Augmented Knowledge Base Creation and Curation using Large Language Models: A Proof-of-Concept Implementation

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Abstract: This paper presents the Chelle Knowledge Model (CKM), a novel framework for leveraging Large Language Models (LLMs) in organizational knowledge management. The research addresses critical challenges in maintaining knowledge currency, accessibility, and scalability through automated knowledge extraction and organization. We present a proof-of-concept implementation demonstrating the practical application of zero-shot information extraction techniques, context-aware knowledge processing, and human-in-the-loop validation. The implementation reveals that while significant technical challenges exist in scaling LLM-based knowledge management systems, these challenges are primarily engineering problems rather than fundamental limitations. Our findings suggest that automated ontology creation can transform organizational knowledge management by enabling rapid, iterative knowledge structuring and deployment.

Note: *The length of this paper is significantly longer than the 10-12 page limit, however, the bulk of this is the appendices and the Chelle Knowledge Model. The actual paper is about 12 pages.*

I. Introduction

Organizations face significant challenges in managing their institutional knowledge. Studies show that employees spend 19% of their time searching for and gathering information (Chui et al., 2012), while knowledge silos impair organizational decision-making processes (Deloitte, 2020). The volume of organizational data continues to grow exponentially (Taylor, 2023; Gartner, 2023), with information scattered across departments, systems, versions, and documents (Deloitte, 2020). These inefficiencies represent both operational and productivity costs.

The knowledge management challenge encompasses several key dimensions. First, organizations must maintain knowledge currency in rapidly evolving fields (Tamayo et al., 2023). Second, they must address departmental silos that

prevent effective knowledge sharing (Cross et al., 2004). Third, they must ensure consistent knowledge access across their workforce while managing domain-specific vocabulary and concepts (Otero et al., 2015). Traditional knowledge management approaches, based on manual curation and hierarchical structures, have limitations in addressing these needs (AIIM, 2023). Research indicates that knowledge management effectiveness decreases as organizational complexity increases, with larger enterprises reporting lower satisfaction rates with their systems (Heisig et al., 2016).

The emergence of Large Language Models (LLMs) presents new opportunities for addressing these organizational knowledge management challenges. Recent research demonstrates that LLMs can significantly enhance knowledge extraction and ontology development processes (Babaei Giglou et al., 2023). However, effective implementation requires addressing several technical challenges, including context limitations and potential hallucination issues (Bikeyev, 2023; Wang et al., 2023).

This paper presents the Chelle Knowledge Model (CKM), a novel approach to organizational knowledge management that leverages LLMs for automated knowledge extraction and organization, along with a proof-of-concept implementation demonstrating its practical application. The CKM specifically addresses the challenges of knowledge currency, accessibility, and scalability through a structured approach to knowledge processing and organization.

The CKM framework integrates three core components for knowledge processing: entity extraction, relation extraction, and ontology mapping. This approach builds on recent advances in zero-shot learning for knowledge base population (Caufield et al., 2024) and entity mapping (Matentzoglu et al., 2023). The system employs a human-in-the-loop validation approach to ensure accuracy and build trust in automated knowledge extraction processes.

The core architecture of CKM comprises:

1. A Knowledge Extractor Application that processes unstructured textual data
2. Document Processing Models that handle entity extraction, relation extraction, and ontology mapping
3. An integration layer that connects these components while maintaining semantic consistency
4. A validation framework that ensures extracted knowledge accuracy

This approach differs from traditional knowledge management systems in several key aspects. First, it employs zero-shot information extraction techniques (Wei et al., 2024) to reduce manual curation requirements. Second, it maintains explicit context tracking and versioning to preserve semantic integrity across different organizational contexts. Third, it implements formal relationship modeling that allows for flexible knowledge evolution while maintaining consistency. The accompanying proof-of-concept implementation demonstrates the practical feasibility of these concepts.

Contributions

The contributions of this work include:

1. A novel framework for structuring LLM interactions in knowledge management that specifically addresses organizational challenges. The CKM approach demonstrates how LLMs can be effectively integrated into existing knowledge management processes while maintaining semantic consistency and supporting natural knowledge evolution (Matentzoglu et al., 2023).

2. A proof-of-concept implementation that validates the feasibility of automated knowledge extraction and organization using LLMs. The implementation demonstrates practical solutions to challenges in scaling LLM-based knowledge processing systems, particularly in handling complex document processing workloads and managing worker load balancing.

3. Practical insights into the challenges and solutions for LLM-based knowledge processing in organizational contexts. While existing research has focused on theoretical approaches to knowledge extraction (Caufield et al., 2024), this work provides concrete implementation strategies and identifies specific engineering considerations for deploying such systems at scale.

4. A framework for context-aware knowledge extraction that preserves semantic relationships across different organizational contexts. This extends current approaches to ontology learning (Babaei Giglou et al., 2023) by incorporating explicit context management and relationship modeling.

5. Architectural patterns for building scalable knowledge processing systems that integrate LLMs with traditional knowledge management approaches. These patterns address practical concerns such as worker load balancing, API management, and system scalability while maintaining semantic consistency in knowledge extraction and organization.

The research and implementation demonstrate that while significant technical challenges exist in scaling LLM-based knowledge management systems, these challenges are primarily engineering problems rather than fundamental limitations of the approach. The successful implementation of core functionality supports the viability of using LLMs to transform organizational knowledge management through automated extraction and organization processes.

The remainder of this paper is organized as follows: Section II presents the Chelle Knowledge Model (CKM) in detail, including its design principles and core components. Section III describes the knowledge processing pipeline implementation and technical architecture. Section V discusses implementation progress, challenges, and implications for future work. Finally, Section VI concludes with an analysis of the transformative potential of automated ontology creation in organizational knowledge management.

II. The Chelle Knowledge Model (CKM)

Overview and Motivation

Traditional knowledge bases often fail to effectively manage and preserve context, leading to significant inefficiencies in knowledge extraction and application. According to AIIM (2023), 74% of organizational content systems remain disconnected from other business systems, creating persistent knowledge silos. The rapid growth of scientific and technical literature further compounds these challenges, outpacing traditional manual curation efforts (Caufield et al., 2024).

The Chelle Knowledge Model addresses these limitations through a structured approach to knowledge organization and processing. The model recognizes that knowledge meaning and relationships evolve with context, necessitating a formal framework for preserving semantic integrity while supporting natural knowledge evolution.

Design Principles

The Chelle Knowledge Model (CKM) is founded on five fundamental design principles:

1. **Semantic Integrity and Context Preservation**

- Explicit context tracking across all knowledge transformations
- Version control for all knowledge elements
- Provenance tracking from raw assets through refined knowledge
- Preservation of semantic relationships across organizational contexts

2. **Mathematical Formalism**

- Complete lattice structure for relationship hierarchies
- Formal relationship classification system with precise mathematical semantics
- Computationally verifiable constraints and validations
- Rigorous dependency management through directed acyclic graphs

3. **Operational Transparency**

- Bidirectional traceability between conceptual and operational elements
- Explicit validation requirements at every transformation step
- Complete audit trails for all knowledge operations
- Clear separation between raw assets and refined knowledge

4. **Knowledge Evolution Management**

- Structured approaches for handling concept relationships over time
- Formal procedures for relationship validation and strength calculations
- Systematic mapping validation across knowledge domains
- Clear versioning and inheritance rules for knowledge structures

5. **Human-in-the-Loop Validation**

- Explicit roles for knowledge curation and oversight
- Authority designation for knowledge validation
- Systematic quality checks with human verification
- Clear certification processes for knowledge understanding

Core Components

The CKM implements its design principles through three integrated layers:

1. **Knowledge Foundation Layer**

- Knowledge Representation: Manages raw assets, refined knowledge, and their relationships
- Semantic Layer: Implements the complete relationship lattice and validation framework
- Context Management: Handles organizational context, versioning, and knowledge evolution

2. **Operational Layer**

- Implementation Framework: Transforms abstract concepts into concrete operational elements
- Validation System: Ensures consistency between conceptual and operational components
- Tools & Templates: Standardized patterns for knowledge implementation

3. **Instruction Layer**

- Assessment Framework: Measures and validates understanding levels
- Role Management: Handles mentor/learner interactions and authority designation
- Learning Structure: Organizes knowledge into guides and learning paths

Each layer maintains bidirectional traceability and implements the model's mathematical formalism through computably verifiable constraints and validations.

Implementation Considerations

Theoretical Requirements The theoretical framework of CKM translates into specific technical requirements across three key areas: document processing, storage architecture, and integration requirements. Document processing encompasses context-aware lexeme identification, relationship detection within and across contexts, and validation against formal CKM rules. The storage architecture demands context-preserving schema design, efficient indexing for context-based retrieval, version control implementation, and change tracking across contexts.

Integration requirements focus on four critical aspects:

- API design for LLM interaction
- Worker load balancing for scalable processing
- Cache management for efficient retrieval
- Human-in-the-loop validation interfaces

These theoretical considerations guided our architectural decisions in the proof-of-concept implementation described below.

Proof-of-Concept Implementation The proof-of-concept implementation of CKM was built as a containerized microservices architecture, with the following key technical decisions:

1. **Infrastructure Design**

   - Docker-based containerization for all services
   - NGINX reverse proxy for load balancing and routing
   - Redis for queue management and caching
   - MongoDB for persistent storage
   - Scalable API instances (20 replicas) and worker nodes (4 replicas)

2. **Backend Architecture**

   - FastAPI framework for RESTful API endpoints
   - Python RQ (Redis Queue) for distributed task processing
   - Langfuse for LLM operation monitoring
   - Resource management with container-level CPU/memory limits
   - WebSocket support for real-time updates

3. **Frontend Implementation**

   - Next.js framework replacing initial Streamlit interface
   - React components for interactive knowledge visualization
   - Real-time updates via WebSocket connections
   - Static asset optimization through NGINX

4. **Development Environment**

   - Jupyter Lab integration for interactive development
   - RQ Dashboard for queue visualization
   - Hot-reload capability for rapid iteration
   - Comprehensive Python package management
   - Automated setup and fixture loading

5. **Integration Patterns**

   - AWS Bedrock for Claude API access
   - Structured prompts for knowledge extraction
   - Context-aware processing pipeline
   - Human-in-the-loop validation interfaces

The implementation directly addresses the theoretical requirements through several key architectural decisions:

1. **Document Processing Requirements**

   - Context-aware lexeme identification implemented via specialized processor classes
   - Relationship detection handled through structured prompts and validation chains
   - CKM rule validation enforced through typed model constraints
   - Processing state tracking via MongoDB document versioning

2. **Storage Architecture Requirements**

   - Context preservation achieved through metadata enrichment and version control
   - Efficient retrieval enabled by MongoDB indexing on context fields
   - Change tracking implemented via event sourcing pattern
   - Version control managed through immutable document patterns

3. **Integration Requirements**

   - LLM interaction managed through structured prompt templates and validation chains
   - Worker load balancing achieved via Redis Queue with 4 worker nodes
   - Human validation interfaces built into the Next.js frontend components

This architecture demonstrates that the theoretical CKM framework can be practically implemented, though scaling challenges remain around concurrent processing and validation chain performance.

III. Implementation of the Knowledge Processing Pipeline

The proof-of-concept implementation focused on establishing core functionality for automated knowledge extraction and concept formation using Large Language Models. The current implementation demonstrates basic pipeline functionality while revealing important technical challenges that inform future development.

Architecture Overview

The system implementation follows a processor-based architecture, with distinct components handling specific aspects of document analysis and knowledge extraction. The core processors are organized in a hierarchical structure:

```
api/processors/assets/
- process_citations.py
- process_definitions.py
- process_images.py
- process_lexemes.py
```

```
- process_refined.py
- process_refined_metadata.py
- process_refined_splitting.py
- process_tables.py
```

Each processor implements a specific stage in the knowledge extraction pipeline, with processing flows managed through an asynchronous task system.

Document Processing Pipeline

The current implementation successfully demonstrates several key components:

Document Classification and Metadata Extraction   The system employs domain-specific prompts to analyze incoming documents, classifying them into categories including Technical, Educational/Academic, Commercial/Business, Legal/Compliance, Research/Scientific, Administrative/Operational, and General/Mixed. This classification determines subsequent processing strategies.

Lexeme Extraction   The system implements both general-purpose and domain-specific lexeme extraction. Domain-specific extractors use carefully crafted prompts targeting particular document types. For example, academic document processing focuses on identifying learning components, pedagogical elements, and domain-specific terminology. These prompts are organized in a structured repository:

```
prompts/assets/lexeme/
- academic.txt
- administrative.txt
- business.txt
- general.txt
- legal.txt
- research.txt
- technical.txt
```

Citation Processing   For each identified lexeme, the system extracts supporting citations from the source document. This component currently processes lexemes sequentially, which has revealed significant scalability challenges when handling documents with high lexeme density (>25 lexemes).

Concept Formation   The system synthesizes lexemes and their supporting citations into structured concept definitions using a JSON-based prompt structure. This ensures consistent concept representation while maintaining traceability between concepts and their supporting evidence.
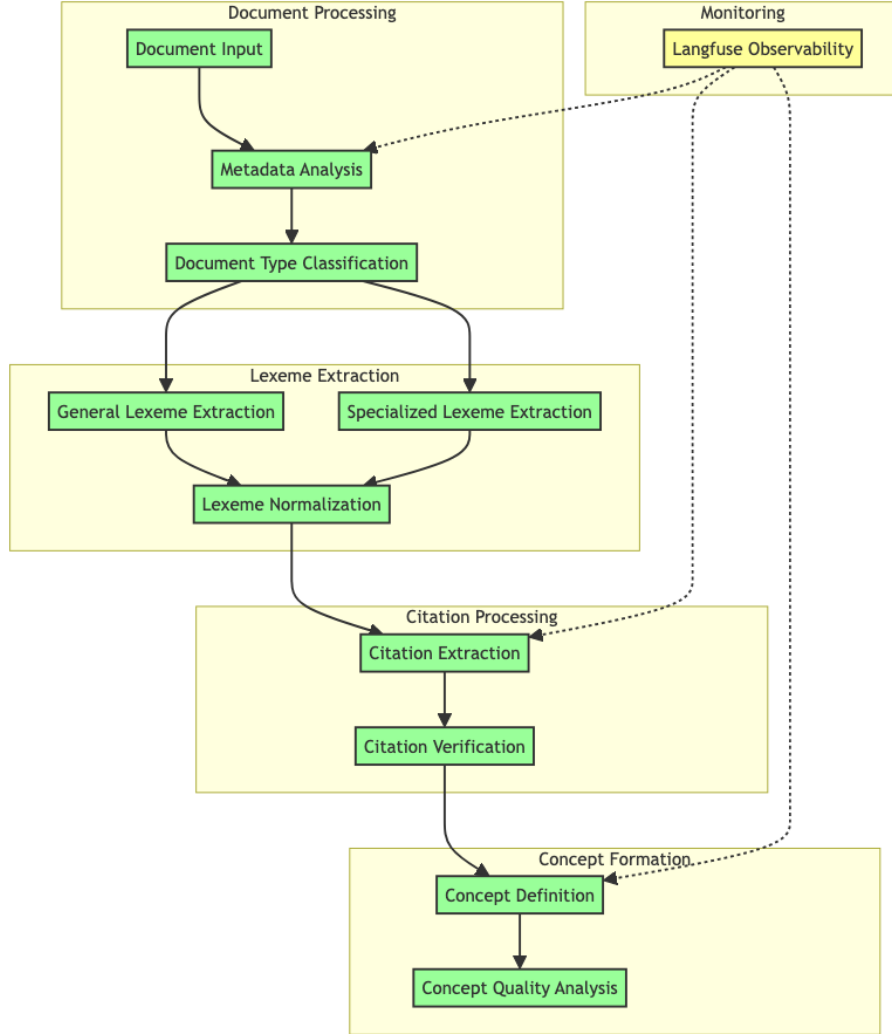
Technical Challenges and Solutions

Several significant technical challenges emerged during implementation:

1. **Asynchronous Processing**: The system's initial design revealed limitations in handling multiple concurrent lexeme processing tasks. Integration of Langfuse monitoring provided crucial insights into processing bottlenecks and component interaction patterns.

2. **Worker Load Balancing**: Initial attempts to address performance issues through API server load balancing proved insufficient. Subsequent implementation of worker-level load balancing demonstrated more promising

results, though requiring substantial architectural refactoring.

3. **Debug Complexity**: The asynchronous nature of the processing pipeline complicated debugging efforts, particularly for delayed processing functions. This challenge led to the implementation of comprehensive trace logging and monitoring.

Monitoring and Observability

The integration of Langfuse provided essential observability into the LLM-based processing pipeline. The monitoring system tracks:

- Processing duration for each pipeline stage
- Success/failure rates for processing tasks
- Resource utilization patterns
- Component interaction sequences

This monitoring infrastructure has proved invaluable for both development iteration and system optimization.
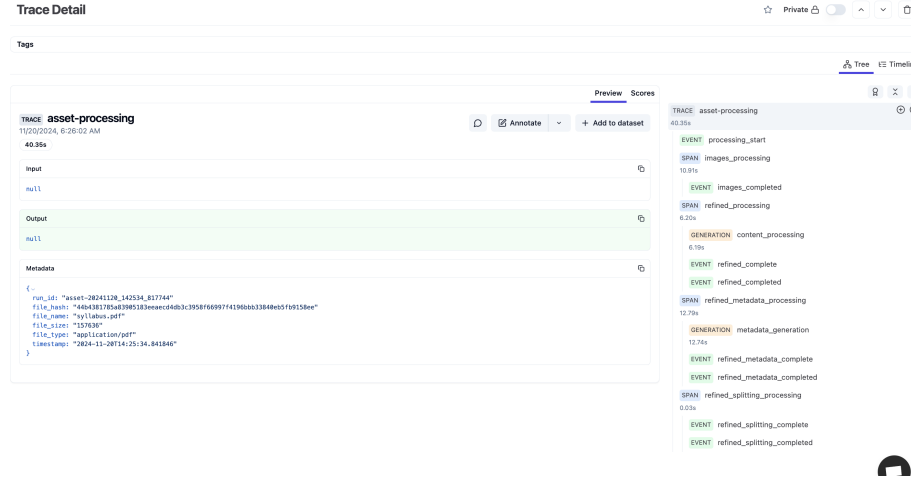

Figure 1: An Example Langfuse Trace

Current State and Limitations

The current implementation successfully demonstrates core functionality while revealing important insights about scaling LLM-based knowledge processing systems. Key limitations include:

- Sequential processing constraints for citation extraction
- Processing time scaling issues with complex documents
- Debug complexity in asynchronous operations

These limitations, while significant, represent engineering challenges rather than fundamental conceptual flaws in the approach.

IV. Discussion

The implementation of the knowledge processing pipeline demonstrated both promising results and revealed important technical challenges that impact system scalability. While core functionality was successfully implemented and performed well, several key insights emerged during development.

Implementation Progress and Challenges

The core system functionality was successfully implemented and demonstrated effective performance. However, a significant scalability challenge emerged when processing rich documents containing numerous concepts (>25 lexemes), leading to performance degradation. This bottleneck led to exploring two distinct solution paths:

1. Initial attempts focused on load balancing the API server to better utilize system resources
2. Subsequently, attention shifted to worker load balancing, which proved to be the correct approach but required substantial code refactoring

Notably, the troubleshooting process led to the discovery and integration of Langfuse, a monitoring and observability solution for LLM applications. This addition to the technology stack emerged as a silver lining of the scalability challenges, providing valuable insights into LLM operation and performance that will benefit future development iterations.

Scope Management Insights

A key learning from this implementation process was the importance of careful scope management in research projects. While the theoretical framework of the CKM was well-developed and remains sound, the implementation would have benefited from a more targeted initial approach focusing on:

1. Small, representative document samples rather than full-scale processing
2. Core functionality demonstration over scalability optimization
3. Complete implementation of basic features before addressing performance challenges

This experience provides valuable insight for similar projects in the field: when implementing complex theoretical frameworks, starting with minimal viable examples can provide faster validation of core concepts while avoiding premature optimization challenges. The integration of Langfuse during troubleshooting demonstrates how technical challenges can lead to unexpected improvements in system architecture.

Preliminary Results

Initial results from concept extraction and definition were promising, based on ad hoc analysis of system logs. The LLM-based approach demonstrated effectiveness in identifying and defining concepts from input documents. However, it should be noted that due to development focusing on core functionality, the system's output capture mechanisms were not implemented in a way that would support rigorous research validation and presentation.

Time Constraints and Future Work

The primary limiting factor in this implementation was time rather than fundamental issues with the system architecture or approach. The underlying architectural decisions appear sound based on the implemented components' performance. Development of the system will continue, with particular focus on:

1. Completing the relationship extraction functionality
2. Implementing robust output capture for proper evaluation
3. Leveraging the refactored worker load balancing system for improved scalability
4. Expanding the use of Langfuse for monitoring and optimization of LLM interactions

Manual experiments with knowledge model construction and LLM interaction have provided encouraging indicators of the system's potential effectiveness, though formal validation remains to be completed. The successful implementation of core functionality, despite scalability challenges, supports the viability of the overall architectural approach. Future work will build upon these foundations to realize the full potential of the system.

V. Conclusion

Transformative Potential of Automated Ontology Creation

The most significant insight from this research is not merely the automation of ontology creation through LLMs, but rather how this automation fundamentally transforms the role of ontologies in knowledge management. When ontology creation shifts from a months-long expert endeavor to a rapid, iterative process, it enables ontologies to be deployed for previously impractical use cases - much like how the accessibility of databases or notebooks has enabled their widespread adoption in diverse contexts.

Implementation Insights

While the proof-of-concept implementation faced expected challenges in scaling complex machine learning systems, these challenges proved to be primarily engineering hurdles rather than fundamental limitations. The core functionality

demonstrated the viability of the architectural approach, particularly in concept extraction and definition, though full relationship extraction capabilities remain to be implemented.

The development of the Chelle Knowledge Model (CKM) emerged as a foundational framework - akin to a constitutional document - providing guiding principles for knowledge management implementation. This theoretical foundation, combined with consistently promising outputs from experimental work, suggests strong potential for the overall approach.

Practical Applications

The immediate practical application of this work focuses on educational contexts, specifically facilitating connections between students, teachers, and knowledge resources. This narrow but concrete focus provides a clear path for validating the approach while avoiding overextension of the system's capabilities.

Future Work

Two critical areas require attention for advancing this work:

1. Development of a complete working system implementation that demonstrates the full potential of the theoretical framework
2. Rigorous validation of the system's effectiveness in real-world applications

The successful implementation of core functionality, despite various technical challenges, supports the fundamental viability of using LLMs to transform knowledge management through rapid ontology creation and deployment. While significant work remains, particularly in validation and scaling, the potential to fundamentally change how organizations approach knowledge structuring and management appears promising.

Appendix

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Chelle Knowledge Model

Purpose

Chelle manages an organization's information via construction of a knowledge model (KM) for that organization.

A KM is used for:

- Encoding an organization's knowledge (concepts, definitions, facts, relationships)
- Organizing an organization's documents (documents are tagged by concept)

Document Conventions

In this document, the following conventions apply, which should help in navigating:

- The sub-headings are the terms contained in the Glossary, and the content within is the complete definition of the term, followed by the facts we know about the term.
- When a definition or fact makes reference to another term in the Glossary, the term is *italicized*. A term is **bolded** in its own definition.
  - Example: '**Understanding** is a degree of demonstrated retention of a *Concept*.' Concept is italicized here because it is a term belonging to the Glossary. Understanding is bolded because this is its own definition.
- When a definition makes use of customized language in defining a property of the term, the customized language is put in "quotes". For example, if a term from the Glossary defines an entity which has a property that may only contain certain values, and those values are enumerated, they would be quoted. Customized language from the definition of one term may appear in the definition of another term.
  - An example of this can be found in the *Concept* term, where we use the word "lexeme". That word is a child of the term *Concept*, so it's not big enough to be its own term in the Glossary, but it may need to be referenced elsewhere, so the quotes help identify it.

Core Principles

Dependency Ordering A term T_1 must be defined before term T_2 if and only if T_2's definition contains T_1. This creates a directed acyclic graph (DAG) of definitional dependencies.

Term Structure Each term entry consists of two parts:

- Definition: A precise statement that uniquely identifies the term using only previously defined terms

- Citations: Verified statements about the term that document its properties, behaviors, and relationships

Completeness Rule The glossary G is complete if and only if:

- Every term used in any definition is itself defined earlier in G
- Every term has exactly one definition
- No definition creates a circular dependency
- Every citation has a verifiable source

Relationship Uniqueness Rule The system maintains exactly one explicit relationship between any pair of Concepts:

Every pair of Concepts (A, B) must have exactly one Relationship Type R

Relationship Types are mutually exclusive

No implicit or derived relationships are stored

Mathematical Foundations

Lattice Operations The relationship hierarchy forms a complete lattice with the following operations:

Join Operation ($\cup$) Definition: For any two relationship types R_1 and R_2, their join $R_1 \cup R_2$ is the least upper bound that satisfies both relationships

Formally: $R_1 \cup R_2 = \min\{R | R \geq R_1 \text{ and } R \geq R_2\}$

Meet Operation ($\cap$) Definition: For any two relationship types R_1 and R_2, their meet $R_1 \cap R_2$ is the greatest lower bound that is satisfied by both relationships

Formally: $R_1 \cap R_2 = \max\{R | R \leq R_1 \text{ and } R \leq R_2\}$

Knowledge System

Knowledge Definition: The fundamental unit of transferable information.

Citations:

- Has identifiable source
- Can be validated
- Can be versioned
- Can be structured
- Can be referenced

Knowledge Structure Definition: A Knowledge Structure is a formal representation system for storing and managing *Knowledge*.

Citations:

- Must be versioned with unique identifier
- Must maintain referential integrity
- Must be computably verifiable

Properties:

- Consistency: No contradictory statements allowed
- Completeness: All referenced Concepts must exist
- Computability: All operations must terminate in finite time

Validation Rules:

- All references must be resolvable
- Version changes must maintain dependency consistency
- All operations must have specified complexity bounds

Knowledge Operations Definition: A set of permitted operations for manipulating *Knowledge Structures*.

Operations:

- Create: Initialize new Knowledge Structure
- Update: Modify existing Knowledge Structure
- Compose: Combine multiple Knowledge Structures
- Validate: Verify Knowledge Structure consistency

Constraints:

- All operations must preserve Knowledge Structure properties
- All operations must be reversible
- All operations must maintain audit trail

Term Categories

Primitive Terms

- Terms that require no other terms in their definition
- Must appear first in the glossary
- Examples: "Lexeme", "Citation"

Composite Terms

- Terms that require other terms to be defined first
- Must appear after all terms referenced in their definition
- Example: "Concept" - requires both "Lexeme" and "Citation" in its definition

Relationship Terms

- Terms that define connections between other terms
- Must appear after all terms they connect
- Example: "Knowledge Dependency" - requires both "Concept" and "Understanding"

Primitive Terms

Lexeme Definition: A **Lexeme** is a unit of meaning in a language, consisting of a word or group of words.

Citation Definition: A **Citation** is a verifiable statement that documents a property, behavior, or relationship of a term within its organizational context.

Validations:

- Every Citation must: a. Reference only defined terms b. Be computably verifiable c. Have an explicit source or derivation

Property Definition: A Property is a verifiable characteristic or attribute that can be tested for presence or absence.

Classifications:

- Primitive Properties:
    - Cannot be derived from other properties
    - Must have direct verification procedure
    - Must be atomic (cannot be decomposed)
- Derived Properties:
    - Must specify source properties explicitly
    - Must provide derivation function
    - Must maintain traceable derivation chain

Computably Verifiable Requirements:

- Must have an algorithm A that terminates in finite time
- $A(x)$ returns true $\iff$ x has property P
- $A(x)$ returns false $\iff$ x does not have property P
- Must have specified worst-case complexity bound $\mathcal{O}(f(n))$

Equivalence Definition: A binary relation that is reflexive, symmetric, and transitive.

Citations:

- For any x, x is equivalent to itself (reflexivity)
- If x is equivalent to y, then y is equivalent to x (symmetry)
- If x is equivalent to y and y is equivalent to z, then x is equivalent to z (transitivity)

Basic Terms

User   Definition: A **User** is an individual person who is using the product via a logged in account.

- **Users** are managed externally to the product, via Clerk.
- **Users** can be either *Mentors* or *Learners.*
- what about admins/users in Clerk?

Organization   Definition: An **Organization** is a group of Users that use the product in tandem.

- **Organizations** are managed externally to the product, via Clerk.
- It is not possible to use Chelle and not belong to an **Organization**

Integration   Definition: An **Integration** is an authorized connection between the product and an *Organization's* account on a third party platform for the purpose of ingesting data.

- **Integrations** fall into categories: documentation, codebases, conversations, and meets.
- Connecting an **Integration** does not automatically "register" all *Assets* it provides access to.

Asset   Definition: An **Asset** is a raw source of information.

- An **Asset** may be text, image, video, audio, or structured data.
- It may be uploaded directly by a *User* or acquired via an *Integration.*

Raw Asset   Definition: A **Raw Asset** is an unprocessed unit of information from an Integration or direct upload that has not yet undergone refinement or classification.

Citations:

- Must have a unique identifier
- Must maintain provenance data (source, timestamp, uploader)
- Must track original format and encoding
- Can be text, image, video, audio, or structured data
- Cannot be modified after ingestion
- Must be versioned

Asset Metadata   Definition: **Asset Metadata** is the collection of properties that describe and classify an Asset's characteristics, provenance, and processing state.

Citations:

- Must include content type identification

- Must track processing history
- Must maintain provenance chain
- Must include version information
- Must track modification timestamps
- Must reference source Asset

Refined Asset   Definition: A **Refined Asset** is a processed version of a Raw Asset that has been normalized, classified, and enriched with Asset Metadata.

Citations:

- Must maintain reference to source Raw Asset
- Must track all processing steps
- Must include confidence scores for processing
- Must be re-generatable from Raw Asset
- Must maintain version lineage
- Must track refinement timestamp

Markdown File   Definition: A **Markdown File** is a Refined Asset containing structured text with semantic formatting that follows the Markdown specification.

Citations:

- Must preserve original Markdown syntax
- Must identify document structure:
  - Headers and hierarchy
  - Lists and nesting
  - Code blocks and language hints
  - Block quotes
  - Tables
  - Links and references
- Must track inline formatting:
  - Emphasis (bold, italic)
  - Code spans
  - Links
- Must maintain internal reference resolution
- Must include parsing confidence scores
- Must preserve raw source mapping
- ,Must track frontmatter metadata if present

Table   Definition: A **Table** is a structured Refined Asset containing data organized in rows and columns with explicit relationships between elements.

Citations:

- Must have defined column schema
- Must maintain cell data types
- Must preserve structural relationships

- Must track header information
- Must maintain source cell positions
- Must include parsing confidence scores

Image   Definition: An **Image** is a visual Refined Asset that has been processed for content extraction and analysis.

Citations:

- Must maintain original resolution
- Must track visual element detection
- Must preserve text extraction results
- Must include layout analysis
- Must maintain spatial relationships
- Must track processing confidence scores

Definition   Definition: A **Definition** is a statement composed of a *Lexeme* and its essential *Citations* that uniquely identify the term.

Citations:

- A Definition must be expressed using only previously defined terms or primitive concepts
- A Definition must be decidable (can be verified in finite time)
- A Definition must be unambiguous
- A Definition must use only defined terms or primitive concepts

Validations:

- Every term used must either be:
    - A primitive term
    - Previously defined in the glossary
    - Explicitly marked as external to the system
- All Citations must be verifiable
- Citations must be minimal (contain only essential distinguishing characteristics)

Core Concept Structure

Concept   Definition: A **Concept** is a *Lexeme* with an associated *Definition* owned by an *Organization.*

Citations:

- A **Concept** is identified either manually by a *Mentor*, or automatically via AI.
- A **Concept** contains *Knowledge.*
- A **Concept** is associated with other Concepts through *Mentions* in its *Knowledge.*
- A **Concept** has an associated "Summative" *Assessment.*

- A **Concept** may have a "Formative" *Assessment* constructed for it ad-hoc.
- Two **Concepts** from different *Organizations* may have identical "lexemes", but they must have different identities.
- A **Concept** may have "synonyms", which are alternative "lexemes".

Glossary   Definition: A **Glossary** is the set of *Concepts* owned by a particular *Organization.*

Citations:

- The **Glossary** is the primary interface through which *Users* interact with *Knowledge.*

Relationship Foundation

Relationship Type   Definition: A **Relationship Type** is a formal classification of how two *Concepts* relate to each other within a *Glossary.*

Citations:

- Every relationship type has a precise mathematical definition
- Relationship types form a complete lattice
- Relationship types are mutually exclusive
- Any two Concepts must have exactly one Relationship Type between them

Validation Rules:

- Attempting to add a relationship when one exists must be rejected
- Relationship changes must be atomic operations
- All relationship changes must maintain audit trail

Relationship Category   Definition: A **Relationship Category** is a grouping of *Relationship Types* that share common mathematical properties.

Citations:

- "Equivalence Category" contains relationships that are reflexive, symmetric, and transitive
- "Order Category" contains relationships that are antisymmetric and transitive
- "Similarity Category" contains relationships that are symmetric but not necessarily transitive
- "Distinction Category" contains relationships that are symmetric and anti-transitive

Relationship Classification   Definition: A **Relationship Classification** is a formal system that categorizes all possible *Relationship Types* between *Concepts* in a *Glossary.*

Citations:

- Forms a complete lattice with well-defined meet and join operations
- Preserves the relationship hierarchy
- Enforces mutual exclusivity between classifications

Relationship Types

None   Definition: A **None** is a *Relationship Type* indicating the absence of any semantic connection between two *Concepts*.

Citations:

- None is symmetric
- None is the minimal element in the relationship lattice
- If A has None relationship with B, then A and B share no properties

Disjoint   Definition: A **Disjoint** is a *Relationship Type* where two *Concepts* have no properties in common.

Citations:

- Disjoint is symmetric
- If A is disjoint with B, and B subsumes C, then A is disjoint with C
- Disjoint *Concepts* cannot have common instances

Overlap   Definition: An **Overlap** is a *Relationship Type* where two *Concepts* share some but not all properties.

Citations:

- Overlap is symmetric
- Overlap is not transitive
- Two overlapping *Concepts* must have at least one common property

Related   Definition: A **Related** is a *Relationship Type* where two *Concepts* have a meaningful semantic connection that is weaker than *Overlap* but stronger than *Disjoint*.

Citations:

- Related is symmetric
- Related is not transitive
- Related requires explicit categorization via a "Connection Type"

Interaction Rules:

- Related relationships can coexist with stronger relationships
- If A Subsumes B, then A Related B is implied with Connection Type "Functional"
- If A Overlaps B, then A Related B is implied with Connection Type "Spatial"

- Related relationships cannot contradict stronger relationships
- Multiple Related relationships with different Connection Types are allowed if consistent

Connection Type   Definition: A **Connection Type** is a classification that specifies the semantic nature of a *Related* relationship between *Concepts.*

Citations:

- Valid "Connection Types" are: "Causal", "Temporal", "Spatial", "Functional"
- Each Connection Type has specific validation rules
- Connection Types are enumerable and extensible per *Organization*

Axioms:

- Distinctness: Each Connection Type is distinct and mutually exclusive
- Finite Enumeration: The set of Connection Types is finite and enumerable
- Extensibility: New Connection Types can be added but must satisfy all axioms
- Verification: Each Connection Type must have a decidable verification procedure

Dependencies:

- Connection Types must form a directed acyclic graph (DAG)
- Each Connection Type must declare its dependencies explicitly
- No circular dependencies are permitted

Subsumption   Definition: A **Subsumption** is a *Relationship Type* where the source *Concept* (parent) completely contains all properties of the target *Concept* (child).

Definition: A Subsumption is a directed Relationship Type where the source Concept (parent) completely contains all properties of the target Concept (child).

Citations:

- Direction is explicit: A Subsumes B means A is parent, B is child
- When A Subsumes B, B is subsumed by A (but we don't store this as a separate relationship)
- The relationship is stored only once with direction indicator
- The relationship strength is always calculated from parent to child

Storage Requirements:

- Store as directed edge: (source, target, SUBSUMES)
- Query support must handle both directions:
    - Get all concepts that subsume X
    - Get all concepts that are subsumed by X

Property Inheritance Rules:

- Complete Inheritance: If A Subsumes B, then B inherits all properties of A
- Local Override: B may strengthen but not weaken inherited properties
- Transitivity: If A Subsumes B and B Subsumes C, then C inherits from both A and B

Validation Requirements:

- All properties from parent concept must exist in child concept
- Child concept properties must satisfy parent concept constraints
- Child may add properties but cannot remove inherited ones
- Child may strengthen but cannot weaken inherited properties

Validation Rules:

For any A Subsumes B:

- A is the parent/broader concept
- B is the child/narrower concept
- B inherits all properties from A
- B may add additional properties
- B may not remove A's properties

Equivalence (as Relationship Type) Definition: An **Equivalence** is a *Relationship Type* where two *Concepts* share exactly the same set of essential *Citations* in their *Definitions*.

Citations:

- Inherits mathematical properties from primitive Equivalence relation:
    - Reflexive: Every Concept is equivalent to itself
    - Symmetric: If A is equivalent to B, then B is equivalent to A
    - Transitive: If A is equivalent to B and B is equivalent to C, then A is equivalent to C
- Has *Relationship Strength* of 1.0
- Is the maximal element in the *Relationship Hierarchy*
- Creates equivalence classes within a *Glossary*
- Cannot exist between Concepts from different Organizations (by definition of Concept)
- Must satisfy strict Citation matching (not just semantic similarity)

Validations:

- All essential Citations must match exactly
- Both Concepts must belong to same Organization
- Equivalence must be computably verifiable

Relationship Properties

Relationship Strength   Definition: A **Relationship Strength** is a measure of the semantic coupling between two *Concepts* connected by a *Relationship Type*.

Citations:

- Strength is normalized on a [0,1] scale where 1 represents *Equivalence* and 0 represents *None*
- Strength is monotonically decreasing along the relationship hierarchy
- Strength can be computed automatically or specified manually by a *Mentor*

Relationship Constraint   Definition: A **Relationship Constraint** is a rule that must be satisfied for a particular *Relationship Type* to be valid between two *Concepts*.

Citations:

- Constraints are validated during relationship creation and modification
- Constraints may reference *Citations* as evidence
- Constraints must be computably verifiable

Relationship Hierarchy   Definition: A **Relationship Hierarchy** is an ordered structure that defines the relative strength and implications of all *Relationship Types* within a *Glossary*.

Citations:

- Forms a complete lattice from *Equivalence* (maximal) to *None* (minimal)
- Each level implies all weaker relationships below it
- Preserves transitive properties across levels

The relationship types form a complete lattice:

1. Equivalence
2. Subsumption
3. Overlap
4. Related
5. Disjoint
6. None

Each level in this hierarchy is strictly weaker than the ones above it and strictly stronger than the ones below it. This forms a total order over relationship types.

Cross-Reference Rules   All relationships must be:

- Single (Exactly one relationship between any two Concepts)
- Well-defined (have precise mathematical semantics)
- Decidable (can be computed in finite time)
- Consistent (preserve logical constraints)

Relationship composition must preserve:

- Transitivity where applicable
- Symmetry properties
- Hierarchical constraints

Validation requirements:

- Every relationship must be validated
- Validation must be deterministic
- Failed validations must be actionable

Relationship Strength Calculations   Definition: A formal system for computing and resolving relationship strengths between *Concepts*.

Base Strength Values:

- Equivalent: 1.0
- Subsumes: 0.8
- Overlap: 0.6
- Related: 0.4
- Disjoint: 0.2
- None: 0.0

Modifier Rules:

- Property overlap ratio: strength *= (shared_properties / total_properties)
- Connection Type weight: if Related, apply weight based on Connection Type
- Citation overlap: strength *= (shared_citations / total_citations)

Transitivity Rules:

- Direct Rule: strength(A,C) $\geq$ strength(A,B) strength(B,C)
- Path Rule: strength along any path $\leq$ minimum strength of any edge
- Resolution Rule: actual strength = maximum strength across all paths

Mention System

Mention Resolution   Definition: A formal system for identifying and managing references between *Concepts*.

Resolution Rules:

- Exact match: Direct lexeme correspondence
- Synonym match: Alternative lexeme forms
- Context match: Semantic equivalence in context

Validation Requirements:

- All mentions must resolve to exactly one Concept
- Ambiguous mentions must be explicitly resolved

- Circular mentions must be prevented

Mention Processing Definition: The system for processing and maintaining *Mentions* between *Concepts*.

Processing Steps:

1. Detection
   1. Identify potential mentions in text
   2. Validate against known lexemes
   3. Record context and metadata
2. Resolution 4. Resolve to specific Concept 5. Handle ambiguity 6. Validate consistency
3. Maintenance 7. Track mention validity 8. Update on Concept changes 9. Maintain dependency graph

Validation States:

- "Resolved": Unique Concept identified
- "Ambiguous": Multiple possible Concepts
- "Invalid": No matching Concept

Relationship Validation Definition: Formal procedures for validating relationship operations.

Required Checks:

1. Uniqueness Validation
   1. Verify no existing relationship before creation
   2. Verify exactly one relationship exists after operation
   3. Verify no implicit relationships are stored
2. Consistency Validation 4. Verify relationship is valid for both Concepts 5. Verify all constraints are maintained 6. Verify strength hierarchy is respected
3. Dependency Validation 7. Verify all dependent relationships remain valid 8. Verify no circular dependencies created 9. Verify transitive properties maintained

Error States:

- "DuplicateRelationship": Attempt to add relationship when one exists
- "InvalidTransition": Invalid relationship change attempted
- "ConstraintViolation": Operation violates system constraints

Resolution Requirements:

- All errors must be actionable
- Error messages must be specific
- Recovery procedures must be defined

Mapping

Mapping   Definition: A **Mapping** is a correspondence that associates elements of one set with elements of another set while preserving their *Relationship Types*.

Citations:

1. Structural Properties:
   - Every mapping has exactly one source and one target
   - A mapping may have associated metadata
   - A mapping preserves structural properties between sets
2. Relationship Consistency Rules:
   - If A maps to A' and B maps to B', then:
     - If A is *Equivalent* to B, then A' must be *Equivalent* to B'
     - If A *Subsumes* B, then A' must *Subsume* B'
     - If A *Overlaps* with B, then A' must *Overlap* with B'
     - If A is *Related* to B, then A' must be *Related* to B' with the same "Connection Type"
     - If A is *Disjoint* from B, then A' must be *Disjoint* from B'
     - If A has *None* relationship with B, then A' must have *None* relationship with B'
3. Validation Requirements:
   - All relationship consistency rules must be verifiable in finite time
   - Violations must be detected and reported with specific details
   - Mapping is invalid if any relationship consistency rule is violated
4. Relationship Strength Preservation:
   - For any two mapped concepts, their *Relationship Strength* must be preserved within a specified tolerance
   - The tolerance must be explicitly defined in the mapping metadata
   - Violations of strength preservation must be logged and flagged
5. Categorical Constraints:
   - Mappings must preserve *Relationship Category* memberships
   - If a concept belongs to a category in the source, its mapped counterpart must belong to the equivalent category in the target
   - Category preservation violations invalidate the mapping

Mapping Validation   Definition: A **Mapping Validation** is a process that verifies the consistency of a *Mapping* with respect to all *Relationship Types* and constraints.

Citations:

1. Validation Process:
   - Checks all pairs of mapped concepts for relationship preservation
   - Verifies category membership preservation
   - Validates relationship strength preservation
   - Confirms connection type consistency
2. Validation Results:

- Produces a detailed report of all violations
- Categorizes violations by severity
- Provides specific remediation suggestions
3. Validation States:
    - "Valid": All relationship consistency rules are satisfied
    - "Warning": Relationship strengths vary but within tolerance
    - "Invalid": One or more relationship consistency rules are violated

Operational Layer

Operational Layer   Definition: The **Operational Layer** provides the implementation framework for transforming abstract *Concepts* and *Relationships* into concrete knowledge entities within an organization.

Citations:

- Must maintain bidirectional traceability between conceptual and operational elements
- Must enforce validation at every transformation step
- Must provide verifiable implementation patterns
- Must preserve semantic relationships during operationalization

Operational Layer Components

Implementations   Definition: An Implementation is a concrete realization of a *Concept.*.

Citations:

- Must specify measurable properties
- Must define completion criteria
- Must have clear categorization
- Must track execution states

Examples:

- Concept: "Primary Brand Colors", Slate Blue, #5B7C99; Apricot, #ED820E
- Concept: "Sales Pipeline" Implementation: Hubspot deal stages configuration with specific probability percentages
- Concept: "Customer Segmentation" Implementation: SQL views defining customer cohorts based on revenue/engagement
- Concept: "Sales Territory" Implementation: Geospatial mapping rules in CRM with assigned representatives
- Concept: "Brand Voice" Implementation: GPT prompt template with specific tone parameters
- Concept: "Campaign Performance" Implementation: Real-time dashboard with defined KPI calculations

- Concept: "Content Calendar" Implementation: Structured JSON schema for content planning
- Concept: "Learning Outcome" Implementation: Bloom's Taxonomy classifier with success criteria
- Concept: "Student Progress" Implementation: Weighted scoring algorithm across assessment types
- Concept: "Curriculum Sequence" Implementation: Directed acyclic graph of prerequisite relationships
- Concept: "Code Quality" Implementation: SonarQube ruleset configuration
- Concept: "System Architecture" Implementation: Infrastructure-as-code templates with security policies
- Concept: "Release Process" Implementation: GitHub Actions workflow definitions

Procedures Definition: A Procedure is a defined sequence of steps that implements a *Concept*.

Citations:

- Must be step-by-step reproducible
- Must have defined outcomes
- Must have verifiable steps
- Must capture exceptions handling

Examples:

- Concept: "Lead Qualification" Procedure:
  1. Check company size and industry match
  2. Verify budget authority
  3. Score against ideal customer profile
  4. Route to appropriate sales team
- Concept: "Campaign Launch" Procedure:
  1. Validate creative assets against brand guidelines
  2. Configure audience targeting parameters
  3. Set up tracking pixels and conversion events
  4. Schedule coordinated content distribution
- Concept: "Assessment Creation" Procedure:
  1. Map questions to learning objectives
  2. Generate difficulty ratings
  3. Create rubric with scoring criteria
  4. Validate with peer review
- Concept: "Service Deployment" Procedure:
  1. Run security scan on dependencies
  2. Execute integration test suite
  3. Update configuration in target environment
  4. Perform canary deployment

Constraints Definition: A Constraint is an operational rule that enforces integrity when working with a concept.

Citations:

- Must have stated limitations
- Must be explicitly bounded
- Must have verifiable conditions
- Must specify scope

Examples:

- Concept: "Discount Authorization" Constraints:
  - Maximum discount percentage by deal size
  - Required approvals above thresholds
  - Margin preservation rules
- Concept: "Ad Spend" Constraints:
  - Budget allocation limits by channel
  - Minimum ROAS thresholds
  - Frequency capping rules
- Concept: "Class Size" Constraints:
  - Maximum student-to-teacher ratios
  - Required support staff thresholds
  - Physical space requirements
- Concept: "API Performance" Constraints:
  - Maximum response time limits
  - Rate limiting rules
  - Concurrent connection caps

Validations Definition: A Validation is a process that verifies the correctness of operational elements against their conceptual definitions.

Citations:

- Must define test cases
- Must have completion states
- Must track acceptance criteria
- Must verify against source material

Examples:

- Concept: "Revenue Recognition" Validations:
  - Contract terms completeness check
  - Payment schedule verification
  - Multi-currency conversion accuracy
- Concept: "Attribution Model" Validations:
  - Touch point data integrity
  - Channel classification accuracy
  - Conversion path completeness

- Concept: "Student Achievement" Validations:
  - Assessment reliability metrics
  - Progress trend analysis
  - Comparative cohort performance
- Concept: "Code Review" Validations:
  - Test coverage metrics
  - Static analysis results
  - Performance benchmark compliance

Standards Definition: A Standard is a formalized set of requirements that operational elements must satisfy.

Citations:

- Must specify quality metrics
- Must define acceptance levels
- Must have measurable outcomes
- Must maintain traceability

Examples:

- Concept: "Sales Documentation" Standards:
  - Required fields for opportunity records
  - Meeting note format and storage
  - Deal stage transition criteria
- Concept: "Digital Assets" Standards:
  - Image resolution and format specifications
  - Metadata tagging requirements
  - File naming conventions
- Concept: "Course Material" Standards:
  - Accessibility compliance requirements
  - Learning objective format
  - Content review cycle
- Concept: "Code Style" Standards:
  - Language-specific formatting rules
  - Documentation requirements
  - Commit message format

Templates Definition: A Template is a standardized pattern for implementing conceptual elements consistently.

Citations:

- Must have reusable elements
- Must be parameterized
- Must maintain consistency
- Must track variations

Examples:

- Concept: "Proposal" Templates:
  - Solution architecture diagrams
  - Pricing configuration tables
  - Implementation timeline
- Concept: "Email Campaign" Templates:
  - Responsive email layouts
  - A/B test configuration
  - Performance report format
- Concept: "Lesson Plan" Templates:
  - Activity sequence structure
  - Resource requirement checklist
  - Assessment rubric format
- Concept: "Technical Design" Templates:
  - Architecture decision records
  - API documentation format
  - Deployment runbook structure

Data Definition: Definition: Data is the literal content extracted from organizational Assets, stored within the system in a structured format.

Citations:

- Must be versioned with source Asset reference
- Must maintain original fidelity
- Must be queryable
- Must track extraction confidence

Examples:

1. The complete semantic layering model extracted from our UX team's accessibility standards documentation
2. A mapping of regulatory compliance requirements to specific engineering design patterns from our security handbook
3. The statistical correlation between customer support response times and renewal rates from our quarterly business review
4. Student progression patterns through prerequisite chains extracted from three years of course completion data
5. The decision matrix for market segment targeting derived from our annual strategic planning session
6. Manufacturing tolerance specifications and their relationship to customer satisfaction metrics from product quality reports

Data Store Definition: A Data Store defines connection patterns to external knowledge repositories where organizational concepts are maintained.

Examples:

1. Connection to the design system repository where brand identity concepts are maintained as living documentation
2. Integration with the HR knowledge base that maintains our evolving organizational structure and role definitions
3. Link to our research department's experiment tracking system containing hypothesis validation patterns
4. Reference to the sales enablement platform where our value proposition frameworks are continuously refined
5. Connection to our medical knowledge graph maintaining symptom-treatment relationship patterns
6. Integration with our legal team's compliance database tracking regulatory requirement interpretations

Figure   Definition: A Figure is a visual representation of operational elements and their relationships.

Citations:

- Must have clear notation
- Must be consistent
- Must show relationships
- Must maintain accuracy

Examples:

- Concept: "Sales Process" Figures:
  - Pipeline stage flow diagram
  - Territory mapping visualization
  - Forecast modeling charts
- Concept: "User Journey" Figures:
  - Touchpoint sequence diagram
  - Channel attribution sankey
  - Engagement funnel visualization
- Concept: "Learning Path" Figures:
  - Prerequisite relationship graph
  - Skill progression tree
  - Mastery level indicators
- Concept: "System Architecture" Figures:
  - Component relationship diagram
  - Data flow visualization
  - Infrastructure topology map

Tools   Definition: A Tool is a software application or platform used to implement and manage operational elements.

Examples

- Figma: UI/UX implementation

- Miro: System visualization
- LucidChart: Process mapping
- NextJS: Web application framework
- GitHub: Code and configuration management
- Docker: Containerization platform
- HuggingFace: Model deployment
- LangChain: LLM orchestration
- Weights & Biases: Experiment tracking
- HubSpot: CRM implementation
- Salesforce: Sales process automation
- Marketo: Marketing automation

Operational Element Definition: An Operational Element is any concrete implementation component that realizes a conceptual or relationship layer construct.

Properties:

- Type classification
- Source reference
- Extraction confidence
- Related concepts
- Version information
- Usage context
- Review status

Cross-Reference Phase Definition: A Cross-Reference Phase is a systematic process for ensuring consistency between operational elements.

Steps:

1. Check for dependencies between operational elements
2. Verify consistency across components
3. Identify conflicts or overlaps
4. Document relationships
5. Update related concept definitions if needed

Validation Phase Definition: A Validation Phase is a structured process for verifying operational integrity.

Steps:

1. Verify completeness of extraction
2. Check consistency with concept definition
3. Validate against source material
4. Review with subject matter experts
5. Document confidence level

Implementation Rules

Completeness Requirements:

- All conceptual elements must have corresponding implementations
- All relationships must have operational representations
- All validations must be executable
- All constraints must be enforceable

Consistency Requirements:

- Implementations must preserve conceptual semantics
- Operational relationships must mirror conceptual relationships
- Validation results must be reproducible
- Standards must be uniformly applied

Traceability Requirements:

- Every operational element must link to its conceptual source
- All transformations must be documented
- Implementation decisions must be justified
- Validation results must be preserved

Instruction Layer

Core System Roles

Role   Definition: A Role is a constrained set of permissions and capabilities that a User may assume within the system.

Citations:

- Two fundamental types: Mentor and Learner
- Determines available operations and access rights
- Must be explicitly tracked and validated
- Has defined transition rules between types

Active Role   Definition: An Active Role represents the current Role assumed by a User within their App Session.

Citations:

- Must be explicitly set within each App Session
- Can be changed based on User permissions
- Determines available operations and interfaces
- Must maintain audit trail of changes
- Must enforce type-specific constraints

Job   Definition: A Job is the professional position and responsibilities of a User within their Organization.

Citations:

- Must be formally specified with measurable outcomes
- Creates context for work assignments
- Must be validated against Organization structure
- Determines required capabilities and knowledge access

Assessment Framework

Assessment Type   Definition: An Assessment Type is a classification of evaluation methods used to measure capability.

Citations:

- Two distinct categories:
    - "Formative": Ongoing learning measurement
    - "Summative": Final capability validation
- Question format limited to multiple choice
- Results must be computably verifiable
- Must maintain validation trace to source material

Assessment   Definition: An Assessment is a structured collection of questions of a specific Assessment Type used to measure capability.

Citations:

- Must map to specific measurement levels
- Must maintain validation trace to source material
- Results must be computably verifiable
- Must have clear completion criteria
- Must track attempt history

Understanding Level   Definition: An Understanding Level is a quantified measure of demonstrated capability.

Citations:

- Two classification schemes:
    - "Practical": None, Functional, Practical, Proficient
    - "Theoretical": None, Basic, Intermediate, Mastery
- Levels must form a strict total order
- Each level must have verifiable criteria
- Transitions between levels must be validated

Understanding   Definition: Understanding is a measured level of demonstrated capability regarding a Concept, validated through Assessment.

Citations:

- Must be quantifiably measurable via Assessment
- Level determined by Assessment Type and performance
- Must have clear progression criteria
- Must track historical development
- Must be regularly validated

Knowledge Definition: Knowledge is the complete set of validated instructional materials associated with a Concept.

Citations:

- Must maintain versioning and provenance
- May be AI-generated or User-created
- Storage requirements:
    - Primary storage as structured text
    - Support for multimedia delivery
- Must track content relationships
- Must maintain consistency with source material

Evaluation Definition: An Evaluation is a formal measurement using Assessment to quantify current Understanding.

Citations:

- Distinct from regular Assessment in:
    - Focus on measurement rather than learning
    - Can be administered at any time
    - Results affect progression tracking
- Must provide quantifiable results
- Must track historical progression

Task Definition: A Task is a Job-relevant work assignment that demonstrates Understanding.

Citations:

- Must have clear completion criteria
- Must be relevant to assigned Job
- Must maintain completion audit trail
- Must have validation requirements
- Requires specific evidence for completion

Role Implementations

Learner Definition: A Learner is a Role focused on Knowledge acquisition and Understanding demonstration.

Citations:

- Primary interaction through structured learning
- Progress tracked via Understanding Levels
- Access to Knowledge consumption interfaces
- Can attempt Assessments
- Must complete assigned Tasks

Mentor   Definition: A Mentor is a Role responsible for Knowledge curation and learning oversight.

Citations:

- Manages learning materials
- Creates and maintains learning structures
- Assigns Tasks to Learners
- Monitors Understanding progression
- Can modify content relationships

Authority   Definition: The Authority is a designation given to a User who owns specific Knowledge.

Citations:

- Can be assigned by any Mentor
- Responsible for Knowledge validation
- Maintains approval on Understanding criteria
- Must have relevant Job context

Learning Structure

Guide   Definition: A Guide is a structured learning unit that packages related Concepts, Assessments, and Tasks into a cohesive learning experience.

Citations:

- Required components:
    - Objective statement
    - Concept set with explicit relationships
    - Assessment sequence
    - Practical Task
- Completion requires:
    - Certification for all included Concepts
    - Task completion validation
- Must maintain referential integrity with Concepts
- Must preserve Relationship constraints

Learning Path   Definition: A Learning Path is a directed acyclic graph of Concepts ordered by their Dependencies, terminating at a target Concept.

Citations:

- Construction via topological sort of Concept subgraph
- Must respect both Knowledge and Definitional Dependencies
- Must maintain consistency with Relationship Hierarchy
- Path validity must be computably verifiable

Certification Definition: A Certification is a verified record of achieved Understanding for a specific Concept.

Citations:

- Automatically awarded upon Summative Assessment completion
- Must maintain cryptographic proof of completion
- Must track Understanding level achieved
- Must preserve assessment evidence
- Must be verifiable against source Knowledge

Dependencies

Knowledge Dependency Definition: A Knowledge Dependency represents the requirement for "Practical" or "Intermediate" Understanding of a prerequisite Concept.

Citations:

- Created from Knowledge Mentions
- Must respect Relationship Hierarchy
- Must maintain transitive closure
- Must be computably verifiable
- Cannot create circular dependencies

Definitional Dependency Definition: A Definitional Dependency represents the requirement for "Basic" or "Functional" Understanding of a prerequisite Concept.

Citations:

- Created from Definition Mentions
- Stronger constraint than Knowledge Dependency
- Must respect Relationship Hierarchy
- Must maintain transitive closure
- Must be computably verifiable

Mention Definition: A Mention is an occurrence of a Concept's lexeme that creates an explicit Dependency.

Citations:

- Types determined by context:
    - Knowledge context creates Knowledge Dependency

- Definition context creates Definitional Dependency
- Must be automatically detected and validated
- Must maintain referential integrity
- Must be updated when Knowledge changes
- Must respect Relationship constraints

Content Organization

Article Definition: An Article is a narrative presentation of a Concept's Knowledge optimized for learning engagement.

Citations:

- Must preserve all Knowledge relationships
- Must maintain consistent structure
- Must support multimedia integration
- Must track engagement metrics
- Must validate against source Knowledge

Teaser Definition: A Teaser is a condensed presentation of Concept Knowledge designed to rapidly establish basic Understanding.

Citations:

- Must target "Functional" or "Basic" Understanding level
- Must maintain accuracy with full Knowledge
- Must be automatically generated
- Must be validated against source material
- Must respect Dependencies

Corpus Definition: A Corpus is the organized collection of all Assets and their derived Knowledge within an Organization.

Citations:

- Organization-specific containment
- Must maintain Asset provenance
- Must track all derived Knowledge
- Must enforce Relationship constraints
- Must maintain referential integrity

Norm Definition: A Norm is a universally recognized lexeme that is automatically provisioned across Organizations as an empty Concept.

Citations:

- Created without associated Knowledge
- Can be populated differently per Organization
- Optional removal supported

- Must maintain lexeme consistency
- Must respect Relationship constraints