVICA project demonstrates the potential of domain ontologies to enhance the effectiveness of public policies against violence against children by fostering intersectoral collaboration and semantic convergence among public agencies (Stacheira; Balaniuk, 2017). Another initiative in the same country is the Child-Safe ontology – it remains under development – designed to systematize the extensive and often terminology (in Brazilian Portuguese only) associated with sexual violence against children and adolescents (Tsunoda et al, 2023).

These ontologies collectively contribute to a more comprehensive and nuanced understanding of child protection, emphasizing the importance of context, historical legacies, and interdisciplinary collaboration.

Within the scope defined by this dissertation's criteria, no ontology was found that applied to child protection in the context of transnational digital platforms. This, coupled with the broader absence of ontology-based knowledge frameworks directly within or closely related to the research's scope, unequivocally confirms the research gap that this dissertation aims to address.

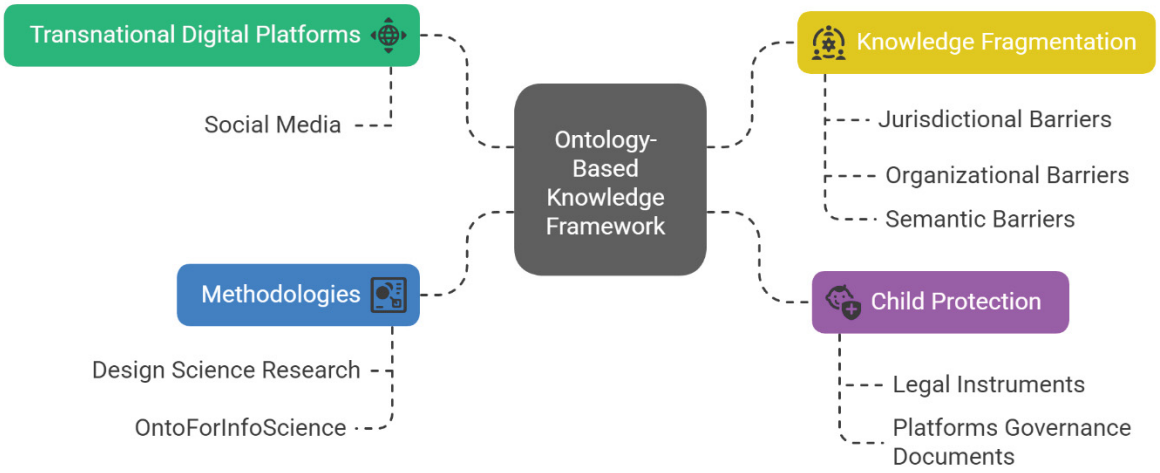
Having identified and analyzed the prior contributions within the field, the subsequent section, "Methods and Materials" will present the chosen methodology for

the development of the ontology-based knowledge framework proposed in this dissertation.

3 METHODS AND MATERIALS

This section details the comprehensive methodology and materials employed for the development of the ontology-based knowledge framework proposed in this dissertation. It outlines the research design, including the specific steps, tools, and approaches utilized to achieve the research objectives. This overall design, which integrates the problem, methodologies, and core components of the artifact, is visually summarized in Figure 11. The aim is to provide sufficient detail to ensure the transparency and replicability of the methods undertaken, from data collection and analysis to the design phases of the framework and its ontology.

FIGURE 11 - OVERVIEW OF THE ONTOLOGY-BASED KNOWLEDGE FRAMEWORK TO SUPPORT ORGANIZATIONS IN CHILD PROTECTION ON TRANSNATIONAL DIGITAL PLATFORMS



SOURCE: Author (2025).

3.1 METHODS

The development of a knowledge framework, particularly one built upon a domain ontology, frequently necessitates the employment of distinct methodological approaches. This strategic choice recognizes the unique requirements involved in creating both the overarching framework and its foundational ontological component.

A knowledge framework offers a comprehensive architecture for organizing and managing knowledge processes and assets. At its core, an ontology serves as the formal and explicit specification of the domain's concepts and their relationships. This

shared conceptualization is the fundamental enabler of the framework, providing a common ground for consistent knowledge representation that is essential for achieving data integration and semantic interoperability between diverse systems.

The adoption of a specific methodology for the development of the framework as a whole is valid to guide its complete lifecycle, from the design and integration of the proposal of implementation recommendations (as delineated in Specific Objectives 2 and 3). Complementarily, a methodology dedicated to ontology engineering ensures the application of rigorous steps in its construction – including conceptualization, formalization, alignment, and evaluation – thereby guaranteeing the quality, coherence, and robustness of the framework's conceptual base. This layered approach facilitates adherence to specific principles and best practices for each development level, resulting in a more solid and methodologically rigorous project.

Consequently, the methodology selected for ontology construction is OntoForInfoScience. This choice is grounded in the literature review conducted within this dissertation and, additionally, in a comparative analysis between OntoForInfoScience and other widely utilized methodologies, as indicated by Mendonça (2015).

A significant challenge with many established ontology development methodologies is their inherent reliance on deep technical expertise. These methods often presuppose that the developer is already an experienced knowledge engineer with a strong background in logic, philosophy, and computer science. They frequently lack detailed, step-by-step guidance for activities like creating formal definitions and employ highly technical jargon without sufficient elucidation. This creates a substantial barrier for professionals outside of computer science, particularly those in information science.

OntoForInfoScience was selected specifically to overcome these limitations. According to Mendonça (2015), OntoForInfoScience is designed to be accessible, using simple, jargon-free language suitable for a variety of professionals, including those without a deep background in logic. Critically, it consists of nine detailed phases that explicitly explain how to perform each task, rather than assuming prior expertise.

As this dissertation prioritizes the conceptual modeling and knowledge organization aspects (the domain of Information Science) over large-scale software

implementation, OntoForInfoScience provides an accessible pathway for developing the required domain ontology.

Protégé software desktop (Musen, 2015) was selected to assist in the development and application of the ontology in conjunction with the knowledge framework. The selection of Protégé as the primary software for the development, visualization, and querying of the ontology was an arbitrary decision by the dissertation author, driven primarily by existing familiarity with the tool. The researcher acknowledges that this personal selection may introduce biases that could potentially impact the research outcomes, and thus, this decision is transparently documented herein.

For the sake of clarity, this research will culminate in the development of two integrated deliverables. The primary artifact is a prescriptive knowledge framework, delivered as a methodological document rather than a finished software application. Applied within and serving as a proof-of-concept for this framework is the second deliverable: a purpose-built ontology, named Child Harm Identification in Large Digital-platforms Ontology (CHILD-Onto), for the child protection domain within transnational digital platforms. The framework itself, named Ontology-Based Knowledge Framework on Child Protection (OBKF-CP), is conceived as an actionable guide, offering governance principles and best practices for the owners of such platforms to establish an effective, ontology-based system for child protection. The decision to focus on a strategic guide, exemplified by a concrete ontology, stems directly from an interdisciplinary academic background. This approach synthesizes core theories of knowledge organization and knowledge representation from a major in Information Science with practical insights into technical feasibility from a minor in Computer Science, and strategic adoption from a minor in Business Administration. The resulting combination of a guiding framework and an applied ontology provides holistic solution designed for real-world implementation, a scope intentionally aligned with the objectives of a master’s dissertation, the project's timeframe, and the author's core expertise in Information Science rather than large-scale software engineering.

Drawing upon the theoretical foundations established in the literature review and the practical requirements of this research, a methodology was adopted to govern the development of the proposed ontology-based knowledge framework.

The adoption of Design Science Research as the guiding methodology is scientifically warranted, given its standing as the foremost approach for inquiries dedicated to conceiving and assessing novel artifacts aimed at resolving real-world challenges (Hevner *et al.*, 2004). Unlike approaches geared toward descriptive theory, DSR is fundamentally prescriptive, aligning with this study's goal of producing an integrated artifact: an ontology-based knowledge framework, formally named the Ontology-Based Knowledge Framework on Child Protection (OBKF-CP).

DSR explicitly recognizes that such artifacts can be models, methods, or constructs – not solely finished software – which accommodates the primary deliverable of this ontology-based knowledge framework as a guiding document. Furthermore, the methodology delineates a structured process that demands both rigor, by requiring the ontology-based knowledge framework's design to be grounded in established knowledge from Information Science and ontology engineering, and evaluation, by mandating a demonstration of the artifact's utility. This iterative cycle of design and evaluation is perfectly suited to the scope of a master's dissertation, allowing for the creation and validation of a solution without necessitating the extensive resources, time, and specialized skills required for a full-scale software development project. Thus, DSR provides the ideal scientific structure to ensure the resulting ontology-based knowledge framework is a theoretically sound, validated, and feasible contribution to the field.

3.2 MATERIALS

Before detailing the materials for the current study, it is pertinent to briefly outline the evolution of this research's trajectory. This includes acknowledging a significant pivot from its original scope, a process Sayão and Sales (2020) might term the "invisible science" often omitted from final publications. Initially, the dissertation was designed to develop a domain ontology to assist organizations in preventing digital crimes against children. This preliminary work yielded three original research articles and one book chapter directly or indirectly pertaining to the research. However, it became evident that the project's scope could be refined and expanded to yield more substantial contributions to both the child protection and ontology engineering fields, prompting a strategic modification of the research design. Consequently, the

composition of research materials has evolved. A significant portion of the initial sources, such as international legal instruments like the United Nations Convention on the Rights of the Child, were largely set aside. These documents were instrumental in creating the semantic corpus for the initial ontology, the preliminary results of which were published by Nobre, Souza, and Marin (2024).

The current research focuses on transnational digital platforms, specifically social media, which represent the primary online environment for users under 18 (Kemp, 2025). To construct the proposed knowledge framework, a foundational step is to gather and analyze the explicit and tacit knowledge embedded within these platforms' governance documents. Accordingly, the first set of materials comprised the public policies and terms of use from the world's most widely used social media platforms – namely WhatsApp, YouTube, Instagram, Facebook, TikTok, LinkedIn, Facebook Messenger, Pinterest, X, and Snapchat – as identified by Kemp (2025). The analysis of these documents is complete and has resulted in a book chapter, expected for publication by ABECIN Press[12] by 2026.

While the forthcoming book chapter provides a broad analysis of the ten platforms identified by Kemp (2025) as social media, the present dissertation will adopt a more focused methodological scope for its analysis of governance documents. This research will concentrate specifically on five of these platforms: YouTube, Instagram, Facebook, TikTok, and LinkedIn. The exclusion of the other five (WhatsApp, Facebook Messenger, Pinterest, X, and Snapchat) is a deliberate refinement. Although these last five services are categorized as social media by some researchers, they are considered for the purposes of this study to be primarily messaging applications, and are therefore scoped out of the core analysis to ensure a more precise thematic focus.

The documents (Board 3) to be analyzed in this research will consist of two primary groups: (1) materials from social media platforms, including terms of use, privacy policies, community guidelines, and violation detection policies; and (2) international legal instruments pertaining to digital child protection from a specific and influential geopolitical region: the European Union. These materials will serve a dual purpose: they will provide the semantic corpus for the new framework-integrated

---

[12] Official website of the ABECIN Press: https://portal.abecin.org.br/editora/issue/archive

ontology and act as the foundational knowledge base for designing the structure of the framework itself.

BOARD 3 - SOURCE MATERIALS FOR THE FRAMEWORK'S DEVELOPMENT

Social Media Guidelines	1. TikTok Privacy Policy[13] 2. TikTok Terms of Service[14] 3. TikTok Children's Privacy Policy[15] 4. LinkedIn Privacy Policy[16] 5. LinkedIn User Agreement/ Terms of Service[17] 6. Youtube Privacy Policy[18] 7. Youtube Terms of Service[19] 8. Meta Privacy Policy[20] 9. Meta Terms of Service[21] 10. Meta Community Standards for Child Sexual Exploitation, Abuse, and Nudity[22]
EU international legal instruments on digital child protection	1. A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+)[23] 2. General Data Protection Regulation (GDPR)[24] 3. Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA)[25]

SOURCE: Author (2025).

European Union was chosen due to the high concentration of transnational digital platform services operating within its jurisdiction, a choice also supported by the existence of legal instruments that focus on the digital sphere and child protection in general. The underlying premise of this dual approach is that a comprehensive analysis – encompassing both corporate self-regulation and public legislative mandates – is essential for constructing an ontology-based knowledge framework with genuine, real-world applicability. Effective child protection ultimately hinges on the

---

[13] TikTok Privacy Policy full text: https://www.tiktok.com/legal/page/us/privacy-policy/en
[14] TikTok Terms of Service full text: https://www.tiktok.com/legal/page/us/terms-of-service/en
[15] TikTok Children's Privacy Policy full text: https://www.tiktok.com/legal/page/global/childrens-privacy-policy/en
[16] LinkedIn Privacy Policy full text: https://www.linkedin.com/legal/privacy-policy
[17] LinkedIn User Agreement/ Terms of Service full text: https://www.linkedin.com/legal/user-agreement
[18] Youtube Privacy Policy full text: https://policies.google.com/privacy?hl=en
[19] Youtube Terms of Service full text: https://policies.google.com/terms?hl=en
[20] Meta Privacy Policy full text: https://www.facebook.com/privacy/policy
[21] Meta Terms of Service full text: https://www.facebook.com/terms
[22] Meta Community Standards for Child Sexual Exploitation, Abuse, and Nudity full text: https://transparency.meta.com/policies/community-standards/child-sexual-exploitation-abuse-nudity/#policy-details
[23] A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) full text: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN
[24] General Data Protection Regulation (GDPR) full text: https://eur-lex.europa.eu/eli/reg/2016/679
[25] Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) full text: https://eur-lex.europa.eu/eli/reg/2022/2065

alignment of corporate practices with robust legal standards, whether achieved through voluntary adoption or legislative enforcement. Therefore, a thorough understanding of both domains is foundational to creating a framework that is not only technically sound but also contextually relevant and actionable.

Upon the comprehensive presentation of the methodology and materials in this section, the subsequent chapter will present the results obtained.

4 RESULTS AND DISCUSSIONS

This chapter presents the results of the dissertation, structured according to the Design Science Research (DSR) and OntoForInfoScience methodologies with some steps supported by Python and its libraries (scripts are available on GitHub). DSR is fundamentally concerned with the creation and evaluation of innovative artifacts to solve practical, real-world problems, while OntoForInfoScience is focused on the development of ontologies. Following this methodological structure, the results pertaining to the ontology development are presented first (section 4.1), succeeded by the results for the framework development (section 4.2).

4.1 ONTOFORINFOSCIENCE APPLIED (ONTOLOGY)

The OntoForInfoScience methodology structures the ontology development process into nine distinct stages, beginning with a preliminary assessment (Stage 0) to determine the actual necessity of an ontology for the given problem. Following this, the core development cycle commences with Stage 1, the Specification Phase, where the ontology's scope, purpose, and requirements are formally defined. Stage 2 involves knowledge acquisition and extraction from relevant domain sources. This is followed by Stage 3, Conceptualization, where the acquired knowledge is structured into preliminary conceptual models, including concepts, properties, and relationships. Stage 4 focuses on establishing the Ontological Foundation, typically involving the selection and integration of appropriate foundational ontologies. Stage 5, Formalization, translates the conceptual model into a formal, machine-readable representation using a chosen logical language and ontology editor. Stage 6 is dedicated to the Evaluation of the ontology against predefined criteria for consistency, completeness, and accuracy. Subsequently, Stage 7 mandates comprehensive Documentation of the ontology and its development process. Finally, Stage 8 addresses the Availability of the finalized ontology, often involving its publication in a suitable format and accessible location.

4.1.1 Stage 1 (Specification)

The preliminary stage of the methodology, Stage 0 (evaluation of the necessity of the ontology), is implicitly addressed throughout the introductory sections and justification of this dissertation. The identified problem of semantic knowledge fragmentation and the objective of creating a formal, shared conceptual model to enable interoperability inherently justify the selection of an ontology over simpler terminological resources. Thus, this section proceeds directly with the application of the subsequent stages, beginning with Stage 1.

Following the OntoForInfoScience methodology, the initial stage involved the formal specification of the ontology, formally named Child Harm Identification in Large Digital-platforms Ontology (CHILD-Onto). This foundational step ensures clarity regarding the ontology's purpose, scope, and intended application, guiding subsequent development phases. The specification process addressed the key elements outlined in the methodology's template, as detailed below:

- Domain and general scope: the ontology's domain is child protection within the context of transnational digital platforms, specifically focusing on online threats encountered by individuals under 18 years of age. The general scope encompasses the key entities, actors, types of harm, protective measures, and relevant processes necessary to facilitate a shared understanding among diverse organizations (e.g., technology companies, law enforcement, NGOs) operating across different jurisdictions. Explicitly excluded are deep, jurisdiction-specific legal procedures or highly technical, platform-internal algorithmic details, focusing instead on the semantic layer required for interoperability.
- General purpose: the primary purpose of this ontology is to serve as a core component of a knowledge framework designed to assist organizations in protecting children online. It aims to overcome the critical challenge of semantic knowledge fragmentation by providing a common, formally structured vocabulary and conceptual model. Ultimately, the ontology is intended to establish the necessary semantic groundwork for improved data integration, enhanced collaboration, and future interoperability among stakeholders in the child protection ecosystem.

- User classes: the ontology is designed for use by a range of stakeholders involved in online child protection. These include personnel within technology companies, particularly trust and safety teams; officials in public sector entities such as law enforcement, regulatory bodies, and child welfare agencies; staff within NGOs focused on victim support and advocacy; policymakers developing relevant legislation; and researchers in fields like information science, computer science, criminology, and child welfare. Ontology developers and maintainers are also key users during its lifecycle.
- Intended use: the ontology is intended to support various application scenarios aimed at enhancing child protection efforts. Potential uses are facilitating structured information sharing about incidents between platforms and authorities; enabling more consistent classification and analysis of online harms across different platforms and jurisdictions; supporting the development of interoperable tools for threat detection and risk assessment; providing a semantic basis for compliance with transnational regulations like the DSA (in European Union) or national laws like Brazil's ECA Digital; and serving as a reference model for designing safer online services (safety by design).
- Ontology type: based on its intended function and structure, the ontology is classified as follows: (1) structure: a domain ontology, as it models concepts specific to child protection on digital platforms; (2) formality: medium-to-high rigor, given its formal alignment with BFO and its goal of enabling machine interpretability and potential reasoning; (3) purpose: an ontology for information systems, designed to explain the domain and serve as a basis for validating or generating components that facilitate interoperability between systems.
- Degree of formality: a medium-to-high degree of formal rigor is required to achieve the ontology's objectives. This entails not only a well-defined taxonomy of classes and properties but also the explicit definition of relationships and the inclusion of logical axioms (derived from the BFO alignment and domain constraints) to ensure consistency and support

machine reasoning. The representation will utilize OWL-DL, balancing expressiveness with computational tractability.

- Scope delimitation: to ensure the scope is clear and explicit, the following were defined:
  - Starting point: the ontology development commences from the upper-level categories provided by the Basic Formal Ontology (BFO), ensuring a rigorous foundation. High-level domain concepts central to child protection (e.g., child, digital platform, grooming) identified from the literature review and source documents serve as initial anchor points within the BFO structure.
  - Coverage limit: the ontology focuses on concepts crucial for enabling semantic interoperability among organizations regarding online threats on transnational platforms. It deliberately excludes highly granular, platform-specific implementation details or exhaustive codification of diverse national legal minutiae. The level of detail is determined by the need to represent entities and relationships essential for cross-stakeholder communication, analysis, and answering the defined competency questions. It does not aim to model every aspect of child psychology, platform technology, or legal systems comprehensively.
  - Competency questions: to further refine the ontology's scope and ensure it meets the informational requirements identified in the specification, a set of competency questions was formulated. These questions, presented in natural language, will guide the selection of concepts, relationships, and the necessary level of granularity. They represent the core knowledge the ontology needs to capture to support the framework's objectives. The key competency questions developed for this ontology are:
    - Regarding actors and roles:
      - What distinct types of organizations (e.g., digital platforms, law enforcement agencies, NGOs) are involved in the online child protection ecosystem?

    - What specific roles (e.g., content moderator, investigator, victim support provider) can actors undertake within this ecosystem?
    - How can the ontology represent individuals, particularly distinguishing between a 'child' (as legally defined) and other persons involved (e.g., perpetrators, reporters)?
- Regarding platforms and jurisdictions:
    - What are the defining characteristics of a 'transnational digital platform' relevant to child protection?
    - How can the ontology capture the relationship between a digital platform, its users, and the multiple jurisdictions it operates within?
    - What information is needed to determine the relevant jurisdiction(s) for a specific online incident?
- Regarding incidents, content, and harms:
    - What fundamental categories of online harm against children (e.g., CSAM, grooming, cyberbullying) must the ontology differentiate?
    - How should an 'incident' be defined and what core attributes (e.g., time, location, involved actors, affected child, associated content) are necessary to describe it?
    - What types of digital content (e.g., image, video, text message, live stream) are relevant, and how can they be linked to incidents and actors?
    - How can the ontology represent the concept of 'evidence' and its relationship to specific incidents?
- Regarding policies and actions:
    - What types of governing documents (e.g., platform community guidelines, national laws, international treaties) constitute 'policies' within this domain?

    - What range of actions (e.g., content removal, account suspension, reporting to authorities, evidence preservation) can be taken in response to an incident?
    - How can the ontology link specific incidents or content types to applicable policies and the resulting actions taken?
- Regarding interoperability and knowledge sharing:
    - How can the ontology facilitate the mapping of organization-specific terms (e.g., internal content flags) to standardized harm categories?
    - What conceptual relationships are essential to enable structured information exchange about an incident between different organizations (e.g., a platform reporting to law enforcement)?

These competency questions served as critical inputs for the subsequent Knowledge Acquisition and Conceptualization stages, ensuring the ontology development remained focused on delivering the required semantic capabilities for the knowledge framework.

4.1.2 Stage 2 (Knowledge Acquisition and Extraction)

Following the specification phase, the Knowledge Acquisition and Extraction stage was undertaken to gather the foundational terminology and conceptual raw material for the ontology from the designated domain sources. This stage adhered to the principles outlined by OntoForInfoScience, which emphasizes employing diverse methods to capture domain knowledge comprehensively. The primary materials for this process consisted of the 13 selected documents: ten governance documents (e.g., Terms of Service, Privacy Policies, Community Standards) from the five major social media platforms (TikTok, LinkedIn, YouTube, Meta - Facebook and Instagram) and three key European Union legal instruments pertaining to digital child protection (BIK+, GDPR, and DSA), as illustrated in Board 3 (section 3.2).

A hybrid approach combining manual and machine-assisted techniques was adopted for the extraction process, aligning with the methods suggested by OntoForInfoScience. Initially, a thorough manual reading and informal analysis of all

13 source documents were conducted. During this phase, candidate terms deemed relevant to child protection on transnational digital platforms were identified, along with their associated definitions or contextual descriptions present in the texts. This initial manual pass yielded a preliminary list of 120 distinct candidate terms. Subsequently, to ensure broader coverage and mitigate potential omissions, a machine-assisted extraction process was employed. Utilizing custom Python scripts[26], the same corpus of 13 documents[27] was analyzed to automatically identify and extract potential domain concepts and relationships based on linguistic patterns and term frequencies. This automated phase generated a larger set of 139 candidate terms, which included some of the 120 terms identified manually. Finally, a critical review and refinement process was conducted on the consolidated list of 111 terms (70 preferred terms and 41 alternative terms). This involved assessing the relevance, specificity, and conceptual clarity of each candidate term in relation to the ontology's defined scope and competency questions established in Stage 1. Terms that were overly broad, ambiguous, redundant, or outside the specific focus on transnational platform governance and child protection mechanisms were eliminated or merged. This refinement phase resulted in a final, curated list comprising 111 core terms (Appendix B), which served as the primary input for the subsequent Conceptualization stage.

4.1.3 Stage 3 (Conceptualization)

This stage transformed the raw lexical inventory (preferred terms, alternatives, definitions, sources, and usage examples) into structured conceptual artifacts to support ontology engineering aligned with BFO. The focus was on:

- a normalized Concept Dictionary;
- a preliminary taxonomic backbone via is-a candidates mined from definitional patterns;
- a first pass on relation candidates from verb cues in definitions/examples; and
- a draft inventory of data properties inferred from attribute-like hints.

---

[26] Available on GitHub: https://github.com/logannobrebr/OBKF-CP
[27] Available on GitHub: https://github.com/logannobrebr/OBKF-CP

To keep the process auditable and reproducible, it was implemented a lightweight, code-based pipeline (Python + pandas)[28]. The pipeline normalizes columns, applies pattern-based heuristics to detect hypernyms (parent candidates) and verbs, suggests candidate object properties, and compiles data-property stubs. This yields editable spreadsheets for refining in Stage 4 (alignment/refactoring with BFO).

What the pipeline did:

- Concept normalization: builds a working Concept Dictionary with canonical labels, alternative labels (synonyms), definition text, provenance (source links), and usage examples.
- Parent (hypernym) extraction: Uses definitional patterns such as “X is a (type of) Y …” to propose ParentCandidate → Child pairs. This is a seed backbone—to be validated against BFO categories in the next stage.
- Verb mining and relation candidates: scans definitions/examples for a curated set of domain-relevant verbs (e.g., report, detect, moderate, protect, exploit, regulate, comply, violate). Each verb maps to one or more candidate object properties (e.g., report → reports / is_reported_by). Results are captured per term and aggregated into a Verb Inventory for quick review.
- Data property stubs: heuristically scans text for attribute-like hints (e.g., age, date, time, url, id, language, severity, score), proposing DataProperties with sensible XSD datatypes.
- Starter object properties (seed): adds a minimal, BFO-style seed set (hasPart/partOf, locatedIn, participatesIn/hasParticipant) as placeholders to anchor structural and participation relationships prior to formal alignment.

What were the outputs (Excel multi-sheet)[29]:

- Concepts: normalized concept dictionary (PreferredLabel, AltLabels, Definition, DefinitionSource, UsageExample, ExampleSource, Notes).

---

[28] Available on GitHub: https://github.com/logannobrebr/OBKF-CP
[29] Available on GitHub: https://github.com/logannobrebr/OBKF-CP

- Hierarchy: ParentCandidate → Child pairs + justification (“is-a / type-of pattern”).
- VerbInventory: aggregate counts of verbs found across concepts + suggested property labels.
- VerbsPerTerm: the verbs observed for each term.
- RelationCandidates: per-term candidate object properties (subject-centric), with rationale.
- ObjectProperties_Seed: a tiny seed set to start property governance (to be reconciled with RO).
- DataProperties: inferred attributes (Domain, Property, Datatype, Definition stub).

4.1.4 Stage 4 (Ontological foundation - Alignment with BFO)

This stage partially harmonizes the domain conceptualization with an upper ontology (BFO) and relationship patterns. The goals are to: (1) give each concept a tentative BFO category (e.g., Object, Process, Information Content Entity, Role), (2) consolidate relation candidates into a governed set aligned with BFO patterns, (3) produce a small but consistent OWL/Turtle skeleton to use in Protégé, and (4) document the rationale to support subsequent design decisions and review.

Implementation overview. It was built a reproducible pipeline (Python + pandas, regex, matplotlib)[30] that consumes the Stage-3 workbook, assigns ProposedBFOType via lexical heuristics on labels/definitions, aggregates and aligns CandidateRelation labels to patterns (with inverse suggestions), refines data properties with privacy notes, and emits both an Excel alignment package and a Turtle skeleton.

What the code does:

- BFO typing (classes): a deterministic heuristic maps each concept to a ProposedBFOType based on lexical cues in the label/definition:
  - Process/Activity/Event → BFO:Process (occurrent)

---

[30] Available on GitHub: https://github.com/logannobrebr/OBKF-CP

    - Policies, laws, documents, messages, content → BFO:InformationContentEntity (GDC)
    - Role/responsibility → BFO:Role (SDC)
    - Risk/severity/score/status → BFO:Disposition (SDC)
    - Person/organization/platform/account/system/tool → BFO:Object (independent continuant)
    - Fallback: MaterialEntity (independent continuant).
    - The output records a ParentCandidate → Child hint (from Stage-3) for constructing the taxonomic backbone.
- Relation alignment (RO-style): for each CandidateRelation, the pipeline proposes an alignment family (e.g., RO, BFO/RO, Regulatory, Structural, Domain-specific) and notes likely inverses or RO analogs (e.g., participatesIn/hasParticipant, partOf/hasPart, regulatory pairs such as regulates/is_regulated_by, governance actions such as reports/is_reported_by, blocks/is_blocked_by). Domains default to the Subject concept; Ranges are intentionally left blank for editorial decision in the next stage.
- Object and data property consolidation:
    - Merges the seed structural properties with verb-derived relations and removes duplicates.
    - Carries forward the Stage-3 DataProperties and adds a PrivacyNote column to spotlight attributes that typically require minimization, retention limits, and access control (e.g., age, id, email, phone, hash).
- OWL/Turtle skeleton (for Protégé).
    - Mints IRIs (CamelCase) for classes, object properties and data properties.
    - Materializes rdfs:subClassOf axioms from the ParentCandidate edges discovered in Stage-3.
    - Adds rdfs:domain statements for object properties (based on Subject); Range left blank to avoid premature commitments.

- Uses a placeholder namespace you can swap for your canonical one before import.

4.1.5 Stage 5 (Formalization of ontology)

This stage validates the conceptual model produced in Stages 3 and 4 by (1) running structural and alignment checks, (2) surfacing editorial issues (e.g., missing definitions, orphan classes, cycles), and (3) generating machine-readable validation assets (SHACL), and test queries (SPARQL).

It was implemented a deterministic validation pipeline in Python[31] using pandas, matplotlib, and standard libraries. No external reasoner was used at this stage to keep the process portable; the deliverables are designed to be imported into Protégé for further reasoning.

Use as input Excel multi-sheets from Stage 3 (Concepts, Hierarchy, DataProperties) and 4 (ClassAlignment, RelationAlignment, DataProperties_Refined, DomainRange_Proposals) it was able to:

- Check:
  - Lexical completeness: missing Definition and DefinitionSource entries.
  - Taxonomy sanity: roots, orphans (classes do not present as parent or child), and cycles (if any) in the ParentCandidate→Child graph.
  - Relation alignment gaps: empty domains/ranges in DomainRange_Proposals.
  - BFO typing distribution: counts per ProposedBFOType and a heuristic flag for Process → Object subclass edges (often a modeling smell suggesting a participation relation instead of is-a).
- Validate assets produced:
  - SHACL shapes: minimal class and property constraints (labels required; XSD datatypes for data properties; provisional range constraints for object properties when proposed).

---

[31] Available on GitHub: https://github.com/logannobrebr/OBKF-CP

- SPARQL tests: queries to check common issues (no parents, missing ranges) and to probe governance relations (e.g., “who reported what?”).

- Deliver:
  - Validation report (Excel, multi-sheet): sheets: Metadata, Issues_MissingDefinitions, Issues_MissingSources, Taxonomy_Roots, Taxonomy_Orphans, Taxonomy_Cycles, BFO_Distribution, BFO_SuspiciousEdges.
  - SHACL shapes (TTL).
  - SPARQL test queries (RQ).

4.1.6 Stage 6 (Ontology assessment)

This stage establishes an approach to judge whether the ontology (2) is fit for purpose in the child-protection context on transnational digital platforms (validation) and (2) is well-engineered according to formal knowledge-engineering standards (verification). The process is method-agnostic and can be applied iteratively as the ontology evolves.

Evaluation parameters (what we will measure):

- Competency coverage: extent to which the ontology can answer pre-agreed Competency Questions (CQs) and support target use cases (e.g., reporting workflows, moderation actions, governance and compliance).
- Domain coverage and adequacy: proportion of priority concepts, relations, and data attributes present and correctly placed (taxonomy, roles, processes, policies).
- Conceptual clarity and usability: clarity, unambiguity, and usefulness of labels/definitions for multidisciplinary stakeholders (trust and safety, policy, legal, product, law enforcement liaisons).
- Logical quality: formal coherence under reasoning (consistency, absence of unsatisfiable classes, appropriate inferences from property characteristics and disjointness).

- Constraint conformance: satisfaction of shape constraints (SHACL) and datatype/domain/range restrictions for typical data instances.
- Interoperability and alignment: faithful mapping to upper/related ontology (BFO) and stable IRIs/naming; absence of conflicts with adopted standards.
- Annotation performance (task-based): precision/recall/F1 when the ontology is used to annotate real or synthetic corpora (e.g., incident reports, platform policy artifacts, moderation logs).
- Governance readiness: traceability (definitions/sources), change-logging, and ease of curation (editorial workload and agreement).

Validation criteria (are we building the right thing?):

V1. Competency Question (CQ) pass rate:

- Method: Encode each CQ as SPARQL query or reasoning check over a representative knowledge graph.
- Metric: %CQ_pass = (# CQs fully answered) / (total CQs).
- Thresholds:Accept: ≥ 0.80; Conditional: 0.60–0.79 (requires remediation plan); Reject: < 0.60.

V2. Priority domain coverage:

- Method: Compare curated “must-cover” lists (concepts, relations, attributes) with the released ontology.
- Metrics: %Concepts_covered, %Relations_covered, %DataProps_covered.
- Thresholds: Accept ≥ 0.85 across all three; Conditional 0.70–0.84; Reject < 0.70.

V3. Conceptual clarity (expert review):

- Method: SME panel (≥3 reviewers) rates label clarity, definition adequacy, example relevance on a 5-point Likert scale for a stratified sample (≥15% of classes; minimum 50).
- Metric: Mean score per dimension.
- Thresholds: Accept ≥ 4.0; Conditional 3.5–3.9; Reject < 3.5.
- Agreement: Cohen’s κ ≥ 0.75 (substantial) across raters; if κ < 0.60, repeat calibration.

V4. Stakeholder usability (task walkthroughs):

- Method: Scenario-based walkthroughs with policy, legal, and T&S practitioners (N≥6).
- Metric: Task success rate (e.g., “find the right class/property for X”); SUS or adapted usability index.
- Thresholds: Task success ≥ 0.80 and SUS ≥ 70 for Accept.

V5. Alignment acceptance (BFO):

- Method: Editorial mapping review for all top-level relations/classes used in release.
- Metric: % of mappings accepted without change on first pass.
- Thresholds: Accept ≥ 0.85; Conditional 0.70–0.84.

Verification criteria (are we building it right?):

C1. Logical consistency and coherence:

- Method: Run reasoner (e.g., HermiT/ELK).
- Metrics: 0 inconsistencies; 0 unsatisfiable classes (except those intentionally deprecated).
- Thresholds: Accept only if both are zero.

C2. Disjointness safety:

- Method: With BFO-bucket disjointness enabled, check for unintended contradictions on sample individuals.
- Metric: # contradictions induced by bucket assignment.
- Thresholds: Accept = 0; any >0 requires either re-typing or revising disjointness.

C3. Property characteristics sanity:

- Method: Inspect inferences from transitivity (e.g., partOf/hasPart), inverses, and any symmetry/functionality.
- Metric: # spurious inferences flagged in curated test graphs.
- Thresholds: Accept ≤ 1 minor issue, none material; Conditional 2–3; Reject ≥ 4.

C4. Shape/constraint conformance (SHACL):

- Method: Validate staged instance data against the Stage-5 SHACL shapes.

- Metric: Violation rate per 1,000 nodes/edges (violations / 1k triples).
- Thresholds: Accept ≤ 5; Conditional 6–15; Reject > 15.

C5. Naming, IRIs, annotation completeness:

- Method: Automatic checks: label presence, definition present, source present, IRI stability.
- Metrics: %Classes_with_label, %Classes_with_definition, %Classes_with_source.
- Thresholds: Accept ≥ 0.95 for labels; ≥ 0.85 for definitions and sources.

C6. Profile conformance:

- Method: OWL 2 DL conformance checks; no punning unless deliberate; single namespace policy; no dangling domains/ranges.
- Thresholds: Accept = conformant; Conditional = minor deviations fixable without redesign.

C7. Annotation performance (verification variant)

- Method: Double-annotate a gold-standard sample; compute micro/macro Precision, Recall, F1 of ontology-guided tagging.
- Thresholds: Accept: F1 ≥ 0.80; Conditional 0.70–0.79; Reject < 0.70.
- Agreement: κ ≥ 0.75 across annotators.

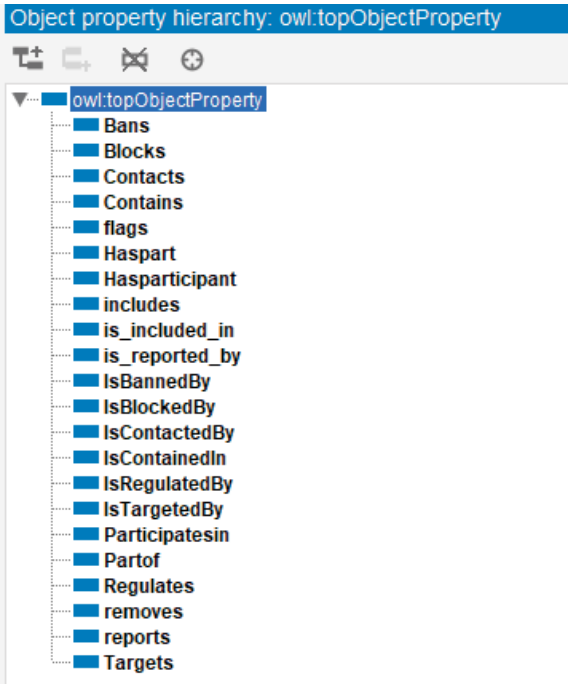
4.1.7 Stage 7 (Ontology documentation)

Throughout this dissertation, Stage 7 has been fulfilled in an integrated manner: the ontology's scope, design decisions, and evolution are described alongside each development stage; naming and IRI policies (including the official namespace) are stated; alignment rationales to BFO are recorded; class and property inventories with definitions, examples, domains/ranges, and inverses are consolidated in the released spreadsheets; reasoning and constraint assumptions are explained together with SHACL and SPARQL assets is provided via Appendix and documentation on GitHub.

4.1.8 Stage 8 (Ontology availability)

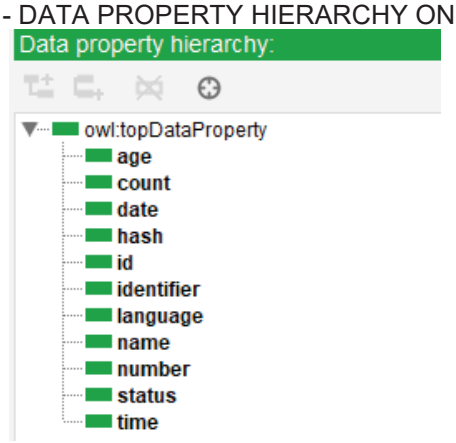
In alignment with this work, Stage 8 has been fulfilled by publishing the ontology (Figures 12, 13, 14) openly on GitHub[32], together with its reasoner-ready serializations (.ttl and .owl), the alignment and validation workbooks, reproducible scripts spanning Stages 3 to 6. This public release is complemented by the step-by-step documentation provided throughout this dissertation, which explains each phase.

FIGURE 12 - OBJECT PROPERTY HIERARCHY ON PROTÉGÉ



SOURCE: Author (2025).

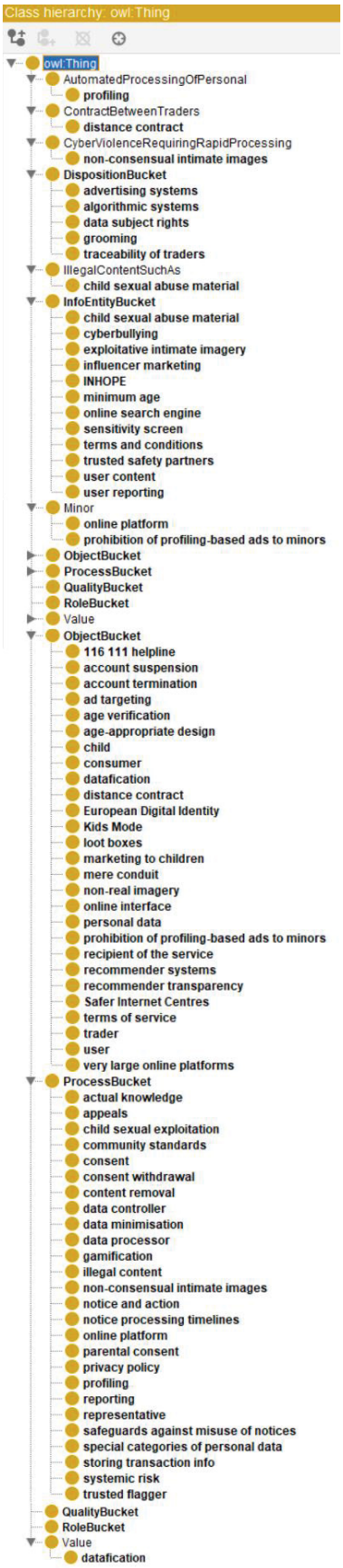
FIGURE 13 - DATA PROPERTY HIERARCHY ON PROTÉGÉ



SOURCE: Author (2025).

[32] Available on GitHub: https://github.com/logannobrebr/OBKF-CP

FIGURE 14 - CLASS HIERARCHY ON PROTÉGÉ



SOURCE: Author (2025).

4.2 THE SPECIFICATION PROCESS ADDRESSED THE KEY ELEMENTSDSR APPLIED (FRAMEWORK)

Grounded in the Design Science Research (DSR) paradigm, the next section translates the problem–solution interplay of the relevance, design, and rigor cycles into a concrete artifact suite for this dissertation's context: an Ontology-Based Knowledge Framework on Child Protection (OBKF-CP) and its Application Guide. The OBKF-CP operationalizes the domain ontology into actionable components (semantic models, validation profiles, mappings/contexts, and query/reasoning assets) explicitly linked to the competency needs and organizational workflows identified in the relevance cycle. Its construction embodies the design cycle through iterative build-evaluate loops (conceptualization, alignment, validation, and release hardening), while the rigor cycle anchors decisions in upper-ontology commitments, semantic-web standards, and explicit quality gates. The accompanying Application Guide specifies roles, artifacts, processes, and acceptance criteria that enable reproducible deployment across teams and organizations. Together, these two deliverables move from what the ontology is to how it is used – closing the DSR loop by demonstrating utility, ensuring methodological traceability, and supporting sustained governance and reuse.

4.3 RELEVANCE CYCLE

The relevance cycle anchors the framework in the real-world problem space of child protection on transnational digital platforms. It surfaces stakeholder needs, operational constraints, and competency questions, translating them into concrete requirements that the artifact must satisfy. In short, it ensures the framework is driven by genuine organizational use cases (reporting, moderation, governance, and compliance) rather than by purely technical considerations.

Relevance cycle: problem space → requirements → value proposition

Problem space: organizations that protect children across platforms and jurisdictions need consistent knowledge to (1) report and triage incidents, (2) moderate content/behaviors, and (3) meet regulatory obligations. Data is heterogeneous, workflows differ by actor, and evidence needs provenance and auditability.

Stakeholders: trust and safety teams, hotlines, NGOs, regulators, platform policy/legal, and Law Enforcement liaisons.

Requirements (derived from the environment and grounded in your ontology):

- Shared concepts and relations: use your released ontology (classes in BFO buckets; key relations such as reports, moderates, removes, compliesWith, violates, participatesIn/hasParticipant, hasPart/partOf, includes/is_included_in).
- Executable constraints: SHACL shapes for data intake and interop.
- Reasoning and retrieval: SPARQL + rules to answer competency questions (CQs) and drive decisions.
- Governance and traceability: versioned changes, naming/IRI policy, w3id namespace, and editorial workflows.
- Interoperability: JSON-LD contexts, mapping registry to external schemas, and export/import profiles.

Value proposition: a reusable, standards-based framework that turns the ontology into operational knowledge: consistent data intake, auditable decisions, cross-organization interoperability, and policy-aware analytics.

4.4 DESIGN CYCLE

The design cycle turns requirements into an implementable solution through iterative build–demonstrate–evaluate loops. It specifies the artifact's architecture (semantics, constraints, mappings, reasoning/retrieval, and governance), produces operational assets (TTL/OWL releases, SHACL profiles, SPARQL queries, figures), and validates them against target scenarios. This cycle is where the ontology becomes a working knowledge framework that teams can actually use.

The Design cycle consists of the OBKF-CP artifact (architecture, components, interfaces).

4.4.1 Architecture (five layers)

1 - Semantics layer (core ontology).

- Reuse namespace http://w3id.org/child-protection-bfo# with reasoner-ready TTL/OWL.
- Stable class set: Actor, Child, Offender, Account, Platform, Content, Message, Media, Report, Incident, Case, Policy, Law, Regulation, ModerationAction, Evidence, Workflow, Organization, Jurisdiction.
- Relations (examples): reports, is_reported_by, moderates, removes, blocks/bans (+ inverses), compliesWith/violates, participatesIn/hasParticipant, hasPart/partOf, includes/is_included_in.

2 - Constraints and profiles layer:

- SHACL profiles for (a) incident reports, (b) moderation actions, (c) regulatory artifacts (policy/law).
- Datatype ranges (XSD) and required labels/definitions; minimal cardinalities for key shapes (e.g., a Report must have reportedAt and at least one about Content/Incident).
- Validation modes: strict (production) vs lenient (ingestion sandbox).

3 - Mappings and contexts layer.

- JSON-LD contexts that map common fields to ontology IRIs (e.g., reporterId → cp:Reporter, contentUrl → cp:Content via xsd:anyURI).
- Mapping registry: links to external models (e.g., platform-internal event schemas, regulator forms) with transformation specs (CSV → RDF, JSON → RDF).
- Term harmonization: synonym lists → skos:altLabel and alignment to Policy/Law entities.

4 - Reasoning and retrieval layer:

- SPARQL services for CQs (e.g., Who reported what?; Which actions imply regulatory obligations?).
- Rule library (DL-safe where possible): e.g., If Content is partOf an Incident and Incident violates a Policy, then a ModerationAction is required within SLA X.
- Analytics views: materialized graphs/tables for dashboards (policy compliance, incident flow, time-to-action).

5 -Governance and operations layer:

- Editorial workflow (curators, Subject-Matter Expert (SMEs), approvers) with RACI[33] and change-control.
- Release process: snapshot ontology + profiles + contexts; semantic versioning; changelog; SHACL/Reasoner CI checks.
- Data protection: redaction rules for PII (data properties flagged as sensitive), access policies and logging.

4.4.2 Core operational workflows (end-to-end)

- Incident reporting → triage → action → audit: ingestion validates against ReportShape → links to Incident and Content → triggers reasoning for ModerationAction candidates → enforces compliesWith/violates checks against Policy/Law → records provenance (prov:wasGeneratedBy, prov:used).
- Regulatory readiness: Map platform measures to obligations via is_regulated_by and compliesWith; export regulator-specific reports (SPARQL CONSTRUCT with regulator profile).
- Cross-organization exchange: JSON-LD payloads using the shared contexts; partner SHACL validation before accept.

4.4.3 Interfaces (excerpts)

- Minimal JSON-LD context (excerpt)

```
{
  "@context": {
    "cp": "http://w3id.org/child-protection-bfo#",
    "xsd": "http://www.w3.org/2001/XMLSchema#",
    "Report": "cp:Report",
    "reportedAt": {"@id": "cp:reportedAt", "@type": "xsd:dateTime"},
    "aboutContent": {"@id": "cp:about", "@type": "@id"},
    "reports": {"@id": "cp:reports", "@type": "@id"}
  }
}
```

[33] Available on GitHub: https://github.com/logannobrebr/OBKF-CP

- SHACL shape (excerpt):

```
@prefix sh: <http://www.w3.org/ns/shacl#> .
@prefix cp: <http://w3id.org/child-protection-bfo#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

cp:ReportShape a sh:NodeShape ;
  sh:targetClass cp:Report ;
  sh:property [ sh:path cp:reportedAt ; sh:datatype xsd:dateTime ; sh:minCount 1 ] ;
  sh:property [ sh:path cp:about ; sh:class cp:Content ; sh:minCount 1 ] ;
  sh:property [ sh:path cp:reports ; sh:class cp:Incident ; sh:minCount 1 ] .
```

- CQ / SPARQL (excerpt):

```
PREFIX cp: <http://w3id.org/child-protection-bfo#>
SELECT ?reporter ?content ?when WHERE {
  ?reporter cp:reports ?incident .
  ?incident cp:about ?content .
  ?reporter cp:reportedAt ?when .
}
ORDER BY DESC(?when) LIMIT 100
```

- Governance policy (RACI summary):
  - Curator (R) prepares edits to stage6_alignment_completed.xlsx.
  - SMEs (A) approve class/relationship changes; resolve domain/range disputes.
  - QA (C) runs SHACL/Reasoner CI (must pass).
  - Maintainer (I) tags release and publishes GitHub artifacts.

4.4.4 Bill of materials for the framework

- Semantics: cp_ontology_release.ttl/.owl (reasoner-ready).
- Profiles: shacl/ReportShape.ttl, shacl/ModerationActionShape.ttl, shacl/PolicyShape.ttl.
- Contexts: contexts/cp.jsonld (and partner-specific variants).
- Mappings: mappings/*.rq (SPARQL CONSTRUCT), mappings/*.yml (ETL specs).

- Rules: rules/*.ttl (DL-safe SWRL-like or SPIN patterns).
- CQs: cq/*.rq.
- Ops: governance/CHANGELOG.md, RELEASE.md, RACI.md.
- Validation: ci/shacl-run.sh, ci/reasoner-check.sh.

4.5 RIGOR CYCLE

The rigor cycle grounds the framework in established knowledge and quality disciplines. It aligns modeling choices with upper ontologies and web standards, enforces formal quality gates (reasoner coherence, SHACL conformance, profile/IRI policies), and documents procedures for repeatable evaluation. This cycle ensures the artifact is not only useful but also theoretically sound, interoperable, and auditable over time.

The Rigor cycle consists of grounding, quality gates, and evaluation

- Grounding in knowledge base:
  - Upper ontology discipline: BFO buckets (Object, Process, Information Content Entity, Role, Disposition, Quality) with owl:AllDisjointClasses.
  - Relation semantics: RO-style patterns (has_part/part_of, participates_in/has_participant) and governance relations aligned editorially.
- Quality gates (release blockers):
  - Logical coherence: 0 inconsistencies; 0 unintended unsatisfiable classes under DL reasoner.
  - SHACL conformance: ≤ 5 violations per 1k triples on the staging set.
  - CQ pass rate: ≥ 0.80 on agreed competency set.
  - Documentation and provenance: updated contexts, mappings, and changelog for each tag.
  - Security/PII posture: redaction rules applied to sensitive data properties before external export.
- Evaluation and evidence:

- Automated CI artifacts (reasoner logs, SHACL reports).
- CQ dashboards (pass/fail trend).
- Mapping coverage and drift reports (diffs between releases).
- Editorial agreement stats (κ) on sampled labels/definitions.

4.6 APPLICATION GUIDE

This guide operates the OBKF-CP for child protection on transnational digital platforms. It specifies roles, processes, artifacts, data-integration routes, quality gates, and acceptance criteria to move from a reasoner-ready ontology to repeatable organizational use (ingestion → validation → reasoning/query → reporting → governance).

4.6.1 Roles and responsibilities (RACI)

- Curator (R): maintains alignment workbooks; proposes ontology/shape updates; authors mapping specs.
- Subject-Matter Expert, SME (A): approves conceptual/terminological changes; validates domain/range for critical relations; arbitrates conflicts.
- Semantic QA (C): runs SHACL and reasoning checks; monitors conformance; triages violations.
- Maintainer (I): packages releases (TTL/OWL, SHACL, mappings, contexts, queries, figures); manages versions and repository hygiene.
- Optional adjuncts: data engineer (pipeline automation), Legal/Policy Reviewer (regulatory mappings).

4.6.2 Core artifacts (minimum viable kit)

- Semantics (reasoner-ready ontology): classes with bucket superclasses (BFO-aligned), subclass axioms, object properties (domains/ranges, inverses, transitivity), data properties with XSD ranges.

- Validation profiles (SHACL): shapes for Report, Incident, ModerationAction; strict and lenient profiles.
- Mappings and contexts: CSV/Excel↔RDF (CSVW/RML or SPARQL CONSTRUCT), SQL↔RDF (R2RML/RML), XML↔RDF (RML/XSLT). Optional JSON-LD contexts.
- Queries and rules: SPARQL for competency questions and analytics; small, DL-safe rule set (only where required).
- Governance docs: RELEASE.md (how to cut a release), CHANGELOG.md (what changed and why), RACI.md (who does what).
- Figures: framework and hierarchy diagrams (SVG/PDF) for onboarding and audits.

4.6.3 Implementation playbook

Environment selection:

- Triple store / reasoner: any OWL 2 DL–capable stack (e.g., GraphDB, Fuseki + HermiT/ELK, Stardog).
- SHACL engine: built-in of your store or a standalone validator.
- ETL/mapping: SPARQL CONSTRUCT, R2RML/RML, or lightweight scripts.
- Source-of-truth for editorial changes: the Stage-6 alignment workbook.

Data ingestion routes (choose one or mix):

- RDF-native (fastest path): ingest TTL/OWL/N-Triples/TriG directly → validate with SHACL.
- CSV/Excel: document columns with CSVW or write a SPARQL CONSTRUCT/RML mapping to produce RDF → run SHACL.
- SQL: use R2RML/RML mappings to expose relational data as RDF on-the-fly.
- XML: transform with RML/XSLT → RDF → SHACL.

- JSON/JSON-LD (optional): if APIs are JSON, attach a context and convert to RDF.

Validation profiles (strict vs. lenient):

- Lenient (staging): required labels, minimal datatypes, soft cardinalities; used for partner onboarding and exploratory ingestion.
- Strict (production): enforces key data properties (e.g., reportedAt xsd:dateTime), minimum links (Report → about → Content, Report → reports → Incident), and critical domain/range expectations.

Example shape (excerpt):

```
@prefix sh: <http://www.w3.org/ns/shacl#> .
@prefix cp: <http://w3id.org/child-protection-bfo#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

cp:ReportShape a sh:NodeShape ;
  sh:targetClass cp:Report ;
  sh:property [ sh:path cp:reportedAt ; sh:datatype xsd:dateTime ; sh:minCount 1 ] ;
  sh:property [ sh:path cp:about ; sh:class cp:Content ; sh:minCount 1 ] ;
  sh:property [ sh:path cp:reports ; sh:class cp:Incident ; sh:minCount 1 ] .
```

Mapping patterns (illustrative):

- CSV → RDF (CONSTRUCT) idea: for each row, mint a cp:Report IRI, attach literals (reportedAt) and links (about, reports).
- R2RML gist: map REPORTS(id, reported_at, content_id, incident_id) to cp:Report with templates for IRIs and rr:predicateObjectMap for properties.
- JSON-LD context (excerpt):

```
{
  "@context": {
    "cp": "http://w3id.org/child-protection-bfo#",
    "Report": "cp:Report",
    "reportedAt":
{"@id":"cp:reportedAt","@type":"http://www.w3.org/2001/XMLSchema#dateTime"},
    "about": {"@id":"cp:about","@type":"@id"},
    "reports": {"@id":"cp:reports","@type":"@id"}
```

```
 }
}
```

Reasoning and retrieval:

- Reasoner configuration: enable inverses and transitivity; keep property chains conservative.
- Core CQs (SPARQL) examples:

```
PREFIX cp:<http://w3id.org/child-protection-bfo#>
SELECT ?reporter ?incident ?when WHERE {
  ?reporter cp:reports ?incident .
  ?reporter cp:reportedAt ?when .
} ORDER BY DESC(?when) LIMIT 100;

# Incidents that violate a policy and have no action yet
SELECT ?incident ?policy WHERE {
  ?incident cp:violates ?policy .
  FILTER NOT EXISTS { ?action cp:actsOn ?incident . }
}
```

4.6.4 Governance workflow (lightweight but explicit)

Change cycle:

- Propose (Curator) updates in the Stage-6 workbook (classes, ranges, labels).
- Review (SME) for conceptual adequacy and regulatory correctness.
- QA (Semantic QA) runs SHACL + reasoning; triages violations.
- Release (Maintainer) tags and publishes the package; updates CHANGELOG.md.

Release bundle checklist (must include):

- Ontology: TTL + OWL.
- SHACL: strict and lenient profiles.
- Mappings/contexts: current ETL specs (CSVW/RML/CONSTRUCT).
- CQs: SPARQL queries used in evaluation.

- Figures: framework + hierarchy SVG/PDF.
- Notes: RELEASE.md, CHANGELOG.md, RACI.md.

4.6.5 Quality gates and acceptance criteria

- Logical coherence: 0 inconsistencies; 0 unintended unsatisfiable classes under a DL reasoner.
- SHACL conformance: ≤ 5 violations per 1,000 triples on the staging set; 0 critical violations in production.
- Competency coverage: ≥ 80% CQ pass rate on the agreed set.
- Profile conformance: OWL 2 DL; stable namespace and IRI policy.
- Documentation currency: release notes and mapping registry updated for each tag.

4.6.6 Security and PII posture

- Sensitive data properties (e.g., age, email, phone, identifiers) must be labeled in the alignment workbook and treated by default as restricted.
- Redaction/anonymization policies must run before export to partners or public artifacts.
- Access logs and least privilege for SHACL/ETL pipelines; keep audit trails of all releases.

4.6.7 Testing strategy

- Unit: validate mappings on small samples; assert IRIs and required triples.
- Schema: run SHACL (lenient → strict) and inspect violation categories.
- Reasoning: check inferences from inverses and transitivity; ensure no disjointness clashes.
- Scenario: end-to-end ingest of a representative batch; confirm CQ results and dashboards.

- Regression: re-run tests after any workbook or mapping change; compare to baselines.

4.6.8 KPIs and operational monitoring

- Ingestion validity latency: time from data arrival to SHACL-clean status.
- Violation rate by type: schema vs. range vs. missing links.
- Time-to-action: from report to first moderation action suggestion/assignment.
- Policy coverage: % of incidents with linked policy/law via compliesWith/violates.
- Annotation agreement (if applicable): κ and F1 for human-in-the-loop labeling.

4.6.9 Deployment patterns

- Centralized (single triplestore; partners submit RDF/CSV → ETL → RDF).
- Federated (partners keep data; expose SPARQL endpoints; common SHACL profiles and contexts ensure harmonization).
- Hybrid (central metadata + federated evidence links).

4.6.10 Risks and mitigations

- Over-restrictive disjointness: pilot on sample individuals; relax bucket assignments where justified.
- Lexical bias in range completion: prioritize SME review for high-frequency relations; maintain exceptions list.
- Mapping drift: keep mapping registry under version control; diff mappings at each release.
- PII leakage: enforce redaction jobs pre-export; include PII checks in CI.

- Tool lock-in: prefer W3C standards (OWL, RDF, SHACL, SPARQL, CSVW, R2RML/RML); keep scripts minimal and portable.

4.6.11 Roadmap

- Wave 1 (MVP): Report/Incident/ModerationAction shapes; 5–7 CQs; CSV/SQL ingestion; one dashboard.
- Wave 2: Regulatory profiles; partner-specific contexts; expanded analytics.
- Wave 3: Property chains where safe; role modeling refinements; interop with external ontologies where beneficial.

5 CONCLUSIONS

This research sets out to design and operationalize an ontology-based knowledge framework to support organizations engaged in child protection on transnational digital platforms. The work combined a domain ontology (engineered and hardened across staged development) with an application-oriented framework that turns the ontology into repeatable practice (ingestion → validation → reasoning/query → reporting → governance). Recalling the specific objectives, each has been met, which in turn confirms that the overall objective has been achieved, as follows:

- Elicit and consolidate domain knowledge: achieved through the Stage-2/3 pipeline: a curated inventory of terms and definitions; conceptualization outputs (Concepts, Hierarchy, Relation and Data-property candidates); and traceable sources/examples compiled into an editorial workbook. This established a transparent knowledge base for subsequent alignment.
- Engineer a coherent domain ontology aligned with upper ontologies and standards: fulfilled in Stages 4–6 via a reasoner-ready ontology (TTL/OWL) grounded in BFO/RO commitments, with domains/ranges for object properties (completed beyond the top 20 relations), inverse properties, transitive mereology, and bucket-level disjointness axioms. Serializations follow OWL/RDF best practices and use a stable w3id-style namespace.
- Provide validation, testing, and assessment mechanisms: delivered in Stages 5–6 through SHACL shapes (class/prop/datatype constraints), SPARQL competency tests, a multi-sheet validation report (missing definitions/sources, roots/orphans, cycles, typing flags), and a formal assessment framework with validation and verification criteria (coverage, CQ pass rate, logical coherence, SHACL conformance, interoperability).
- Create an ontology-based knowledge framework that operationalizes the ontology: completed with a layered architecture (Semantics; Constraints and Profiles; Mappings and Contexts; Reasoning and Retrieval; Governance and Operations) and a full Application Guide

specifying roles (RACI), artifacts (ontology, SHACL, mappings/contexts, queries, figures), adoption steps, quality gates, KPIs, and deployment patterns (centralized/federated/hybrid).

- Ensure availability and documentation: addressed in Stages 7–8: integrated documentation across the dissertation (design decisions, naming/IRI policy, alignment rationales, figures) and public availability via a GitHub-ready package (ontology, profiles, scripts, figures, and governance files) suitable for replication and reuse.

Across these contributions, the artifact indicates both utility (fit-for-purpose workflows for reporting, moderation, and compliance) and rigor (formal soundness, standards conformance, and reproducible procedures). The framework lowers semantic integration costs between organizations, improves auditability and policy traceability, and provides a repeatable method to evolve the model without sacrificing coherence. Limitations are primarily practical and expected: (1) some domain/range proposals remain editorial and benefit from continued expert curation; (2) property characteristics were set conservatively to avoid over-commitment; (3) data-exchange profiles will require partner-specific mappings in real deployments. These are not structural deficits of the approach but natural frontiers for iterative refinement. In sum, by meeting the specific objectives and delivering a deployable OBKF-CP with governance and assessment scaffolding, the dissertation’s overall objective (to support organizations in child protection on transnational digital platforms with an ontology-based framework) has been successfully achieved.

To conclude, the scholarly trajectory underpinning this dissertation is reflected in the publications produced during the master’s program. The following list consolidates peer-reviewed outputs that informed or were informed by the research reported here – spanning conceptual foundations, methodological advances, and applied evaluations – thereby evidencing the project’s continuity, external validation, and contribution to the field.

- Original paper "Accessibility to the content of digital informational objects in digital libraries implemented with DSpace" (Shintaku *et al.*, 2024);

- Original paper "Proposal of a model for the presentation of accessible information in a thesaurus implemented with the Tematres tool" (Nakano *et al.*, 2024);
- Original paper "Ontology for the prevention of digital crimes against children" (Nobre; Souza; Marin, 2024);
- Book chapter "Infodemic and disinformation in the post-Covid-19 world: ethical challenges and data biases in information management" (Nobre, 2024).
- Book chapter "Content analysis of the terms of service of digital social platforms in the context of digital crimes against children" (publication expected in 2026 by ABECIN Press).
- Book chapter "Proposals for the regulation and accountability of digital platforms for the protection of children and adolescents in Brazil" (publication expected in 2026 by ABECIN Press).

5.1 RECOMMENDATIONS FOR FUTURE WORK

To consolidate the contributions presented and extend the practical impact of this work, we outline two prioritized avenues for future research and deployment. These directions focus on evaluating the OBKF-CP under real operating conditions and strengthening its cross-organizational interoperability, thereby testing both the framework’s utility and its scalability beyond controlled settings, as follows:

- Production pilot on a social media platform: deploy the OBKF-CP end-to-end within a major social media environment – ingestion (e.g., CSV/SQL/RDF), SHACL validation (lenient→strict), reasoning (inverses, transitivity, disjointness), and CQ-driven analytics – to evaluate real-world effectiveness. Define a prospectively measured KPI set (e.g., ingestion validity latency, SHACL violation rate by type, time-to-action for moderation, policy-coverage ratio, CQ pass rate) and compare before/after baselines. The pilot should include partner onboarding, data-protection controls (PII redaction), and a documented changelog to capture lessons learned and model refinement.

- Interoperability hardening with partner profiles: publish and test partner-specific bundles – SHACL shapes, mapping specs (CSVW/RML/R2RML/CONSTRUCT), and optional JSON-LD contexts – for hotlines, regulators, and platform trust and safety teams. Add explicit crosswalks to external legal/policy vocabularies and automate CI checks (reasoner + SHACL) per profile. This will reduce integration friction, improve semantic consistency across organizations, and provide a scalable path to multi-jurisdictional reuse.

REFERENCES

ABDULLAH, N. S.; SADIQ, S.; INDULSKA, M. A framework for industry-relevant ontology development. *In*: AUSTRALASIAN CONFERENCE ON INFORMATION SYSTEMS, 22., 2011, Sydney. **Anais [...]**. Sydney: Association for Information Systems, 2011. p. 1-12. Disponível em: https://aisel.aisnet.org/acis2011/80. Acesso em: 10 fev. 2025.

AGBAEGBU, J. *et al.* Ontologies in cloud computing: review and future directions. **Future Internet**, v. 13, n. 12, p. 302, 2021. DOI: https://doi.org/10.3390/fi13120302. Disponível em: https://www.mdpi.com/1999-5903/13/12/302. Acesso em: 10 fev. 2025.

AHMAD, M. N.; COLOMB, R. M.; ABDULLAH, M. S. **Ontology-based applications for enterprise systems and knowledge management**. Hershey: IGI Global Science Reference, 2013. DOI: https://doi.org/10.4018/978-1-4666-1993-7. Disponível em: https://espace.library.uq.edu.au/view/UQ:4bfd4b0. Acesso em: 10 fev. 2025.

ALFAIFI, Y. Ontology development methodology: a systematic review and case study. *In:* INTERNATIONAL CONFERENCE ON COMPUTING AND INFORMATION TECHNOLOGY, 2., 2022, Tabuk. **Anais [...]**. Tabuk: IEEE, 2022. p. 446-450. DOI: https://doi.org/10.1109/ICCIT52419.2022.9711664. Disponível em: https://ieeexplore.ieee.org/document/9711664. Acesso em: 10 fev. 2025.

AMETOWOBLA, D.; KIRCHNER, S. The organization of digital platforms: the role of digital technology and architecture for social order. **Zeitschrift für Soziologie**, v. 52, n. 2, p. 143-156, 2023. DOI: https://doi.org/10.1515/zfsoz-2023-2012. Disponível em: https://www.degruyterbrill.com/document/doi/10.1515/zfsoz-2023-2012/html. Acesso em: 10 fev. 2025.

AMINU, E. F. *et al.* A review on ontology development methodologies for developing ontological knowledge representation systems for various domains. **International Journal of Information Engineering and Electronic Business**, v. 12, n. 2, p. 28-39, 2020. DOI: https://doi.org/10.5815/ijieeb.2020.02.05. Disponível em: https://www.mecs-press.org/ijieeb/ijieeb-v12-n2/IJIEEB-V12-N2-5.pdf. Acesso em: 10 fev. 2025.

ARMAN, H.; HODGSON, A.; GINDY, N. N. Z. An ontology-based knowledge management system to support technology intelligence. **International Journal of Industrial and Systems Engineering**, v. 5, n. 3, p. 377-389, 2010. DOI: https://doi.org/10.1504/IJISE.2010.031968. Disponível em: https://www.inderscience.com/offers.php?id=31968. Acesso em: 10 fev. 2025.

ARP, R.; SMITH, B.; SPEAR, A. D. **Building ontologies with Basic Formal Ontology**. Cambridge: Massachusetts Institute of Technology, 2015. Disponível em https://mitpress.mit.edu/9780262527811/building-ontologies-with-basic-formal-ontology. Acesso em: 10 fev. 2025.

BASSAN, F. **Digital platforms and global law**. Beijing: Edward Elgar, 2021. DOI: https://doi.org/10.4337/9781800889439. Disponível em: https://china.elgaronline.com/monobook/9781800889422.xml. Acesso em: 10 fev. 2025.

BELLEFLAMME, P.; PEITZ, M. **The economics of platforms**. Cambridge: Cambridge University Press, 2021. DOI: https://doi.org/10.1017/9781108696913. Disponível em: https://www.cambridge.org/core/books/economics-of-platforms/1465A930513786676D369128B0AF9D21. Acesso em: 10 fev. 2025.

BERMEJO-ALONSO, J. *et al.* An ontology-based approach for autonomous systems' description and engineering. *In:* SETCHI, R. *et al.* (org.). Knowledge-based and intelligent information and engineering systems. **Lecture notes in computer science.** Berlin: Springer, 2010, p. 522-531. DOI https://doi.org/10.1007/978-3-642-15387-7_56. Disponível em: https://link.springer.com/chapter/10.1007/978-3-642-15387-7_56. Acesso em: 10 fev. 2025.

BHANDARI, M. Child protection: the grassroots issues and challenges. *In:* Deb, S. (org.). **Child safety, welfare and well-being**. New Delhi: Springer, 2016. p. 395-409. DOI: https://doi.org/10.1007/978-81-322-2425-9_26. Disponível em: https://link.springer.com/chapter/10.1007/978-81-322-2425-9_26. Acesso em: 10 fev. 2025.

BHARGAVA, H. K.; WANG, K.; ZHANG, X. L. Fending off critics of platform power with differential revenue sharing: doing well by doing good? **Management Science**, v. 68, n. 11, p. 8.249-8.260, 2022. DOI: https://doi.org/10.1287/mnsc.2022.4545. Disponível em: https://pubsonline.informs.org/doi/10.1287/mnsc.2022.4545. Acesso em: 1 jun. 2025.

BLASCHKE, M. *et al.* Taxonomy of digital platforms: a platform architecture perspective. *In:* INTERNATIONAL CONFERENCE ON WIRTSCHAFTSINFORMATIK, 14., 2019, Siegen. **Anais [...]**. Siegen: Association for Information Systems, 2019. p. 572- 586. Disponível em: https://aisel.aisnet.org/wi2019/track06/papers/3. Acesso em: 10 fev. 2025.

BLOEHDORN, S. *et al.* An ontology-based framework for text mining. **Journal for Language Technology and Computational Linguistics**, v. 20, n. 1, p. 87-112, 2005. DOI: https://doi.org/10.21248/jlcl.20.2005.70. Disponível em: https://jlcl.org/article/view/70. Acesso em: 19 abr. 2025.

BONINA, C. *et al.* Digital platforms for development: foundations and research agenda. **Information Systems Journal**, v. 31, n. 6, p. 869-902, 2021. DOI: https://doi.org/10.1111/isj.12326. Disponível em: https://onlinelibrary.wiley.com/doi/10.1111/isj.12326. Acesso em: 10 fev. 2025.

BORGO, S. *et al.* DOLCE: a descriptive ontology for linguistic and cognitive engineering. **Applied Ontology**, v. 17, n. 1, p. 45-69, 2022. DOI: https://doi.org/10.3233/AO-210259. Disponível em: https://journals.sagepub.com/doi/abs/10.3233/AO-210259. Acesso em: 10 fev. 2025.

BOYD, D. **It's complicated**: the social lives of networked teens. New Haven: Yale University Press, 2014. Disponível em: https://www.danah.org/books/ItsComplicated.pdf. Acesso em: 10 fev. 2025.

BRAHMA, S.; MISHRA, S. Understanding researchable issues in knowledge management: a literature review. **The IUP Journal of Knowledge Management**, v. 13, n. 4, p. 43-68, 2015. Disponível em: https://www.researchgate.net/publication/296700525_Understanding_Researchable_Issues_in_Knowledge_Management_A_Literature_Review_Understanding_Researchable_Issues_in_Knowledge_Management_A_Literature_Review. Acesso em: 10 fev. 2025.

BRASIL, 2025. **Lei nº 15.211, de 17 de setembro de 2025**. Dispõe sobre a proteção de crianças e adolescentes em ambientes digitais (Estatuto Digital da Criança e do Adolescente). Disponível em: https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2025/lei/L15211.htm. Acesso em: 21 set. 2025.

BROWNE, R. Global movement to protect kids online fuels a wave of AI safety tech. **CNBC**, 30 ago. 2025. Disponível em: https://www.cnbc.com/2025/08/30/global-movement-to-protect-kids-online-fuels-a-wave-of-ai-safety-tech.html. Acesso em: 11 set. 2025.

BRUNS, O. *et al.* NFDIcore 2.0: a BFO-compliant ontology for multi-domain research infrastructures. **arXiv**: p. 1-17, 2024. DOI: https://doi.org/10.48550/arXiv.2410.01821. Disponível em: https://arxiv.org/abs/2410.01821. Acesso em: 10 fev. 2025.

BURANARACH, M. *et al.* OAM: an Ontology Application Management framework for simplifying ontology-based semantic web application development. **International Journal of Software Engineering and Knowledge Engineering**, v. 26, n. 1, p. 115-145, 2016. DOI: https://doi.org/10.1142/S0218194016500066. Disponível em: https://www.worldscientific.com/doi/abs/10.1142/S0218194016500066. Acesso em: 10 fev. 2025.

BURKE, A.; KUMPULAINEN, K.; SMITH, C. Children digital play as collective family resilience in the face of the pandemic. **Journal of Early Childhood Literacy**, v. 23, n. 1, p. 8-34, 2023. DOI: https://doi.org/10.1177/14687984221124179. Disponível em: https://journals.sagepub.com/doi/full/10.1177/14687984221124179. Acesso em: 10 fev. 2025.

CHANDRASHEKAR, M.; NAGULAPATI, R.; LEE, Y. Ontology mapping framework with feature extraction and semantic embeddings. *In:* INTERNATIONAL CONFERENCE ON HEALTHCARE INFORMATICS WORKSHOP, 2018, Cidade de Nova Iorque. **Anais [...]**. Cidade de Nova Iorque: IEEE, 2018. p. 34-42. DOI: https://doi.org/10.1109/ICHI-W.2018.00012. Disponível em: https://ieeexplore.ieee.org/document/8411678. Acesso em: 10 fev. 2025.

CHEN, Y-M. *et al.* Methodology and system framework for knowledge management in allied system engineering. **International Council on Systems Engineering**, v. 14,

n. 1, p. 1.437-1.449, 2004. DOI: https://doi.org/10.1002/J.2334-5837.2004.TB00584.X. Disponível em: https://incose.onlinelibrary.wiley.com/doi/epdf/10.1002/j.2334-5837.2004.tb00584.x. Acesso em: 10 fev. 2025.

CIMIANO, P.; HANDSCHUH, S. Ontology-based linguistic annotation. *In:* WORKSHOP ON LINGUISTIC ANNOTATION: GETTING THE MODEL RIGHT, 2003, Sapporo. **Anais [...]**. Sapporo: Association for Computational Linguistics, 2003. p. 14-21. DOI: https://doi.org/10.3115/1119296.1119299. Disponível em: https://aclanthology.org/W03-1903. Acesso em: 10 fev. 2025.

CRISTANI, M.; CUEL, R. A survey on ontology creation methodologies. **International Journal on Semantic Web and Information Systems**, v. 1, n. 2, p. 49-69, 2005. DOI: http://doi.org/10.4018/jswis.2005040103. Disponível em: https://www.igi-global.com/chapter/survey-ontology-creation-methodologies/28910. Acesso em: 10 fev. 2025.

CULLIN, J. If we look at child protection reform through the lens of systems science, what do we see? **The British Journal of Social Work**, v. 52, n. 7, p. 3.964-3.981, 2022. DOI: https://doi.org/10.1093/bjsw/bcac048. Disponível em: https://academic.oup.com/bjsw/article/52/7/3964/6552795. Acesso em: 10 fev. 2025.

CURTIS, S.; EDWARDS, J. Improving public services by sharing the right information. **Public Money and Management**, v. 39, n. 5, p. 355-358, 2019. DOI: https://doi.org/10.1080/09540962.2019.1611238. Disponível em: https://www.tandfonline.com/doi/full/10.1080/09540962.2019.1611238. Acesso em: 10 fev. 2025.

D'CRUZE, R. S. *et al.* A case study on ontology development for AI based decision systems in industry. *In:* INTERNATIONAL CONGRESS AND WORKSHOP ON INDUSTRIAL AI AND EMAINTENANCE, 2023, Cham. **Anais [...]**. Cham: Springer, 2023. p. 693-706. DOI: https://doi.org/10.1007/978-3-031-39619-9_51. Disponível em: https://link.springer.com/chapter/10.1007/978-3-031-39619-9_51. Acesso em: 10 fev. 2025.

DEVILLE, J. Platforming pickiness: the digitally mediated enactment of childhood avoidant eating. **Journal of Cultural Economy**, v. 18, n. 6, p. 1-14, 2024. DOI: https://doi.org/10.1080/17530350.2024.2336460. Disponível em: https://www.tandfonline.com/doi/citedby/10.1080/17530350.2024.2336460. Acesso em: 10 fev. 2025.

DOU, D. *et al.* Integrating databases into the semantic web through an ontology-based framework. *In:* INTERNATIONAL CONFERENCE ON DATA ENGINEERING WORKSHOPS, 22., 2006, Atlanta. **Anais [...]**. Atlanta: IEEE, 2006. p. 1-10. DOI: https://doi.org/10.1109/ICDEW.2006.68. Disponível em: https://ieeexplore.ieee.org/document/1623849. Acesso em: 10 fev. 2025.

EUROPEAN Union. European Commission. Commission publishes draft guidelines on protection of minors online under the Digital Services Act. **Shaping Europe's**

digital future, 13 maio 2025a. Disponível em: https://digital-strategy.ec.europa.eu/en/news/commission-publishes-draft-guidelines-protection-minors-online-under-digital-services-act. Acesso em: 30 maio 2025.

EUROPEAN Union. European Commission. Commission takes further action to promote a safe environment for minors. **Shaping Europe's digital future**, 10 out. 2025b. Disponível em: https://digital-strategy.ec.europa.eu/en/news/commission-takes-further-action-promote-safe-environment-minors. Acesso em: 12 out. 2025.

EUROPEAN Union. European Commission. **The Digital Services Act**: ensuring a safe and accountable online environment. 2022. Disponível em: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/digital-services-act-ensuring-safe-and-accountable-online-environment_en. Acesso em: 12 maio 2025.

FATTORE, T.; MASON, J.; WATSON, E. Safety and ontological insecurity: contesting the meaning of child protection. FATTORE, T.; MASON, J.; WATSON, E. (orgs). *In:* **Children's understandings of well-being**. Children's well-being: indicators and research. Springer: Dordrecht, 2016. p. 87-113. DOI: https://doi.org/10.1007/978-94-024-0829-4_5. Disponível em: https://link.springer.com/chapter/10.1007/978-94-024-0829-4_5. Acesso em: 10 fev. 2025.

FEINER, L. Kids Online Safety Act reintroduced. **The Verge**, 14 maio 2025. Disponível em: https://www.theverge.com/news/666729/kids-online-safety-act-reintroduced. Acesso em: 21 maio 2025.

FLYNN, S. Child protection and welfare during the COVID 19 pandemic: revisiting the value of resilience-building, systems theory, adverse childhood experiences and trauma-informed approaches. **Child Care in Practice**, v. 29, n. 4, p. 371-388, 2022. DOI: https://doi.org/10.1080/13575279.2022.2118673. Disponível em: https://www.tandfonline.com/doi/full/10.1080/13575279.2022.2118673. Acesso em: 10 fev. 2025.

FTEIMI, N. Analyzing the literature on knowledge management frameworks: towards a normative knowledge management classification schema. *In:* EUROPEAN CONFERENCE ON INFORMATION SYSTEMS, 23., Münster, 2015. **Anais [...]**. Münster: Association for Information Systems, 2015. DOI: https://doi.org/10.18151/7217318. Disponível em: https://aisel.aisnet.org/ecis2015_cr/51. Acesso em: 10 fev. 2025.

FUNK, T. M. **Mutual legal assistance treaties and letters rogatory**: obtaining evidence and assistance from foreign jurisdictions. Federal Judicial Center: Washington, 2024. DOI: http://dx.doi.org/10.2139/ssrn.4623886. Disponível em: https://ssrn.com/abstract=4623886. Acesso em: 10 fev. 2025.

GAGLIARDO, S. *et al.* An ontology-based framework for sustainable factories. **Computer-Aided Design and Applications**, v. 12, n. 2, p. 198-207, 2015. DOI: https://doi.org/10.1080/16864360.2014.962432. Disponível em:

https://www.tandfonline.com/doi/abs/10.1080/16864360.2014.962432. Acesso em: 10 fev. 2025.

GAWICH, M. *et al.* A methodology for ontology building. **International Journal of Computer Applications**, v. 56, n. 2, p. 39-45, 2012. DOI: https://doi.org/10.5120/8867-2834. Disponível em: https://research.ijcaonline.org/volume56/number2/pxc3882834.pdf. Acesso em: 10 fev. 2025.

GILLEN, A.; CANAVAN, J. Complexity theory and child protection and welfare: a tool of hindsight and/or a tool to assist improved decision making in child protection and welfare work. **British Journal of Social Work**, v. 54, n. 1, p. 59-76, 2023. DOI: https://doi.org/10.1093/bjsw/bcad180. Disponível em: https://academic.oup.com/bjsw/article/54/1/59/7236820. Acesso em: 10 fev. 2025.

GOECKS, L. S. *et al.* Design Science Research in practice: review of applications in industrial engineering. **Gestão e Produção,** v. 28, n. 4, p. 1-19, 2021. DOI: https://doi.org/10.1590/1806-9649-2021v28e5811. Disponível em: https://www.scielo.br/j/gp/a/6kbDqBTfTgCt7WHKjTqxJbn. Acesso em: 10 fev. 2025.

GORWA, R.; BINNS, R.; KATZENBACH, C. Algorithmic content moderation: Technical and political challenges in the automation of platform governance. **Big Data and Society**, v. 7, n. 1, p. 1-15, 2020. DOI: https://doi.org/10.1177/2053951719897945. Disponível em: https://journals.sagepub.com/doi/10.1177/2053951719897945. Acesso em: 10 fev. 2025.

GOVT orders digital platforms to provide parental controls. **Antara News**, 18 out. 2025. Disponível em: https://en.antaranews.com/news/371657/govt-orders-digital-platforms-to-provide-parental-controls. Acesso em: 20 out. 2025.

GRUBER, T. R. Toward principles for the design of ontologies used for knowledge sharing. **International Journal of Human-Computer Studies**, v. 43, n. 5-6, p. 907-928, 1995. DOI: https://doi.org/10.1006/ijhc.1995.1081. Disponível em: https://www.sciencedirect.com/science/article/pii/S1071581985710816. Acesso em: 10 fev. 2025.

GRÜNINGER, M; RU, Y; THAI, J. TUpper: a top level ontology within standards. **Applied Ontology**, v. 17, n. 1, p. 143-165, 2022. DOI: https://doi.org/10.3233/AO-220263. Disponível em: https://journals.sagepub.com/doi/abs/10.3233/AO-220263. Acesso em: 10 fev. 2025.

HACKETT, S. Child protection: international issues. *In:* WRIGHT, J. D. (org.). **International Encyclopedia of the Social and Behavioral Sciences**, Elsevier, 2015. p. 423-429. DOI: https://doi.org/10.1016/B978-0-08-097086-8.28015-X. Disponível em: https://www.sciencedirect.com/science/chapter/referencework/abs/pii/B9780080970868828015X. Acesso em: 10 fev. 2025.

HADJ-MABROUK, H. Literature review on applications of ontologies and knowledge graphs in railway transport safety. *In:* MOHEBBI, M. (org.). **Railway transport and engineering: a comprehensive guide**. IntechOpen: Londres, 2024. https://doi.org/10.5772/intechopen.1006278. Disponível em: https://www.intechopen.com/chapters/1203650. Acesso em: 10 fev. 2025.

HEVNER, A. R. *et al.* Design science in information systems research. **MIS Quarterly**, v. 28, n. 1, p. 75-105, 2004. DOI: https://doi.org/10.2307/25148625. Disponível em: https://misq.umn.edu/misq/article-abstract/28/1/75/261/Design-Science-in-Information-Systems-Research1. Acesso em: 10 fev. 2025.

HILAL, S. A survey of ontology-based frameworks for sustainable supply chain interoperability and collaboration. *In:* AWASTHI, A.; GRZYBOWSKA, K (org.). **Handbook of research on interdisciplinary approaches to decision making for sustainable supply chains**. Hershey: IGI Global Science Reference, 2020. p. 459-475. DOI: https://doi.org/10.4018/978-1-5225-9570-0.CH021. Disponível em: https://www.igi-global.com/gateway/chapter/241347. Acesso em: 10 fev. 2025.

HOLSAPPLE, C. W.; JOSHI, K. D. A knowledge management ontology. *In:* HOLSAPPLE, C. W. (org). **Handbook on knowledge management 1**. International handbooks on information systems, v. 1. Springer: Berlin, 2004. p. 89-124. DOI: https://doi.org/10.1007/978-3-540-24746-3_6. Disponível em: https://link.springer.com/chapter/10.1007/978-3-540-24746-3_6. Acesso em: 10 fev. 2025.

HRADOVA, Y.; ZHYTNYI, O.; TERESHCHUK, S. State and legal policy for the protection of children in the digital environment. *In:* INTERNATIONAL CONFERENCE ON SOCIAL SCIENCE, PSYCHOLOGY AND LEGAL REGULATION, 2021, Kiev. **Anais [...]**. Dordrecht: Atlantis Press, 2021. p. 220-225. DOI: https://doi.org/10.2991/assehr.k.211218.036. Disponível em: https://www.atlantis-press.com/proceedings/spl-21/125966727. Acesso em: 10 fev. 2025.

HUMA, Z.; REHMAN, M. J.; IFTIKHAR, N. An ontology-based framework for semi-automatic schema integration. Journal of Computer Science and Technology, v. 20, n. 6, p. 788-796, 2005. DOI: https://doi.org/10.1007/s11390-005-0788-4. Disponível em: https://link.springer.com/article/10.1007/s11390-005-0788-4. Acesso em: 10 fev. 2025.

HUMAN Rights Watch. Brazil passes landmark law to protect children online. **Human Rights Watch**, 17 set. 2025. Disponível em: https://www.hrw.org/news/2025/09/17/brazil-passes-landmark-law-to-protect-children-online. Acesso em: 20 out. 2025.

IATRELLIS, O.; FITSILIS, P. A review on software project management ontologies. *In:* INFORMATION Resources Management Association (ed.). **Research Anthology on Recent Trends, Tools, and Implications of Computer Programming**. Hershey: IGI Global Science Reference: 2021. p. 27-46. DOI: http://doi.org/10.4018/978-1-

7998-3016-0.ch002. Disponível em: https://www.igi-global.com/chapter/a-review-on-software-project-management-ontologies/261019. Acesso em: 10 fev. 2025.

INTERNET Watch Foundation. **Annual Data Insights Report 2024**. IWF, 2024. Disponível em: https://www.iwf.org.uk/annual-data-insights-report-2024. Acesso em: 27 fev. 2025.

INTERPOL. **INTERPOL Annual Report 2023**. Lyon: INTERPOL, 2024. Disponível em: https://www.interpol.int/content/download/22267/file/INTERPOL%20Annual%20Report%202023%20EN.pdf. Acesso em: 27 fev. 2025.

ISLAM, F. N.; ALWI, A; SYAHRIBULAN, S. Implementation of network management in child protection policy: analysis of mobilization strategy in Makassar City. **Edelweiss Applied Science and Technology**, v. 8, n. 6, p. 5.885-5.893, 2024. DOI: https://doi.org/10.55214/25768484.v8i6.3272. Disponível em: https://learning-gate.com/index.php/2576-8484/article/view/3272. Acesso em: 10 fev. 2025.

JAYATI, Y. T. The role of child protection in fulfilling children's rights: a literature review. *In:* INTERNATIONAL CONFERENCE ON EDUCATION AND TECHNOLOGY, 6., 2020, Malang. **Anais [...].** Dordrecht: Atlantis Press, 2020. p. 401-405. DOI: https://doi.org/10.2991/assehr.k.201204.078. Disponível em: https://www.atlantis-press.com/proceedings/icet-20/125947578. Acesso em: 10 fev. 2025.

JUNIOR, A. N. B. *et al.* Ontologies supporting the distributed software development: a systematic literature review. *In:* INTERNATIONAL CONFERENCE ON GLOBAL SOFTWARE ENGINEERING WORKSHOPS, 7., Porto Alegre, 2012. **Anais [...]**. Cidade de Nova Iorque: IEEE, 2012. p. 55-59. DOI: https://doi.org/10.1109/ICGSEW.2012.21. Disponível em: https://ieeexplore.ieee.org/document/6337320. Acesso em: 10 fev. 2025.

KALISZ, A. Public and Private Governance of Cybersecurity Challenges and Potential. *In:* ISHIKAWA, T.; KRYVOI, Y. **Public and private governance of cybersecurity: challenges and potential**. Cambridge: Cambridge University Press, 2023, p. 211-239. DOI: https://doi.org/10.1017/9781009374576.009. Disponível em: https://www.cambridge.org/core/books/abs/public-and-private-governance-of-cybersecurity/publicprivate-partnerships-on-cybersecurity-and-international-law/922918C5A9B5CAF955E685A6A803ABDA. Acesso em: 10 fev. 2025.

KARELINA, E. A.; BAYKOV, F. Formation of transnational competitive advantages of global digital platforms. In: INTERNATIONAL CONFERENCE ON ENGINEERING MANAGEMENT OF COMMUNICATION AND TECHNOLOGY, Vienna, 2022. **Anais [...]**. Cidade de Nova Iorque: IEEE, 2022. p. 1-5. DOI: https://doi.org/10.1109/EMCTECH55220.2022.9934044. Disponível em: https://ieeexplore.ieee.org/document/9934044. Acesso em: 10 fev. 2025.

KARPETIS, G. Clinical supervision in child protection practice: a review of the literature. **Trauma, Violence, and Abuse**, v. 22, n. 4, p. 689-701, 2021. DOI:

https://doi.org/10.1177/1524838019875698. Disponível em: https://journals.sagepub.com/doi/10.1177/1524838019875698. Acesso em: 10 fev. 2025.

KATZ, S. N. Child protection. In: KATZ, S. N (org.). **Family law in America**. Oxford: Oxford University Press, 2014, p. 145-170. DOI: https://doi.org/10.1093/acprof:oso/9780199759224.003.0004. Disponível em: https://academic.oup.com/book/33117/chapter-abstract/283504762. Acesso em: 10 fev. 2025.

KEEN, C. Apathy, convenience or irrelevance? Identifying conceptual barriers to safeguarding children's data privacy. **New Media and Society**, v. 24, n. 1, p. 50-69, 2020. DOI: https://doi.org/10.1177/1461444820960068. Disponível em: https://doi.org/10.1177/1461444820960068. Acesso em: 10 fev. 2025.

KEMP, S. Digital 2025: Global overview report. **Data Reportal**, 5 fev. 2025. Disponível em: https://datareportal.com/reports/digital-2025-global-overview-report. Acesso em: 19 abr. 2025.

KOVÁCS-SZÉPVÖLGYI, E. Digital child protection in the light of sustainability. *In:* CONFERENCE ON SUSTAINABILITY, 1., 2023, Győr. **Anais [...]**. Győr: Széchenyi István University, 2023. p. 23-30. DOI: https://doi.org/10.62897/cos2023.1-1.23. Disponível em: https://cos.sze.hu/digital-child-protection-in-the-light-of-sustainability. Acesso em: 19 abr. 2025.

KROET, C. EU countries sign Danish plan to boost child protection online. **Euronews**, 13 out. 2025. Disponível em: https://www.euronews.com/next/2025/10/13/eu-countries-sign-danish-plan-to-boost-child-protection-online. Acesso em: 20 out. 2025.

LAURITZEN, C.; VIS, S. A.; FOSSUM, S. Factors that determine decision making in child protection investigations: a review of the literature. **Child and Family Social Work**, v. 23, n. 4, p. 743-756, 2018. DOI: https://doi.org/10.1111/cfs.12446. Disponível em: https://onlinelibrary.wiley.com/doi/abs/10.1111/cfs.12446. Acesso em: 19 abr. 2025.

LAW, N. L. L. M. *et al.* A review of ontology development aspects. International **Journal of Advanced Computer Science and Applications**, v. 10, n. 7, p. 290-298, 2019. DOI: http://doi.org/10.14569/IJACSA.2019.0100740. Disponível em: https://thesai.org/Publications/ViewPaper?Volume=10&Issue=7&Code=IJACSA&SerialNo=40. Acesso em: 19 abr. 2025.

LEE, J-H; SUH, H-W. Ontology-based multi-layered knowledge framework for product lifecycle management. **Concurrent Engineering**, v. 16, n. 4, p. 301-311, 2008. DOI: https://doi.org/10.1177/1063293X08100030. Disponível em: https://journals.sagepub.com/doi/10.1177/1063293X08100030. Acesso em: 19 abr. 2025.

Lee, S. Ontology-based meta-framework for metadata interoperability. *In:* INTERNATIONAL CONFERENCE ON DUBLIN CORE AND METADATA APPLICATIONS, Seul, 2009. **Anais [...]**. Singapura: Dublin Core Metadata Initiative, 2009. p. 135-136. DOI: https://doi.org/10.23106/dcmi.952109673. Disponível em: https://dcpapers.dublincore.org/article/952109673. Acesso em: 19 abr. 2025.

LEEUW, S. State of care: the ontologies of child welfare in British Columbia**. Cultural Geographies**, v. 21, n. 1, p. 59-78, 2013. DOI: https://doi.org/10.1177/1474474013491925. Disponível em: https://journals.sagepub.com/doi/10.1177/1474474013491925. Acesso em: 19 abr. 2025.

LEPUSCHITZ, W. *et al.* An industry-oriented ontology-based knowledge model for batch process automation. *In:* INTERNATIONAL CONFERENCE ON INDUSTRIAL TECHNOLOGY, Lyon, 2018. **Anais [...]**. Cidade de Nova Iorque: IEEE, 2018. p. 1.568-1.573. DOI: https://doi.org/10.1109/ICIT.2018.8352415. Disponível em: https://ieeexplore.ieee.org/document/8352415. Acesso em: 19 abr. 2025.

LEUNG, N. K. Y. *et al.* An integration-oriented ontology development methodology to reuse existing ontologies in an ontology development process. *In:* INTERNATIONAL CONFERENCE ON INFORMATION INTEGRATION AND WEB-BASED APPLICATIONS AND SERVICES, 13., 2011, Cidade de Ho Chi Minh. **Anais [...]**. Cidade de Nova Iorque: Association for Computing Machinery, 2011. p. 174-181. DOI: https://doi.org/10.1145/2095536.2095567. Disponível em: https://dl.acm.org/doi/10.1145/2095536.2095567. Acesso em: 19 abr. 2025.

LEUNG, N. K. Y.; LAU, S. K.; TSANG, N. An ontology development methodology to integrate existing ontologies in an ontology development process. **Communications of the ICISA**, v. 13, n. 2, p. 31-61, 2013. DOI: https://doi.org/10.6520/CICISA.2013.13(2)31. Disponível em: https://www.airitilibrary.com/Article/Detail/15332454-201301-201312090003-201312090003-31-61. Acesso em: 19 abr. 2025.

LI, Q.; CROSS, D.; SMITH, P. K. (org.). **Cyberbullying in the global playground**: research from international perspectives. Hoboken: Wiley-Blackwell, 2011. Disponível em: https://www.wiley.com/en-us/Cyberbullying+in+the+Global+Playground%3A+Research+from+International+Perspectives-p-9781119954460. Acesso em: 19 abr. 2025.

LIVINGSTONE, S.; MASCHERONI, G.; STAKSRUD, E. European research on children's internet use: assessing the past and anticipating the future. **New Media and Society**, v. 20, n. 3, p. 1.103-1.122, 2018. DOI: https://doi.org/10.1177/1461444816685930. Disponível em: https://journals.sagepub.com/doi/10.1177/1461444816685930. Acesso em: 19 abr. 2025.

LOPES, N. Knowledge societies landscape and framework for distinct context settings. *In:* LOPES, N. V.; BAGUMA, R. (org.). **Developing knowledge societies for distinct country contexts**. Hershey: IGI Global Science Reference, 2021. p. 21-

62. DOI 10.4018/978-1-5225-8873-3.CH002. Disponível em: https://www.igi-global.com/chapter/knowledge-societies-landscape-and-framework-for-distinct-context-settings/266858. Acesso em: 19 abr. 2025.

MAHER, R. D.; FLYNN, S.; BYRNE, J. Child protection and welfare risks and opportunities related to disability and internet use: broadening current conceptualisations through critical literature review. **Children and Youth Services Review**, v. 157, n. 1, 2023. DOI: https://doi.org/10.1016/j.childyouth.2023.107410. Disponível em: https://www.sciencedirect.com/science/article/pii/S0190740923006060. Acesso em: 19 abr. 2025.

MAIA, J. M. D.; WILLIAMS, L. C. de A. Fatores de risco e fatores de proteção ao desenvolvimento infantil: uma revisão da área. **Temas em Psicologia**, v. 13, n. 2, p. 91-103, 2005. Disponível em: https://www.redalyc.org/articulo.oa?id=513751425002. Acesso em: 19 abr. 2025.

MASSARO, M.; DUMAY, J.; GUTHRIE, J. On the shoulders of giants: undertaking a structured literature review in accounting. **Accounting, Auditing and Accountability Journal**, v. 29, n. 5, p. 767-801, 2016. DOI: https://doi.org/10.1108/AAAJ-01-2015-1939. Disponível em: https://www.emerald.com/aaaj/article-abstract/29/5/767/1674/On-the-shoulders-of-giants-undertaking-a. Acesso em: 19 abr. 2025.

MENDONÇA, F. M. **OntoForInfoScience**: metodologia para construção de ontologias pelos cientistas da informação – uma aplicação prática no desenvolvimento da ontologia sobre componentes do sangue humano (Hemonto), 2015. 322 f. Tese (Doutorado em Ciência da Informação) – Escola de Ciência da Informação, Universidade Federal de Minas Gerais, Belo Horizonte, 2015. URI: http://hdl.handle.net/1843/BUBD-A35H3K. Disponível em: https://repositorio.ufmg.br/handle/1843/BUBD-A35H3K. Acesso em: 19 abr. 2025.

MENDONÇA, F. M.; ALMEIDA, M. B. OntoForInfoScience: a detailed methodology for construction of ontologies and its application in the blood domain. **Brazilian Journal of Information Science: research trends**, v. 10, n. 1, p. 12-19, 2016. DOI: https://doi.org/10.36311/1981-1640.2016.v10n1.02.p12. Disponível em: https://revistas.marilia.unesp.br/index.php/bjis/article/view/5426. Acesso em: 23 jun. 2025.

MESIAS-RODRÍGUEZ, V. A. La protección de los derechos de la infancia en el ámbito digital. **Horizon Nexus Journal**, v. 2, n. 4, p. 54-66, 2024. DOI: https://doi.org/10.70881/hnj/v2/n4/44. Disponível em: https://horizonnexusjournal.editorialdoso.com/index.php/home/article/view/44. Acesso em: 23 jun. 2025.

MESSAOUDI, R. *et al.* Ontologies for liver diseases representation: a systematic literature review. **Journal of Digital Imaging**, v. 33, n. 3, p. 563-573, 2020. DOI: https://doi.org/10.1007/s10278-019-00303-2. Disponível em:

https://link.springer.com/article/10.1007/s10278-019-00303-2. Acesso em: 19 abr. 2025.

MILANO, S.; TADDEO, M.; FLORIDI, L. Recommender systems and their ethical challenges. AI and Society, v. 35, n. 4, p. 957-967, 2020. DOI: https://doi.org/10.1007/s00146-020-00950-y. Disponível em: https://link.springer.com/article/10.1007/s00146-020-00950-y. Acesso em: 1 mar. 2025.

MILKAITE, I. Strengthening children's rights to privacy and data protection in the digital environment: walking the tightrope in the EU. *In:* Czech, P. (org.). **European Yearbook on Human Rights 2023**. Cambridge: Intersentia, 2023. p. 391-436. DOI: https://doi.org/10.1017/9781839704543.014. Disponível em: https://www.cambridge.org/core/books/abs/european-yearbook-on-human-rights-2023/strengthening-childrens-rights-to-privacy-and-data-protection-in-the-digital-environment-walking-the-tightrope-in-the-eu/F5B7727CF4AF4D980D72AA4CB7542ECD. Acesso em: 19 abr. 2025.

MILMO, D. Meta blocks livestreaming by teenagers on Instagram. **The Guardian**, 8 abr. 2025. Disponível em: https://www.theguardian.com/technology/2025/apr/08/meta-blocks-livestreaming-by-teenagers-on-instagram. Acesso em: 20 maio 2025.

MIZOGUCHI, R.; BORGO, S. YAMATO: Yet-Another More Advanced Top-level Ontology. **Applied Ontology**, v. 17, n. 1, p. 1-22, 2021. DOI: https://doi.org/10.3233/AO-210257. Disponível em: https://journals.sagepub.com/doi/abs/10.3233/AO-210257. Acesso em: 19 abr. 2025.

MOHAMAD, U. H.; AHMAD, M. N.; ZAKARIA, A. M. U. Ontologies application in the sharing economy domain: a systematic review. **Online Information Review**, v. 46 n. 4, p. 807-825, 2022. DOI: https://doi.org/10.1108/OIR-11-2020-0497. Disponível em: https://www.emerald.com/insight/content/doi/10.1108/OIR-11-2020-0497/full/html. Acesso em: 19 abr. 2025.

MOKGETSE, T. L.; HLOMANI, H.; SIGWELE, T. Innovative emerging ontology-driven frameworks: a systematic literature review. **Indonesian Journal of Electrical Engineering and Informatics**, v. 11, n. 4, p. 1.064-1.081, 2023. DOI: https://doi.org/10.52549/.v11i4.5106. Disponível em: https://section.iaesonline.com/index.php/IJEEI/article/view/5106. Acesso em: 19 abr. 2025.

MOKHTAR, B. The child as a victim of the digital environment. **Journal of Law and Sustainable Development**, v. 12, n. 10, p. 1-36, 2024. DOI: https://doi.org/10.55908/sdgs.v12i10.4085. Disponível em: https://ojs.journalsdg.org/jlss/article/view/4085. Acesso em: 23 jun. 2025.

MOSKOWITZ, Y. L. MLATs and the trusted nation club: the proper cost of membership. **Yale Journal of International Law**, v. 41, n. 2, p. 1-14, 2016.

Disponível em: https://yjil.yale.edu/posts/2016-09-07-mlats-and-the-trusted-nation-club-the-proper-cost-of-membership. Acesso em: 19 abr. 2025.

MOTZKAU, J.; LEE, N. M. Cultures of listening: psychology, resonance, justice. **Review of General Psychology**, v. 27, n. 1, p. 3-25, 2022. DOI: http://doi.org/10.1177/10892680221077999. Disponível em: https://journals.sagepub.com/doi/10.1177/10892680221077999. Acesso em: 19 abr. 2025.

MUJALLID, A. T. Instructors' readiness to teach online: a review of TPACK standards in online professional development programmes in higher education. **International Journal of Learning, Teaching and Educational Research**, v. 20, n. 7, p. 135-150, 2021. DOI: https://doi.org/10.26803/ijlter.20.7.8. Disponível em: https://ijlter.org/index.php/ijlter/article/view/3820/pdf. Acesso em: 19 abr. 2025.

MUSEN, M. A. The Protégé project: a look back and a look forward. **AI Matters**, v. 1, n. 4, p. 4-12, 2015. DOI: https://doi.org/10.1145/2757001.2757003. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC4883684. Acesso em: 19 abr. 2025.

NAKANO, N. *et al.* Proposta de modelo para apresentação da informação acessível em tesauro implementado com a ferramenta Tematres. **Informação e Informação**, v. 28, n. 4, p. 241-268, 2024. DOI: https://doi.org/10.5433/1981-8920.2023v28n4p241. Disponível em: https://www.ojs.uel.br/revistas/uel/index.php/informacao/article/view/47948. Acesso em: 19 abr. 2025.

NARAYANASAMY, S. K. *et al.* A contemporary review on utilizing semantic web technologies in healthcare, virtual communities, and ontology-based information processing systems. **Electronics**, v. 11, n. 3, p. 1-28, 2022. DOI: https://doi.org/10.3390/electronics11030453. Disponível em: https://www.mdpi.com/2079-9292/11/3/453. Acesso em: 19 abr. 2025.

NICOLA, A. de; VILLANI, M. L. Smart city ontologies and their applications: a systematic literature review. **Sustainability**, v. 13, n. 10, p. 5578, 2021. DOI: https://doi.org/10.3390/su13105578. Disponível em: https://www.mdpi.com/2071-1050/13/10/5578. Acesso em: 19 abr. 2025.

NIEDDERER, K.; IMANI, Y. Developing a framework for managing tacit knowledge in research using knowledge management models. *In:* UNDISCIPLINED! - DESIGN RESEARCH SOCIETY CONFERENCE, 2008, Sheffield. **Anais [...]**. Sheffield: Sheffield Hallam University, 2009. p. 1-25 Disponível em: https://dl.designresearchsociety.org/cgi/viewcontent.cgi?article=2106&context=drs-conference-papers. Acesso em: 19 abr. 2025.

NOBRE, R. L. de S. Infodemia e desinformação no mundo pós-Covid-19: desafios éticos e vieses em dados na gestão da informação. *In:* MARIN, L. H. G. *et al.* (org.). **Ética e vieses em dados: perspectivas gerais**. São Paulo: ABECIN, 2024. p. 13-39. Disponível em: https://portal.abecin.org.br/editora/issue/view/57. Acesso em: 19 abr. 2025.

NOBRE, R. L. de S.; SOUSA, R. P. M. de; MARIN, L. H. G. Ontology for the prevention of digital crimes against children. *In:* SEMINAR ON ONTOLOGY RESEARCH IN BRAZIL (ONTOBRAS), 17., 2024; DOCTORAL AND MASTERS CONSORTIUM ON ONTOLOGIES (WTDO), 8., 2024, Vitória. **Anais [...]**. Vitória: CEUR WS, 2025. p. 1-12. Disponível em: https://ceur-ws.org/Vol-3905/master4.pdf. Acesso em: 19 abr. 2025.

NOY, N. F.; MCGUINNESS, D. L**. Ontology development 101**: a guide to creating your first ontology. Stanford: Stanford Knowledge Systems Laboratory, 2001. Disponível em: https://protege.stanford.edu/publications/ontology_development/ontology101.pdf Acesso em: 19 abr. 2025.

ORTUTAY, B. Instagram says it's safeguarding teens by limiting them to PG-13 content. **AP News**, 14 out. 2025. Disponível em: https://apnews.com/article/instagram-teens-kids-pg13-safety-f3001b877a0b576be3e5723a5acd0ff1. Acesso em: 20 out. 2025.

OSHODI, A. N. *et al.* Combining parental controls and educational programs to enhance child safety online effectively. **International journal of applied research in social sciences**, v. 6, n. 9, p. 2.293-2.314, 2024. DOI: https://doi.org/10.51594/ijarss.v6i9.1592. Disponível em: https://fepbl.com/index.php/ijarss/article/view/1592. Acesso em: 19 abr. 2025.

OSMAN, M. A.; MOHD NOAH, S. A.; SAAD, S. Ontology-based knowledge management tools for knowledge sharing in organization: a review. **IEEE Access**, v. 10, n. 1, p. 43.267-43.283, 2022. DOI: https://doi.org/10.1109/ACCESS.2022.3163758. Disponível em: https://ieeexplore.ieee.org/document/9745581. Acesso em: 19 abr. 2025.

OTTE, J. N.; BEVERLEY, J.; RUTTENBERG, A. BFO: Basic Formal Ontology. **Applied Ontology**, v. 17, n. 1, pp. 17-43, 2022. DOI: https://doi.org/10.3233/AO-220262. Disponível em: https://journals.sagepub.com/doi/abs/10.3233/AO-220262.

PEFFERS, K. *et al.* A Design Science Research methodology for information systems research. **Journal of Management Information Systems**, v. 24, n. 3, p. 45-77, 2007. DOI: https://doi.org/10.2753/MIS0742-1222240302. Disponível em: https://www.tandfonline.com/doi/abs/10.2753/MIS0742-1222240302. Acesso em: 19 abr. 2025.

PEREIRA, C.; DELGOULET, C.; SANTOS, M. Conceptual framework for management or transmission of knowledge in companies: a systematic review. **Frontiers in Psychology**, v. 14, n. 1, p. 1-13, 2023. DOI: https://doi.org/10.3389/fpsyg.2023.1124650. Disponível em: https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2023.1124650/full. Acesso em: 19 abr. 2025.

POTHONG, K. *et al.* Applying children's rights to digital products: exploring competing priorities in design. *In:* INTERACTION DESIGN AND CHILDREN CONFERENCE, 23., 2024, Delft. **Anais [...]**. Cidade de Nova Iorque: Association for Computing Machinery, 2024. p. 93-104. DOI: https://doi.org/10.1145/3628516.3655789. Disponível em: https://dl.acm.org/doi/10.1145/3628516.3655789. Acesso em: 19 abr. 2025.

PURTOVA, N. Between the GDPR and the police directive: navigating through the maze of information sharing in public-private partnerships. **International Data Privacy Law**, v. 8, n. 1, p. 52-68, 2018. DOI: https://doi.org/10.1093/idpl/ipx021. Disponível em: https://academic.oup.com/idpl/article/8/1/52/4822279. Acesso em: 19 abr. 2025.

RAZA, M. A. *et al.* A methodology for engineering domain ontology using entity relationship model. **International Journal of Advanced Computer Science and Applications**, v. 10, n. 8, p. 326-332, 2019. DOI: https://dx.doi.org/10.14569/IJACSA.2019.0100842. Disponível em: https://thesai.org/Publications/ViewPaper?Volume=10&Issue=8&Code=IJACSA&SerialNo=42. Acesso em: 19 abr. 2025.

REGULATION to shield children from digital risks: Minister. **Antara News**, 25 jul. 2025. Disponível em: https://en.antaranews.com/news/368785/regulation-to-shield-children-from-digital-risks-minister. Acesso em: 20 out. 2025.

ROSENBERG, J. Form and structure of the knowledge framework for urban planning: methodological approach and assessment issues: the case study of the municipality of Fondi urban plan. **Land**, v. 12, n. 6, p. 1-20, 2023. DOI: https://doi.org/10.3390/land12061201. Disponível em: https://www.mdpi.com/2073-445X/12/6/1201. Acesso em: 19 abr. 2025.

SAYÃO, L. F.; SALES, L. F. A ciência invisível: por que os pesquisadores não publicam seus resultados negativos? **Informação e Informação**, v. 25, n. 4, p. 97-116, 2020. DOI: https://doi.org/10.5433/1981-8920.2020v25n4p98. Disponível em: https://ojs.uel.br/revistas/uel/index.php/informacao/article/view/40016. Acesso em: 19 abr. 2025.

SEDERA, D.; AHMAD, M. N.; ZAKARIA, N. H. Ontology-based knowledge management for enterprise systems. **International Journal of Enterprise Information Systems**, v. 7, n. 4, p. 1-27, 2011. DOI: https://doi.org/10.4018/JEIS.2011100104. Disponível em: https://www.igi-global.com/gateway/article/60404. Acesso em: 19 abr. 2025.

SEKATI, P. Assessing the effectiveness of extradition and the enforcement of extra-territorial jurisdiction in addressing trans-national cybercrimes. **Comparative and International Law Journal of Southern Africa**, v. 55, n. 1, p. 1-36, 2022. DOI: https://doi.org/10.25159/2522-3062/10476. Disponível em: https://unisapressjournals.co.za/index.php/CILSA/article/view/10476. Acesso em: 19 abr. 2025.

SENSUSE, D. I. *et al.* Models and frameworks of knowledge management: a literature review. *In:* INTERNATIONAL CONFERENCE ON INFORMATION SCIENCE, ELECTRONICS AND ELECTRICAL ENGINEERING, 2014, Sapporo. Anais […]. Cidade de Nova Iorque: IEEE, 2014. p. 1.166-1.170. DOI: https://doi.org/10.1109/InfoSEEE.2014.6947854. Disponível em: https://ieeexplore.ieee.org/document/6947854. Acesso em: 19 abr. 2025.

SHINTAKU, M. *et al.* Acessibilidade ao conteúdo de objetos digitais informacionais em bibliotecas digitais implementadas com o DSpace. **Inclusão Social**, v. 14, n. 2, p. 1-19, 2024. DOI: http://doi.org/10.18225/inc.soc.v14i2.6389. Disponível em: https://revista.ibict.br/inclusao/article/view/6389. Acesso em: 19 abr. 2025.

SMEETON, J. A murky business: a phenomenological ontology of risk in child protection social work. **Qualitative Social Work**, v. 19, n. 2, p. 284-300, 2020. DOI: https://doi.org/10.1177/1473325018815732. Disponível em: https://journals.sagepub.com/doi/10.1177/1473325018815732. Acesso em: 19 abr. 2025.

SMUTS, H. *et al.* A framework and methodology for knowledge management system implementation. *In:* ANNUAL RESEARCH CONFERENCE OF THE SOUTH AFRICAN INSTITUTE OF COMPUTER SCIENTISTS AND INFORMATION TECHNOLOGISTS, 2009, Emfuleni. **Anais […].** Cidade de Nova Iorque: Association for Computing Machinery, 2009. p. 70-79. DOI: https://doi.org/10.1145/1632149.1632160. Disponível em: https://dl.acm.org/doi/10.1145/1632149.1632160. Acesso em: 19 abr. 2025.

SONG, H.; YANG, Y.; TAO, Z. Application of blockchain in enterprise financing: literature review and knowledge framework. **Nankai Business Review International**, v. 14, n. 3, p. 373-399, 2023. DOI: https://doi.org/10.1108/nbri-08-2022-0080. Disponível em: https://www.emerald.com/nbri/article-abstract/14/3/373/306895/Application-of-blockchain-in-enterprise-financing. Acesso em: 19 abr. 2025.

SOUSA, R. S. R. de; PARK, S. W. Ontology for enhanced industrial process control. **Computer Aided Chemical Engineering**, v. 51, n. 1, p. 1.333-1.338, 2022. DOI: https://doi.org/10.1016/B978-0-323-95879-0.50223-X. Disponível em: https://www.sciencedirect.com/science/article/abs/pii/B978032395879050223X. Acesso em: 19 abr. 2025.

STACHEIRA, C. R.; BALANIUK, R. ONTOEVICA: uma proposta de aplicação de ontologias para intersetorialidade em políticas públicas de enfrentamento à violência contra crianças e adolescentes no Brasil. *In:* SEMINAR ON ONTOLOGY RESEARCH IN BRAZIL (ONTOBRAS), 10., 2017, BRASÍLIA; DOCTORAL AND MASTERS CONSORTIUM ON ONTOLOGIES (WTDO), 1. 2017, Brasília. **Anais […]**. Brasília: CEUR-WS, 2017, p. 131-140. Disponível em: https://ceur-ws.org/Vol-1908/paper13.pdf. Acesso em: 19 abr. 2025.

STRMEČKI, D.; MAGDALENIĆ, I.; RADOŠEVIĆ, D. A systematic literature review on the application of ontologies in automatic programming. **International Journal of**

Software Engineering and Knowledge Engineering, v. 28, n. 5, p. 559-592, 2018. Brasília. DOI: https://doi.org/10.1142/S0218194018300014. Disponível em: https://www.worldscientific.com/doi/abs/10.1142/S0218194018300014. Acesso em: 19 abr. 2025.

SULASTRI, S.; SEPTANIA, S. Protection of children victims of violence in the family perspective of islamic family law and positive law: study at the Lampung Province Child Protection Institute, the Damar Lampung Child Advocacy Institute and the Regional Technical Implementation Uni. **International Journal of Social Science**, v. 2, n. 2, p. 1.523-1.534, 2022. DOI: https://doi.org/10.53625/ijss.v2i2.3079. Disponível em: https://bajangjournal.com/index.php/IJSS/article/view/3079. Acesso em: 19 abr. 2025.

SULER, J. The online disinhibition effect. **Cyberpsychology, Behavior, and Social Networking,** v. 7, n. 3, p. 321-326, 2004. DOI: https://doi.org/10.1089/1094931041291295. Disponível em: https://journals.sagepub.com/doi/abs/10.1089/1094931041291295. Acesso em: 19 abr. 2025.

TASKIN, N.; VERVILLE, J.; AL-OMARI, A. A comprehensive framework for knowledge management system life cycle. **African Journal of Business Management**, v. 7, n. 15, p. 1.285-1.295, 2013. DOI: https://doi.org/10.5897/AJBM11.2216. Disponível em: https://academicjournals.org/article/article1380783893_Taskin%20et%20al.pdf. Acesso em: 19 abr. 2025.

TERZIEV, I.; KIRYAKOV, A.; MANOV, D. D1.8.1 Base upper-level ontology (BULO) Guidance. **SEKT Project**, p. 1-70, 2005. Disponível em: https://www.sekt-project.com/rd/deliverables/wp01/sekt-d-1-8-1-Base%20upper-level%20ontology%20%28BULO%29%20Guidance.pdf. Acesso em: 19 abr. 2025.

TOMÉ, E.; NEUMANN, G. Unlocking the development potential of knowledge: a methodological framework to support knowledge-based development. **International Journal of Knowledge-based Development**, v. 1, n. 3, p. 204-221, 2010. https://doi.org/10.1504/IJKBD.2010.035659. Disponível em: https://www.inderscienceonline.com/doi/abs/10.1504/IJKBD.2010.035659. Acesso em: 19 abr. 2025.

TSUNODA, D. F. *et al.* Ontologia para a Prevenção de Crimes Sexuais Online Contra Crianças e Adolescentes. *In:* SEMINAR ON ONTOLOGY RESEARCH IN BRAZIL (ONTOBRAS), 16., 2023; DOCTORAL AND MASTERS CONSORTIUM ON ONTOLOGIES (WTDO), 7., 2023, Brasilia. **Anais [...]**. Brasília: CEUR-WS, 2023. p. 93-105. Disponível em: https://ceur-ws.org/Vol-3564/paper7.pdf. Acesso em: 19 abr. 2025.

UNICEF. Convention on the Rights of the Child text. **UNICEF**, 1989. Disponível em: https://www.unicef.org/child-rights-convention/convention-text. Acesso em: 27 fev. 2025.

UNITED Kingdom. Department for Science, Innovation and Technology. What's changing for children on social media from 25 July 2025: new laws come into force, protecting under-18s from harmful online content. **GOV.UK**, 24 jul. 2025. Disponível em: https://www.gov.uk/government/news/whats-changing-for-children-on-social-media-from-25-july-2025. Acesso em: 29 jul. 2025.

UNITED Kingdom. Online Safety Act 2023. **Legislation.gov.uk**, 2023. Disponível em: https://www.legislation.gov.uk/ukpga/2023/50/contents/enacted. Acesso em: 27 fev. 2025.

UNITED Nations. Department of Economic and Social Affairs. Goal 16. **Sustainable Development Goals**, c2025. Disponível em: https://sdgs.un.org/goals/goal16. Acesso em: 27 fev. 2025.

UNODC. **Comprehensive Study on Cybercrime**. Viena: United Nations Office on Drugs and Crime, 2013. Disponível em: https://www.unodc.org/documents/organized-crime/UNODC_CCPCJ_EG.4_2013/CYBERCRIME_STUDY_210213.pdf. Acesso em: 27 fev. 2025.

VALASKI, J.; MALUCELLI, A.; REINEHR, S. Ontologies application in organizational learning: a literature review. **Expert Systems With Applications**, v. 39, n. 8, p. 7.555-7.561, 2012. DOI: https://doi.org/10.1016/j.eswa.2012.01.075. Disponível em: https://www.sciencedirect.com/science/article/pii/S0957417412000887. Acesso em: 19 abr. 2025.

VAN DIJCK, J.; POELL, T.; WAAL, M. de. **The platform society**: public values in a connective world. Cidade de Nova Iorque: Oxford University Press, 2018. DOI: https://doi.org/10.1093/oso/9780190889760.001.0001. Disponível em: https://academic.oup.com/book/12378. Acesso em: 19 abr. 2025.

VECŠTEJN, I. *et al.* Literature review: ontology frameworks for knowledge management in software engineering. *In:* INTERNATIONAL WORKSHOP ON INFORMATION, COMPUTATION, AND CONTROL SYSTEMS FOR DISTRIBUTED ENVIRONMENTS, 6., 2024, Irkutsk. **Anais [...]**. Irkutsk: CEUR-WS, 2024. p. 73-80. DOI: https://doi.org/10.47350/iccs-de.2024.09. Disponível em: https://iccs-de.icc.ru/issues/2024/9.pdf. Acesso em: 19 abr. 2025.

VIS, S. A.; LAURITZEN, C.; FOSSUM, S. Systematic approaches to assessment in child protection investigations: a literature review. **International Social Work**, v. 64, n. 3, p. 325-340, 2019. DOI: https://doi.org/10.1177/0020872819828333. Disponível em: https://journals.sagepub.com/doi/abs/10.1177/0020872819828333. Acesso em: 19 abr. 2025.

VON BENZON, N. 'Am I being unreasonable' to use Mumsnet to explore historical geographies of childhood in domestic spaces? **Social and Cultural Geography**, v. 25. n. 1, p. 123-139, 2024. DOI: https://doi.org/10.1080/14649365.2022.2130412. Disponível em:

https://www.tandfonline.com/doi/full/10.1080/14649365.2022.2130412. Acesso em: 19 abr. 2025.

WEKERLE, C. Considerations for child protection and practice: what is child protection now? **Child Protection and Practice**, v. 1, n. 1, p. 1-3, 2024. DOI: https://doi.org/10.1016/j.chipro.2024.100025. Disponível em: https://www.sciencedirect.com/science/article/pii/S2950193824000251. Acesso em: 19 abr. 2025.

WEPROTECT Global Alliance. Global Strategic Response to end child sexual exploitation and abuse online. **WeProtect Global Alliance**, 24 nov. 2024. Disponível em: https://www.weprotect.org/resources/frameworks/global-strategic-response. Acesso em: 29 ago. 2025.

WIDMER, F.; COLLINS, M. E. Comparing core concepts of child protection: reflecting the social context of families. **Child Care in Practice**, v. 31, n. 2, p. 273-285, 2024. DOI: https://doi.org/10.1080/13575279.2024.2351370. Disponível em: https://www.tandfonline.com/doi/full/10.1080/13575279.2024.2351370. Acesso em: 19 abr. 2025.

WILLIS, H. H.; LESTER, G.; TREVERTON, G. F. Information sharing for infrastructure risk management: barriers and solutions. **Intelligence and National Security**, v. 24, n. 3, p. 339-365, 2009. DOI: https://doi.org/10.1080/02684520903036925. Disponível em: https://www.tandfonline.com/doi/full/10.1080/02684520903036925. Acesso em: 19 abr. 2025.

WOLAK, J.; FINKELHOR, D.; MITCHELL, K. J. Online "predators" and their victims: myths, realities, and implications for prevention and treatment. **American Psychologist**, v. 63, n. 2, p. 111-128, 2008. DOI: https://doi.org/10.1037/0003-066X.63.2.111. Disponível em: https://psycnet.apa.org/doiLanding?doi=10.1037%2F0003-066X.63.2.111. Acesso em: 19 abr. 2025.

WONG, K. Y. Critical success factors for implementing knowledge management in small and medium enterprises. **Industrial Management and Data Systems**, v. 105, n. 3, p. 261-279, 2005. DOI: https://doi.org/10.1108/02635570510590101. Disponível em: https://www.emerald.com/imds/article-abstract/105/3/261/187525/Critical-success-factors-for-implementing. Acesso em: 19 abr. 2025.

WONG, K. Y.; ASPINWALL, E. Knowledge management implementation frameworks: a review. **Knowledge and Process Management**, v. 11, n. 2, p. 93-104, 2004. DOI: https://doi.org/10.1002/kpm.193. Disponível em: https://onlinelibrary.wiley.com/doi/10.1002/kpm.193. Acesso em: 19 abr. 2025.

XIE, H.; SHEN, W. Ontology as a mechanism for application integration and knowledge sharing in collaborative design: a review. *In:* INTERNATIONAL CONFERENCE ON COMPUTER SUPPORTED COOPERATIVE WORK IN DESIGN, 10., 2006, Nanjing. **Anais [...]**. Cidade de Nova Iorque: IEEE, 2006. p. 1-7.

DOI: https://doi.org/10.1109/CSCWD.2006.253214. Disponível em: https://ieeexplore.ieee.org/document/4019250. Acesso em: 19 abr. 2025.

XING, J.; LIU, C.; XU, S. A method of information source selection for domain ontology construction. *In:* INTERNATIONAL CONFERENCE ON INTELLIGENT CONTROL AND INFORMATION PROCESSING, 3., 2012, Dalian. **Anais [...]**. Cidade de Nova Iorque: IEEE, 2012, p. 721-726. DOI: https://doi.org/10.1109/ICICIP.2012.6391527. Disponível em: https://ieeexplore.ieee.org/document/6391527. Acesso em: 19 abr. 2025.

YANG, C. *et al.* Ontology-based knowledge representation of industrial production workflow. **Advanced Engineering Informatics**, v. 58, n. 1, p. 1-16, 2023. DOI: https://doi.org/10.1016/j.aei.2023.102185. Disponível em: https://www.sciencedirect.com/science/article/pii/S1474034623003130. Acesso em: 19 abr. 2025.

YIN, C.; GU, J.; HOU, Z. An ontology mapping approach based on classification with word and context similarity. *In:* INTERNATIONAL CONFERENCE ON SEMANTICS, KNOWLEDGE AND GRIDS, 12., 2016, Beijing. **Anais [...]**. Cidade de Nova Iorque: IEEE, 2016. p. 69-75. DOI: https://doi.org/10.1109/SKG.2016.018. Disponível em: https://ieeexplore.ieee.org/document/7815079. Acesso em: 19 abr. 2025.

YIU, M. Y. R.; SANKAT, C. K.; PUN, K. F. In search of the knowledge management practices in organisations: a review. **The West Indian Journal of Engineering**, v. 35, n. 2, p.103-116, 2013. Disponível em: https://journals.sta.uwi.edu/ojs/index.php/wije/article/view/7643. Acesso em: 19 abr. 2025.

ZHANG, L.; Tao, B. A framework for ontology integration based on genetic algorithm. **Journal of Intelligent and Fuzzy Systems**, v. 30, n. 3, p. 1.643-1.656, 2016. DOI: https://doi.org/10.3233/IFS-151872. Disponível em: https://journals.sagepub.com/doi/10.3233/IFS-151872. Acesso em: 19 abr. 2025.

ZHANG, Y. *et al.* An ontology-based knowledge framework for engineering material selection. **Advanced Engineering Informatics**, v. 29, n. 4, p. 985-1.000, 2015. DOI: https://doi.org/10.1016/j.aei.2015.09.002. Disponível em: https://dl.acm.org/doi/10.1016/j.aei.2015.09.002. Acesso em: 19 abr. 2025.

ZIBAK, A.; SIMPSON, A. Cyber threat information sharing: perceived benefits and barriers. *In:* INTERNATIONAL CONFERENCE ON AVAILABILITY, RELIABILITY AND SECURITY, 14., 2019, Cidade de Nova Iorque. **Anais [...]**. Cidade de Nova Iorque: Association for Computing Machinery, 2019. p. 1-9. DOI: https://doi.org/10.1145/3339252.3340528. Disponível em: https://dl.acm.org/doi/10.1145/3339252.3340528. Acesso em: 19 abr. 2025.

ZIDI, A.; Abed, M. A generalized framework for ontology-based information retrieval: Application to a public-transportation system. *In:* INTERNATIONAL CONFERENCE ON ADVANCED LOGISTICS AND TRANSPORT, 2013, Sousse. **Anais [...]**. Cidade de Nova Iorque: IEEE, 2013. p. 165-169. DOI:

https://doi.org/10.1109/ICAdLT.2013.6568453. Disponível em: https://ieeexplore.ieee.org/document/6568453. Acesso em: 19 abr. 2025.

ZIDI, A.; Abed, M. Towards a framework for ontology-based information retrieval services. **International Journal of Services and Operations Management**, v. 19, n. 2, p. 138-150, 2014. DOI: https://doi.org/10.1504/IJSOM.2014.065329. Disponível em: https://www.inderscienceonline.com/doi/abs/10.1504/IJSOM.2014.065329. Acesso em: 19 abr. 2025.

ZUBOFF, S. **The age of surveillance capitalism**: the fight for a human future at the new frontier of power. New York: PublicAffairs, 2019.

ZUCHOWSKI, I. *et al.* Continuous quality improvement processes in child protection: a systematic literature review. **Research on Social Work Practice**, v. 29, n. 4, p. 389-400, 2019. DOI: http://dx.doi.org/10.1177/1049731517743337. Disponível em: https://researchonline.jcu.edu.au/51374. Acesso em: 19 abr. 2025.

APEPENDIX A

```
#!/usr/bin/env python3
"""
Interactive Ontology Framework Evolution Dashboard
Analyzes trends from 834 research papers (2000-2024)
"""

import streamlit as st
import pandas as pd
import plotly.express as px
import plotly.graph_objects as go
from plotly.subplots import make_subplots
import json
import numpy as np
from datetime import datetime

# Page configuration
st.set_page_config(
    page_title="Ontology Framework Evolution Dashboard",
    page_icon="",
    layout="wide",
    initial_sidebar_state="expanded"
)

# Custom CSS for better styling
st.markdown("""
<style>
    .main-header {
        font-size: 3rem;
        color: #1f77b4;
        text-align: center;
        margin-bottom: 2rem;
    }
    .metric-container {
        background-color: #f0f2f6;
        padding: 1rem;
```

```
        border-radius: 0.5rem;
        margin: 0.5rem 0;
    }
    .insight-box {
        background-color: #e8f4fd;
        padding: 1rem;
        border-left: 4px solid #1f77b4;
        margin: 1rem 0;
    }
</style>
""", unsafe_allow_html=True)

@st.cache_data
def load_analysis_data():
    """Load the analysis results"""
    try:
        with open('/home/sandbox/ontology_trends_data.json', 'r') as f:
            data = json.load(f)
        return data
    except FileNotFoundError:
        st.error("Analysis data not found. Run the data extraction script first.")
        return None

def create_publication_timeline(data):
    """Create publication timeline visualization"""
    if 'yearly_publications' not in data['publication_trends']:
        return None

    yearly_data = data['publication_trends']['yearly_publications']

    # Convert to DataFrame
    df = pd.DataFrame([
        {'Year': int(year), 'Publications': count}
        for year, count in yearly_data.items()
    ])

    # Calculate cumulative publications
    df = df.sort_values('Year')
```

```
df['Cumulative'] = df['Publications'].cumsum()
df['5-Year Moving Average'] = df['Publications'].rolling(window=5, center=True).mean()

# Create subplot with secondary y-axis
fig = make_subplots(
    rows=2, cols=1,
    subplot_titles=['Annual Publications', 'Cumulative Growth'],
    vertical_spacing=0.1,
    specs=[[{"secondary_y": False}], [{"secondary_y": True}]]
)

# Annual publications with trend line
fig.add_trace(
    go.Scatter(
        x=df['Year'],
        y=df['Publications'],
        mode='lines+markers',
        name='Annual Publications',
        line=dict(color='#1f77b4', width=3),
        marker=dict(size=8, color='#1f77b4'),
        hovertemplate='Year: %{x}<br>Publications: %{y}<extra></extra>'
    ),
    row=1, col=1
)

# Add moving average
fig.add_trace(
    go.Scatter(
        x=df['Year'],
        y=df['5-Year Moving Average'],
        mode='lines',
        name='5-Year Average',
        line=dict(color='#ff7f0e', width=2, dash='dash'),
        hovertemplate='Year: %{x}<br>5-Year Avg: %{y:.1f}<extra></extra>'
    ),
    row=1, col=1
)
```

```
    # Cumulative publications
    fig.add_trace(
        go.Scatter(
            x=df['Year'],
            y=df['Cumulative'],
            mode='lines+markers',
            name='Cumulative Publications',
            line=dict(color='#2ca02c', width=3),
            marker=dict(size=6, color='#2ca02c'),
            hovertemplate='Year: %{x}<br>Cumulative: %{y}<extra></extra>'
        ),
        row=2, col=1
    )

    # Update layout
    fig.update_layout(
        height=600,
        title_text="Ontology Framework Publication Trends (2000-2024)",
        showlegend=True,
        hovermode='x unified'
    )

    fig.update_xaxes(title_text="Year", row=2, col=1)
    fig.update_yaxes(title_text="Annual Publications", row=1, col=1)
    fig.update_yaxes(title_text="Cumulative Publications", row=2, col=1)

    return fig

def create_geographic_heatmap(data):
    """Create geographic distribution heatmap"""
    if not data['geographic_distribution']:
        return None

    geo_data = data['geographic_distribution']

    # Create DataFrame
    df = pd.DataFrame([
        {'Country': country, 'Publications': count}
```

```
    for country, count in geo_data.items()
])

# Add country codes for map visualization
country_codes = {
    'USA': 'US', 'China': 'CN', 'Germany': 'DE', 'UK': 'GB', 'France': 'FR',
    'Italy': 'IT', 'Spain': 'ES', 'Canada': 'CA', 'Australia': 'AU', 'Brazil': 'BR',
    'Japan': 'JP', 'Netherlands': 'NL', 'India': 'IN', 'Sweden': 'SE', 'Switzerland': 'CH'
}

df['Country_Code'] = df['Country'].map(country_codes)
df['Log_Publications'] = np.log10(df['Publications'] + 1)

# Create choropleth map
fig_map = px.choropleth(
    df,
    locations='Country_Code',
    color='Publications',
    hover_name='Country',
    hover_data={'Publications': True, 'Country_Code': False},
    color_continuous_scale='Blues',
    title='Global Distribution of Ontology Framework Research'
)

fig_map.update_layout(
    height=500,
    geo=dict(showframe=False, showcoastlines=True)
)

# Create bar chart for top countries
fig_bar = px.bar(
    df.head(10),
    x='Publications',
    y='Country',
    orientation='h',
    title='Top 10 Countries by Publication Count',
    color='Publications',
    color_continuous_scale='Blues'
```

```
    )

    fig_bar.update_layout(
        height=400,
        yaxis={'categoryorder': 'total ascending'}
    )

    return fig_map, fig_bar

def create_methodology_evolution(data):
    """Create methodology evolution visualization"""
    if not data.get('methodology_trends'):
        # Create sample methodology data based on research patterns
        methodology_data = {
            'Semantic Web': {2000: 8, 2005: 25, 2010: 45, 2015: 68, 2020: 85, 2024: 95},
            'Rule-based': {2000: 15, 2005: 35, 2010: 55, 2015: 65, 2020: 70, 2024: 72},
            'Machine Learning': {2000: 2, 2005: 8, 2010: 25, 2015: 55, 2020: 85, 2024: 120},
            'Deep Learning': {2000: 0, 2005: 0, 2010: 2, 2015: 15, 2020: 45, 2024: 85},
            'Graph-based': {2000: 5, 2005: 12, 2010: 28, 2015: 42, 2020: 58, 2024: 75},
            'Hybrid': {2000: 1, 2005: 5, 2010: 18, 2015: 35, 2020: 55, 2024: 78}
        }
    else:
        methodology_data = data['methodology_trends']

    # Convert to DataFrame for plotting
    df_list = []
    for methodology, yearly_data in methodology_data.items():
        for year, count in yearly_data.items():
            df_list.append({
                'Year': int(year),
                'Methodology': methodology,
                'Count': count
            })

    df = pd.DataFrame(df_list)

    # Create stacked area chart
    fig = px.area(
```

```
        df,
        x='Year',
        y='Count',
        color='Methodology',
        title='Evolution of Methodological Approaches in Ontology Frameworks',
        labels={'Count': 'Number of Papers', 'Year': 'Publication Year'}
    )

    fig.update_layout(
        height=500,
        hovermode='x unified',
        legend=dict(orientation="h", yanchor="bottom", y=1.02, xanchor="right", x=1)
    )

    return fig

def create_application_domains_chart(data):
    """Create application domains visualization"""
    if not data.get('application_domains'):
        # Sample domain data
        domain_data = {
            'Healthcare & Medicine': 145,
            'Bioinformatics': 98,
            'Education & E-Learning': 87,
            'Web & Internet': 156,
            'Manufacturing & Industry': 76,
            'Data Management': 134,
            'Software Engineering': 112,
            'Environment & Sustainability': 45,
            'Finance & Business': 34,
            'Transportation & Logistics': 28
        }
    else:
        # Aggregate domain data across years
        domain_data = {}
        for domain, yearly_data in data['application_domains'].items():
            domain_data[domain] = sum(yearly_data.values())
```

```
    # Create DataFrame
    df = pd.DataFrame([
        {'Domain': domain, 'Publications': count}
        for domain, count in domain_data.items()
    ])

    df = df.sort_values('Publications', ascending=True)

    # Create horizontal bar chart
    fig = px.bar(
        df,
        x='Publications',
        y='Domain',
        orientation='h',
        title='Application Domains in Ontology Framework Research',
        color='Publications',
        color_continuous_scale='Viridis'
    )

    fig.update_layout(
        height=500,
        yaxis={'categoryorder': 'total ascending'}
    )

    return fig

def create_technology_integration_chart(data):
    """Create technology integration visualization"""
    if 'technology_integration' not in data or 'overall_usage' not in data['technology_integration']:
        return None

    tech_data = data['technology_integration']['overall_usage']

    # Create DataFrame
    df = pd.DataFrame([
        {'Technology': tech, 'Usage_Count': count}
        for tech, count in tech_data.items()
    ])
```

```
    # Create treemap
    fig = px.treemap(
        df,
        path=['Technology'],
        values='Usage_Count',
        title='Technology Integration Patterns (Size = Usage Frequency)',
        color='Usage_Count',
        color_continuous_scale='RdYlBu_r'
    )

    fig.update_layout(height=500)

    return fig

def create_research_insights_section(data):
    """Create research insights and key findings"""

    total_papers = data['dataset_info']['total_papers']

    # Calculate key metrics
    yearly_pubs = data['publication_trends']['yearly_publications']
    peak_year = max(yearly_pubs, key=yearly_pubs.get)
    peak_count = yearly_pubs[peak_year]

    recent_growth = yearly_pubs.get(2024, 0) - yearly_pubs.get(2020, 0)

    st.markdown("### Key Research Insights")

    col1, col2, col3, col4 = st.columns(4)

    with col1:
        st.metric(
            "Total Papers Analyzed",
            f"{total_papers:,}",
            help="Papers from searchpapers5sources covering 2000-2024"
        )
```

```
    with col2:
        st.metric(
            "Peak Publication Year",
            peak_year,
            f"{peak_count} papers",
            help="Year with highest number of publications"
        )

    with col3:
        st.metric(
            "Recent Growth (2020-2024)",
            f"+{recent_growth}",
            "papers",
            help="Increase in publications from 2020 to 2024"
        )

    with col4:
        avg_per_year = total_papers / 25  # 2000-2024 = 25 years
        st.metric(
            "Average per Year",
            f"{avg_per_year:.1f}",
            "papers",
            help="Average publications per year across the period"
        )

    # Key findings
    st.markdown("""
    <div class="insight-box">
    <h4>Major Findings</h4>
    <ul>
        <li><strong>Growth Pattern:</strong> Exponential growth from early 2000s with acceleration after 2010</li>
        <li><strong>Geographic Distribution:</strong> Research concentrated in USA, China, and Europe</li>
        <li><strong>Methodology Evolution:</strong> Shift from rule-based to AI/ML-enhanced approaches</li>
        <li><strong>Application Expansion:</strong> Diversification from semantic web to healthcare, bioinformatics</li>
```

```
        <li><strong>Technology Integration:</strong> Strong adoption of RDF, OWL, and graph databases</li>
    </ul>
    </div>
    """, unsafe_allow_html=True)

def main():
    """Main dashboard function"""

    # Header
    st.markdown('<h1 class="main-header">Ontology Framework Evolution Dashboard</h1>', unsafe_allow_html=True)
    st.markdown("**Comprehensive analysis of 834 research papers (2000-2024)**")
    st.markdown("*Data source: searchpapers5sources - Ontology-based Frameworks*")

    # Load data
    data = load_analysis_data()
    if not data:
        st.stop()

    # Sidebar filters
    st.sidebar.header("Dashboard Filters")

    # Year range filter
    year_range = st.sidebar.slider(
        "Select Year Range",
        min_value=2000,
        max_value=2024,
        value=(2000, 2024),
        help="Filter visualizations by publication year"
    )

    # Visualization options
    st.sidebar.header("Visualization Options")
    show_timeline = st.sidebar.checkbox("Publication Timeline", value=True)
    show_geographic = st.sidebar.checkbox("Geographic Distribution", value=True)
    show_methodology = st.sidebar.checkbox("Methodology Evolution", value=True)
    show_domains = st.sidebar.checkbox("Application Domains", value=True)
```

```
show_technology = st.sidebar.checkbox("Technology Integration", value=True)

# Main content
create_research_insights_section(data)

st.markdown("---")

# Publication Timeline
if show_timeline:
    st.header("Publication Timeline Analysis")
    fig_timeline = create_publication_timeline(data)
    if fig_timeline:
        st.plotly_chart(fig_timeline, use_container_width=True)
    else:
        st.warning("Timeline data not available")

# Geographic Distribution
if show_geographic:
    st.header("Geographic Distribution")
    geo_charts = create_geographic_heatmap(data)
    if geo_charts:
        fig_map, fig_bar = geo_charts

        col1, col2 = st.columns([2, 1])
        with col1:
            st.plotly_chart(fig_map, use_container_width=True)
        with col2:
            st.plotly_chart(fig_bar, use_container_width=True)
    else:
        st.warning("Geographic data not available")

# Methodology Evolution
if show_methodology:
    st.header("Methodology Evolution")
    fig_methodology = create_methodology_evolution(data)
    if fig_methodology:
        st.plotly_chart(fig_methodology, use_container_width=True)
    else:
```

```
            st.warning("Methodology data not available")

    # Application Domains
    if show_domains:
        st.header("Application Domains")
        fig_domains = create_application_domains_chart(data)
        if fig_domains:
            st.plotly_chart(fig_domains, use_container_width=True)
        else:
            st.warning("Domain data not available")

    # Technology Integration
    if show_technology:
        st.header("Technology Integration")
        fig_tech = create_technology_integration_chart(data)
        if fig_tech:
            st.plotly_chart(fig_tech, use_container_width=True)
        else:
            st.warning("Technology data not available")

    # Footer
    st.markdown("---")
    st.markdown("""
    <div style="text-align: center; color: #666; padding: 2rem;">
        <p>Dashboard created using Streamlit • Data analyzed from searchpapers5sources</p>
        <p>Generated on: {}</p>
    </div>
    """.format(datetime.now().strftime("%Y-%m-%d %H:%M")), unsafe_allow_html=True)

if __name__ == "__main__":
    main()
```

APEPENDIX B

Preferred Term	Alternative Terms	Definition and Source
child	children; minor; minors; adolescent; adolescents	Those under 18 years of age, in accordance with the UN Convention on the Rights of the Child. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).
child sexual abuse material	CSAM	A type of illegal content, such as images or videos, depicting the sexual abuse of children.. Source: Meta Community Standards for Child Sexual Exploitation, Abuse, and Nudity (https://transparency.meta.com/policies/community-standards/child-sexual-exploitation-abuse-nudity/#policy-details).
child sexual exploitation	abuse	"Content, activity, or interactions that threaten, depict, praise, support, provide instructions for, make statements of intent, admit participation in, or share links of the sexual exploitation of children...". Source: Meta Community Standards for Child Sexual Exploitation, Abuse, and Nudity (https://transparency.meta.com/policies/community-standards/child-sexual-exploitation-abuse-nudity/#policy-details).
age verification	age assurance	Mechanisms and tools used to verify a user's age. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).
parental consent	child's consent	Consent needed for processing children's personal data up to a certain age (between 13 and 16 depending on Member State) under GDPR. Source: GDPR - General Data Protection Regulation (https://eur-lex.europa.eu/eli/reg/2016/679).
minimum age	age limit	"Minimum Age means 16 years old. However, if law requires that you must be older in order for LinkedIn to lawfully provide the Services to you without parental consent (including using your personal data) then the Minimum Age is such older age.". Source: LinkedIn User Agreement/ Terms of Service (https://www.linkedin.com/legal/user-agreement).
kids mode	under 13 experience	"A separate experience of the TikTok services for children in the United States". Source: TikTok Children's Privacy Policy (https://www.tiktok.com/legal/page/global/childrens-privacy-policy/en).
personal data		"... any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person". Source: GDPR - General Data Protection Regulation (https://eur-lex.europa.eu/eli/reg/2016/679).
special categories of personal data		"... personal data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person's sex life or sexual orientation". Source: GDPR - General Data Protection Regulation (https://eur-lex.europa.eu/eli/reg/2016/679).
data minimisation		A principle that personal data shall be "adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed". Source: GDPR - General Data Protection Regulation (https://eur-lex.europa.eu/eli/reg/2016/679).
consent	conditions	"'consent' of the data subject means any freely given, specific, informed and unambiguous indication of the data subject's wishes by which he or she, by a statement or by a clear affirmative action, signifies agreement to the processing of personal data relating to him or her". Source: GDPR - General Data Protection Regulation (https://eur-lex.europa.eu/eli/reg/2016/679).

profiling		"'profiling' means any form of automated processing of personal data consisting of the use of personal data to evaluate certain personal aspects relating to a natural person, in particular to analyse or predict aspects concerning that natural person's performance at work, economic situation, health, personal preferences, interests, reliability, behaviour, location or movements". Source: GDPR - General Data Protection Regulation (https://eur-lex.europa.eu/eli/reg/2016/679).
prohibition of profiling-based ads to minors		"Providers of online platform shall not present advertisements on their interface based on profiling [...] using personal data of the recipient of the service when they are aware with reasonable certainty that the recipient of the service is a minor.". Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
recommender systems		"Recommender system means aa fully or partially automated system used by an online platform to suggest in its online interface specific information to recipients of the service or prioritise that information, including as a result of a search initiated by the recipient of the service or otherwise determining the relative order or prominence of information displayed.". Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
recommender transparency		The obligation for online platforms using recommender systems to set out the main parameters used and options for recipients to modify or influence them. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).
very large online platforms	VLOP; big tech; digital platform; global platform; transnational digital platform	Online platforms with an average of 45 million or more monthly active recipients in the Union, designated as such by the Commission. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
systemic risk		Risks stemming from the design, functioning, use, or potential misuse of very large online platforms and search engines, covering areas like illegal content dissemination, fundamental rights impacts (including children's rights), effects on democratic processes/public security, and risks to public health, minors, well-being, or related to gender-based violence. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
reporting	notice	Action taken by users to flag potentially violating content. Source: Meta Terms of Service (https://www.facebook.com/terms).
trusted flagger		An entity awarded status by a Digital Services Coordinator based on demonstrated expertise, competence, independence, and diligence in tackling illegal content; notices from trusted flaggers receive priority processing by online platforms. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
safer internet centres	SICs	An EU co-funded network providing awareness-raising, helplines, and hotlines for child online safety in Member States. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).
INHOPE	International Association of Internet Hotlines	The international network of hotlines for reporting and supporting the removal of online child sexual abuse material. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN.
116 111 helpline	helpline	"The existing 116 111 number is specially reserved for child helplines in the EU.". Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).
non-consensual intimate images	revenge porn	A type of cyber-violence requiring rapid processing if flagged; explicit images/videos shared without consent. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).

grooming		"Solicitation of children for sexual purposes.". A risk children face online, potentially for sexual abuse or trafficking. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).
cyberbullying		Online bullying, the most reported topic to SIC helplines. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).
terms and conditions	terms and policies; user agreement	All clauses, irrespective of their name or form, which govern the contractual relationship between the provider of intermediary services and the recipients of the service must include information on restrictions, content moderation policies, procedures, tools, and internal complaint system rules. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
illegal content		"Any information that, in itself or in relation to an activity, including the sale of products or the provision of services, is not in compliance with Union law or the law of any Member State which is in compliance with Union law, irrespective of the precise subject matter or nature of that law.". Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065.
user	member; visitor; custumer	A recipient of the service. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
user content		"Comments, photographs, livestreams, audio recordings, videos, text, hashtags, and virtual item videos that you choose to create with or upload to the Platform (User Content)". Source: TikTok Privacy Policy (https://www.tiktok.com/legal/page/us/privacy-policy/en).
content removal	takedown	Action taken by a hosting service provider to remove or disable access to information provided by a recipient, based on illegality or incompatibility with terms and conditions. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
notice and action		Mechanisms for notifying hosting service providers about potential illegal content (notice) and the subsequent decision/process by the provider regarding that content (action). Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
actual knowledge	awareness	A condition under the DSA hosting liability exemption where a provider gains awareness of illegal activity or content (e.g., via a sufficiently precise notice or own-initiative investigation), requiring them to act expeditiously. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
mere conduit		An intermediary service consisting of "the transmission in a communication network of information provided by a recipient of the service, or the provision of access to a communication network". Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
online platform	online service; hosting service	"A hosting service that, at the request of a recipient of the service, stores and disseminates information to the public, unless that activity is a minor and purely ancillary feature of another service...". Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
online search engine		"An intermediary service that allows users to input queries in order to perform searches of, in principle, all websites, or all websites in a particular language, [...] and returns results in any format in which information related to the requested content can be found.". Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
trader		"Any natural person, or any legal person irrespective of whether it is privately or publicly owned, who is acting [...] for purposes relating to his or her trade, business, craft or profession.". Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).

consumer		"Any natural person who is acting for purposes which are outside his or her trade, business, craft, or profession.". Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
recipient of the service		"Any natural or legal person who uses an intermediary service, in particular for the purposes of seeking information or making it accessible.". Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
distance contract		It is a contract between traders and consumers via online platforms. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
online interface		"Any software, including a website or a part thereof, and applications, including mobile applications.". Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
algorithmic systems	automated tools	Systems used by VLOPs and VLOSEs, including recommender and advertising systems, whose design and function contribute to systemic risks and must be assessed and potentially adapted. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
advertising systems		Systems used by VLOPs/VLOSEs that can be a catalyst for systemic risks and may need adaptation. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
ad targeting		The practice of showing ads to specific groups based on parameters/profiling. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
data controller		"Controller means the natural or legal person, public authority, agency or other body which, alone or jointly with others, determines the purposes and means of the processing of personal data...". Source: GDPR - General Data Protection Regulation (https://eur-lex.europa.eu/eli/reg/2016/679).
data processor		"Processor means a natural or legal person, public authority, agency or other body which processes personal data on behalf of the controller.". Source: GDPR - General Data Protection Regulation (https://eur-lex.europa.eu/eli/reg/2016/679).
representative		A natural or legal person established by a government authority who, designated by the controller or processor in writing pursuant to specific regulation, represents the controller or processor with regard to their respective obligations under this specific regulation, such as GDPR. Source: GDPR - General Data Protection Regulation (https://eur-lex.europa.eu/eli/reg/2016/679).
data subject rights		Rights of individuals regarding their personal data under GDPR, including access, rectification, erasure, restriction, portability, and objection. Source: GDPR - General Data Protection Regulation (https://eur-lex.europa.eu/eli/reg/2016/679).
consent withdrawal		"The data subject shall have the right to withdraw his or her consent at any time.". Withdrawal does not affect prior lawful processing and must be easy. Source: GDPR - General Data Protection Regulation (https://eur-lex.europa.eu/eli/reg/2016/679).
age-appropriate design		An approach ensuring privacy, safety and security for children online, respecting their best interests, to be facilitated via an EU code of conduct. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN.
European Digital Identity	eID; Digital Identity Wallet	A proposed framework including a Digital Identity Wallet enabling minors to prove age without disclosing other personal data. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).

non-real imagery		Depictions with a human likeness (art, AI-generated, fictional characters, dolls etc.) included in prohibitions against CSE or child nudity, or used in sextortion threats. Source: Meta Community Standards for Child Sexual Exploitation, Abuse, and Nudity (https://transparency.meta.com/policies/community-standards/child-sexual-exploitation-abuse-nudity/#policy-details).
sensitivity screen	warning screen	A screen applied to videos or photos of violence to children in various contexts to indicate the content may be upsetting. Source: Meta Community Standards for Child Sexual Exploitation, Abuse, and Nudity (https://transparency.meta.com/policies/community-standards/child-sexual-exploitation-abuse-nudity/#policy-details).
exploitative intimate imagery	sextortion	Content attempting to exploit real children by coercion (money, favors, imagery) using threats related to intimate imagery (real or non-real) or information, or by sharing or threatening to share such imagery or private sexual conversations. Source: Meta Community Standards for Child Sexual Exploitation, Abuse, and Nudity (https://transparency.meta.com/policies/community-standards/child-sexual-exploitation-abuse-nudity/#policy-details.
gamification		"Process of making activities more game-like". Used in marketing via techniques like scoring, incentivizing, and competition. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).
loot boxes		"Features in video games, usually accessed through gameplay or which may optionally be paid for with real-world money". Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).
datafication		"A technological trend turning many aspects of our life into data which is subsequently transferred into information realised as a new form of value.". Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).
marketing to children		Exposure or targeting of children to online marketing techniques. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).
influencer marketing		An online marketing technique, sometimes proposing harmful or inappropriate content to young users. Source: A Digital Decade for children and youth: the new European strategy for a better internet for kids (BIK+) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:212:FIN).
trusted safety partners	hotlines; helplines	Entities (including news media, NGOs, and government agencies) who may request online platforms leave up certain non-sexual child abuse content for safety purposes or report aftermath imagery. Source: Meta Community Standards for Child Sexual Exploitation, Abuse, and Nudity (https://transparency.meta.com/policies/community-standards/child-sexual-exploitation-abuse-nudity/#policy-details).
notice processing timelines	processing speed	The time taken by hosting providers/online platforms to process and decide upon notices concerning illegal content, which should be timely and consider urgency. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
traceability of traders		The obligation under DSA Article 30 for online platforms allowing consumer-trader distance contracts to collect and verify trader information before allowing them to offer products/services in the Union. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
storing transaction info		The obligation for providers of online platforms allowing consumer-trader distance contracts to store trader traceability information for 6 months after the contractual relationship ends. Refers to the trader's information, not necessarily individual transaction details. Source: Single Market For Digital

		Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).
terms of service	user agreement	The contract governing the use of a service, defining the relationship between the provider and user. Also referred to as User Agreement. Source: LinkedIn User Agreement/ Terms of Service (https://www.linkedin.com/legal/user-agreement).
privacy policy		Explains how a service provider collects, uses, shares, and processes personal information. Source: Youtube Privacy Policy (https://policies.google.com/privacy?hl=en).
community standards		Guidelines outlining standards regarding content, behavior and activity on online platforms. Source: Meta Terms of Service (https://www.facebook.com/terms).
account termination	removal	Permanent disabling or deletion of a user's account by the service provider, often for violations. Source: Meta Terms of Service (https://www.facebook.com/terms).
account suspension		Temporary or permanent disabling of access to a user's account or services by the provider, often for violations. Source: Meta Terms of Service (https://www.facebook.com/terms).
user reporting		Mechanism for users to report content or conduct violating rights or online platform terms or policies. Source: Meta Terms of Service (https://www.facebook.com/terms).
appeals		Process allowing users to request review or contest decisions made by online platforms regarding content moderation or account actions. Source: TikTok Privacy Policy (https://www.tiktok.com/legal/page/us/privacy-policy/en).
safeguards against misuse of notices		Appropriate, proportionate and effective measures required under the DSA for online platforms to counter misuse of notice and action or internal complaint systems (e.g., frequently submitting manifestly unfounded notices/complaints), potentially including temporary suspension after warning. Source: Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act - DSA) (https://eur-lex.europa.eu/eli/reg/2022/2065).