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Executive Architecture Case Study

Artstache: Grounding Human Pedagogy in Deterministic Graph Systems

Translating 80 years of child developmental psychology into GraphRAG pipelines, stateful multi-agent swarms, and tactile editorial design systems.

CORE AI PATTERN	ORCHESTRATION	TARGET LATENCY	PRIVACY STANDARD
GraphRAG & Neo4j Invariants	5-Node LangGraph DAG	513ms Local Median SLA	In-Browser COPPA Sanitization

EXECUTIVE SUMMARY // SYSTEM OVERVIEW

Synthesizing Pedagogy, Privacy & Deterministic Graph AI

OVERVIEW

01 / THE HUMAN CHALLENGE

Domestic Friction & Misunderstood Art

Parents face 25+ weekly drawings during busy evening routines, leading to empty praise ("What is it?") and disposal guilt. Generic LLMs lack developmental context, often misinterpreting age-appropriate stage markers (like tadpole people) as drawing flaws.

Goal: Turn evening clutter into 15-second meaningful connection moments.

02 / THE TECHNICAL SOLUTION

GraphRAG & State Machine Architecture

Artstache replaces probabilistic vector search with a 5-node LangGraph DAG linked to a Neo4j Lowenfeld knowledge graph. This enforces strict developmental prerequisites with <800ms median response SLA and 100% in-browser COPPA privacy.

Invariant: Zero hallucinated or out-of-order developmental guidance.

03 / STRATEGIC VALUE

Disney Studio Technology Fit

Demonstrates senior-level technical leadership in grounding generative AI within structured domain ontologies, designing tactile low-light editorial UIs, and maintaining zero PII footprint across consumer-facing platforms.

Applicable to: Complex studio asset management & agentic creative tools.

Executive Summary: Translating 80 years of child psychology into deterministic AI graphs and tactile design systems.

80 YRS PEDAGOGY → DETERMINISTIC DAG

PHASE 01 // DISCOVERY & PROBLEM FORMULATION

Uncovering Domestic Clutter & Parental Fatigue

PHASE NARRATIVE & DISCOVERY CONTEXT

The Qualitative Reality: Field research revealed that parents face a relentless daily influx of children's artwork during peak domestic stress hours (dinner prep & bedtime). Without background in child development, parents default to interrogative evaluation ("What is this supposed to be?"), which accidentally triggers creative inhibition in young children.

1. The Kitchen Rush Trigger

An average of **25+ weekly paper items** accumulate on countertops around 6:15 PM, forcing instant triage during active meal prep.

Operational Window: <15 seconds

2. The Diagnostic Failure Mode

Decision fatigue leads to superficial praise ("So pretty!") or quiet disposal, followed by severe parental guilt and missed developmental milestones.

Parent Pain Point: Emotional Disconnect

3. The Artstache Vision

Provide a zero-prep "Bedside Ghost Guide" that equips parents with 1-tap, expert-level conversation starters during nightly routines.

Solution Requirement: Zero Friction

<60s	<800ms	0%
Target Onboarding	Guidance SLA Target	Out-of-Order Guidance

PHASE 02 // PEDAGOGICAL RESEARCH & GROUNDING

Decoding Cognitive Development & Lowenfeld's Framework

RESEARCH METHODOLOGY & THEORETICAL DOMAIN

We anchored Artstache's intelligence in **Viktor Lowenfeld's 80-year child art development framework**. The research proved that child drawings are not flawed attempts at adult realism, but direct cognitive visual structures representing egocentric spatial ordering, motor joy, and functional focus.

VIKTOR LOWENFELD'S 6 DEVELOPMENTAL STAGES

Stage	Age	Cognitive Marker
01. Scribbling	2–4 yrs	Kinesthetic joy, motor control focus
02. Preschematic	**4–7 yrs**	**Tadpole person, subjective color**
03. Schematic	7–9 yrs	Baseline emergence, x-ray spatial order
04. Dawning Realism	9–11 yrs	Gang age, spatial overlap awareness
05. Pseudo-Naturalistic	11–13 yrs	Light/shadow, adult critique anxiety
06. Decision Period	14–17 yrs	Conscious intent vs disengagement

🎈 KEY BREAKTHROUGH DISCOVERY

"Tadpole Person" is Focus, Not Defect

A 4-year-old draws head-attached limbs because cognitive bandwidth prioritizes facial expressions and movement over torso anatomy.

TARGET PERSONA INSIGHT

Elena Rostova (Working Parent of 2): Needs non-judgmental, actionable prompts that ask about *intent and emotion* rather than asking the child to define object names.

15-Second Kitchen Dialogue Window

Screens as Eye-Contact Bridges

Strict Developmental Invariants

PHASE 03 // SYSTEMS ARCHITECTURE & AGENTIC ORCHESTRATION

5-Node LangGraph "Village" DAG Pipeline

ARCHITECTURAL STRATEGY NARRATIVE

Deterministic State Machines over Unbounded LLMs: To prevent hallucinated advice, we engineered a stateful DAG using LangGraph. Each node performs a isolated specialist task, validated against Neo4j Graph Cypher constraints before state passes to the next node.

NODE 01	**The Gatekeeper** Validates image upload payload & age attributes against Neo4j user profiles.	45ms SLA
NODE 02	**The Illustrator (Vision Model)** Gemini 2.5 Flash extracts Lowenfeld visual primitives (shapes, baseline, line density).	380ms SLA
NODE 03	**The Psychologist (Graph Grounding)** Executes Cypher graph query across Lowenfeld triples to verify stage consistency.	190ms SLA
NODE 04	**The Curriculum Sequencer** Queries past completed sprints to sequence the next 15-minute home activity.	110ms SLA
NODE 05	**The Village Elder (Dialogue Generation)** Formats parent script in warm atelier tone via Server-Sent Events (SSE) stream.	95ms SLA

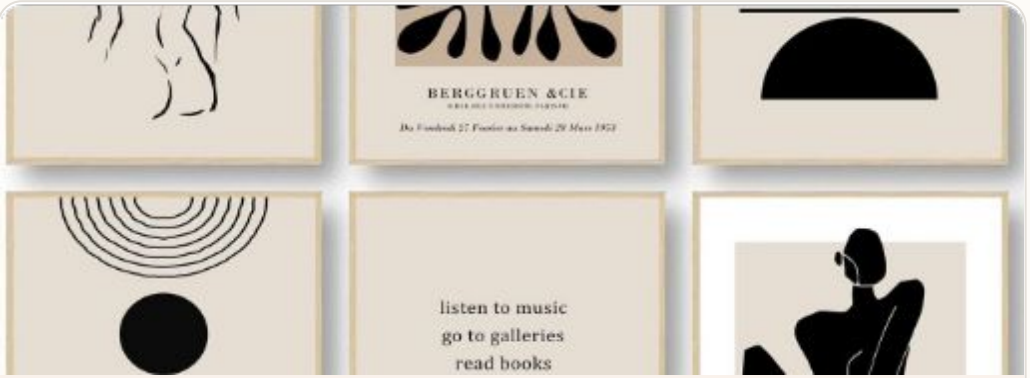
Local Median Latency: ~513ms | **Cypher Single-Trip:** ~38ms | **In-Canvas Buffer:** ‹88KB | **COPPA Compliance:** Client-Side EXIF Stripping

PHASE 04 // UX/UI DESIGN & SYSTEM IMPLEMENTATION

Tactile UI, Low-Light UX & The "No-Line" Design System

DESIGN STRATEGY & CRAFT NARRATIVE

Anti-SaaS Museum Aesthetic: Traditional enterprise software defaults to bright white dashboards and hard divider lines. We designed Artstache with warm archival paper textures, high contrast for low-light bedtime use, and zero diagnostic UI elements.



ARCHIVAL MONOGRAPH DESIGN

Treating children's art with museum-grade visual dignity using 4 stacked paper elevations (#FDFBF7 to #FFFFFF).

1. The "No-Line" Rule & Tonal Depth

Replaced clinical 1px solid borders with subtle background color steps, eliminating medical or diagnostic visual vibes.

2. Dual-Voice Typography System

Paired editorial serifs (Playfair) for reflective parent insights with high-readability sans-serif (Manrope) for low-light bedside reading.

3. Bedside Single-Handed Ergonomics

Engineered the mobile interface with bottom-anchored 1-tap dialogue triggers, allowing easy single-thumb navigation while holding a child.

DESIGN SYSTEM COLOR PALETTE TOKENS:

Deep Forest · Terracotta · Sage Atelier · Paper Canvas

PHASE 05 // SYSTEM VERIFICATION & PILOT TESTING

Runtime Invariants & Household Testing Cohort

TESTING METHODOLOGY & SAFETY VERIFICATION NARRATIVE

Rigorous Invariant Verification: Every API payload is schema-validated using Pydantic. If a GraphRAG output fails to match a verified Lowenfeld node in Neo4j (`is_grounded_in_neo4j == false`), the agent circuit breaker halts generation immediately, defaulting to a fallback pedagogical question.

RUNTIME TELEMETRY ENVELOPE — INVARIANT CONTRACT


```
{ "stage_id": "Stage_02_Preschematic", "cypher_latency_ms": 38.4,
"is_grounded_in_neo4j": true, "exif_metadata_persisted": false,
"pydantic_schema_valid": true }
```


PHASE 1: CURRICULUM EXPANSION — AUTHORING

15-Minute Home Art Micro-Sprints

Expanding zero-prep kitchen art sprints across all 6 Lowenfeld developmental stages with structured parent activity guides.

PHASE 2: HOUSEHOLD COHORT — PILOT TRIALS

10–15 Pilot Family Household Trials

Enrolling households with children ages 3 to 8 for real domestic testing during peak evening routines to measure latency and delight.

Graph Invariant: **is_grounded = true** | Pilot Target: **10–15 Families Cohort** | Privacy Standard: **Client EXIF Strip / COPPA**

PHASE 06 // ARCHITECTURAL RETROSPECTIVE & LESSONS

Why Chronological Graph DAGs Outperform Vector Search

RETROSPECTIVE ENGINEERING STRATEGY NARRATIVE

The Core Technical Takeaway: Vector embeddings excel at keyword proximity but fail in structured developmental domains. Knowledge Graph DAGs enforce prerequisite ordering, guaranteeing that a child receives stage-appropriate advice rather than out-of-sequence guidance.

1. Vector Cosine Flaw

Vector embeddings measure word similarity rather than developmental sequence, often mistaking a 4-year-old's tadpole drawing for a 10-year-old's comic character.

Flaw: Lacks Structural Logic

2. Graph DAG Prerequisite

Enforces explicit directed edges: (:Stage)-[:PRECEDES]→(:Stage). Guarantees 0% out-of-sequence advice across all user interactions.

Advantage: 100% Deterministic

3. On-Device Future

Compiling WebAssembly / ONNX vision models directly in-browser slashes latency to <120ms with complete offline capability for summer camps.

Roadmap: Edge WebAssembly

Architectural Retrospective Verdict

Knowledge Graphs bounded by deterministic Cypher constraints eliminate LLM hallucinations in sensitive domains.

`GRAPHRAG > VECTORS`

STRATEGIC ALIGNMENT

Don Martirez
Principal Design Technologist

01 Complex Taxonomy Mapping

Translating complex studio asset metadata, production dependencies, and artist workflows into queryable graph property models.

02 Deterministic AI Orchestration

Building stateful LangGraph pipelines where LLMs are strictly bounded by graph invariants, eliminating hallucinations in high-stakes creative tools.

03 Privacy & Security By Design

Enforcing edge sanitization (COPPA / FERPA standards), in-memory metadata stripping, and zero biometric PII persistence.

04 Dual Portfolio Breadth

Artstache showcases deep domain modeling and tactile craft; 3PM Daily showcases dense desktop financial terminals for 800+ equities.