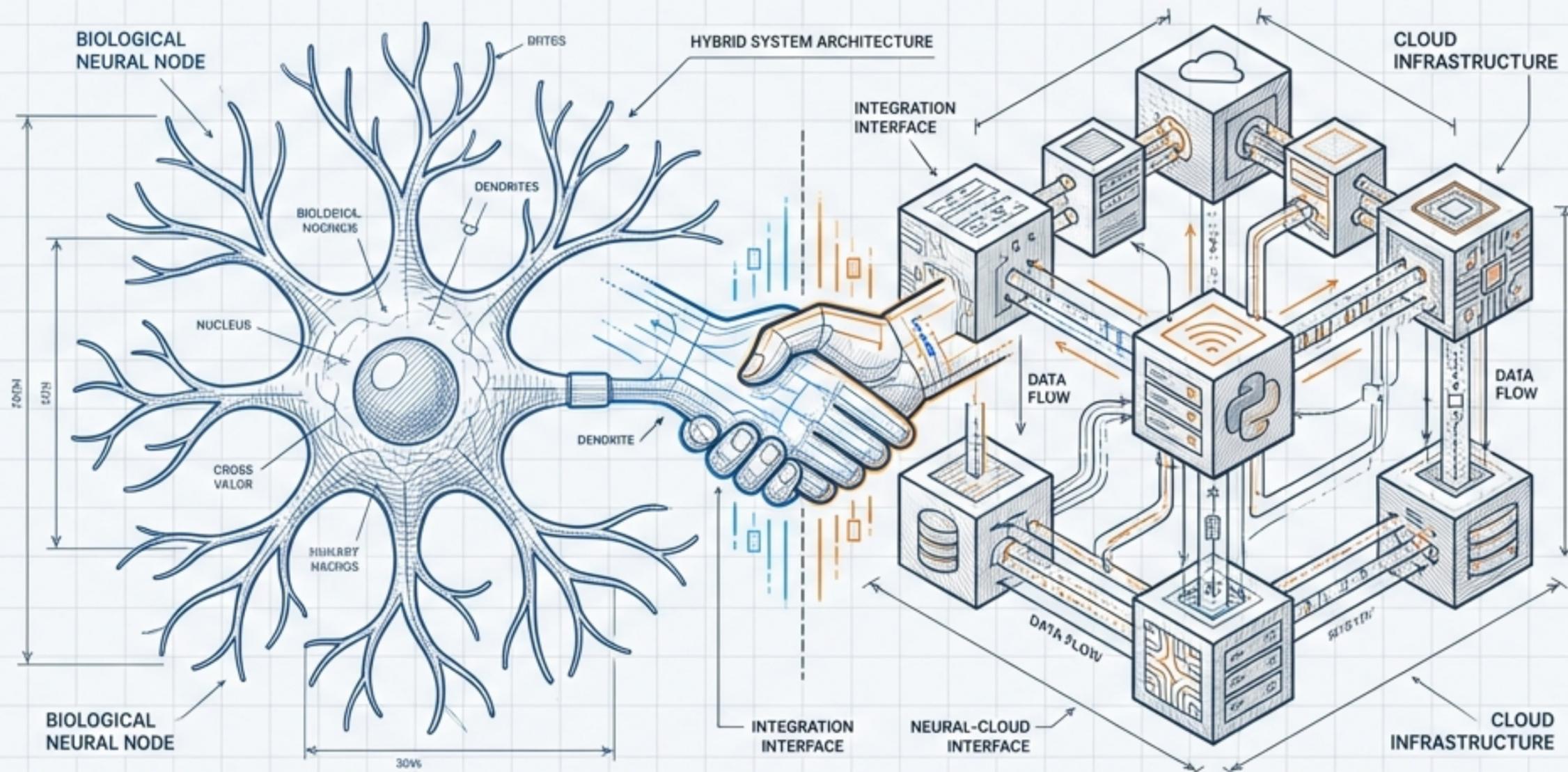


# The Architect's Roadmap: Building an AI-Powered Meta-Tutor

From Pedagogical Theory to a Cloud-Native Multi-Agent Ecosystem on Vertex AI



A technical guide to constructing self-referential Intelligent Tutoring Systems (ITS).  
Simulating the engineering lifecycle: Pedagogy (The Why) → Architecture (The What) → Implementation (The How).

# Defining the Meta-Tutor

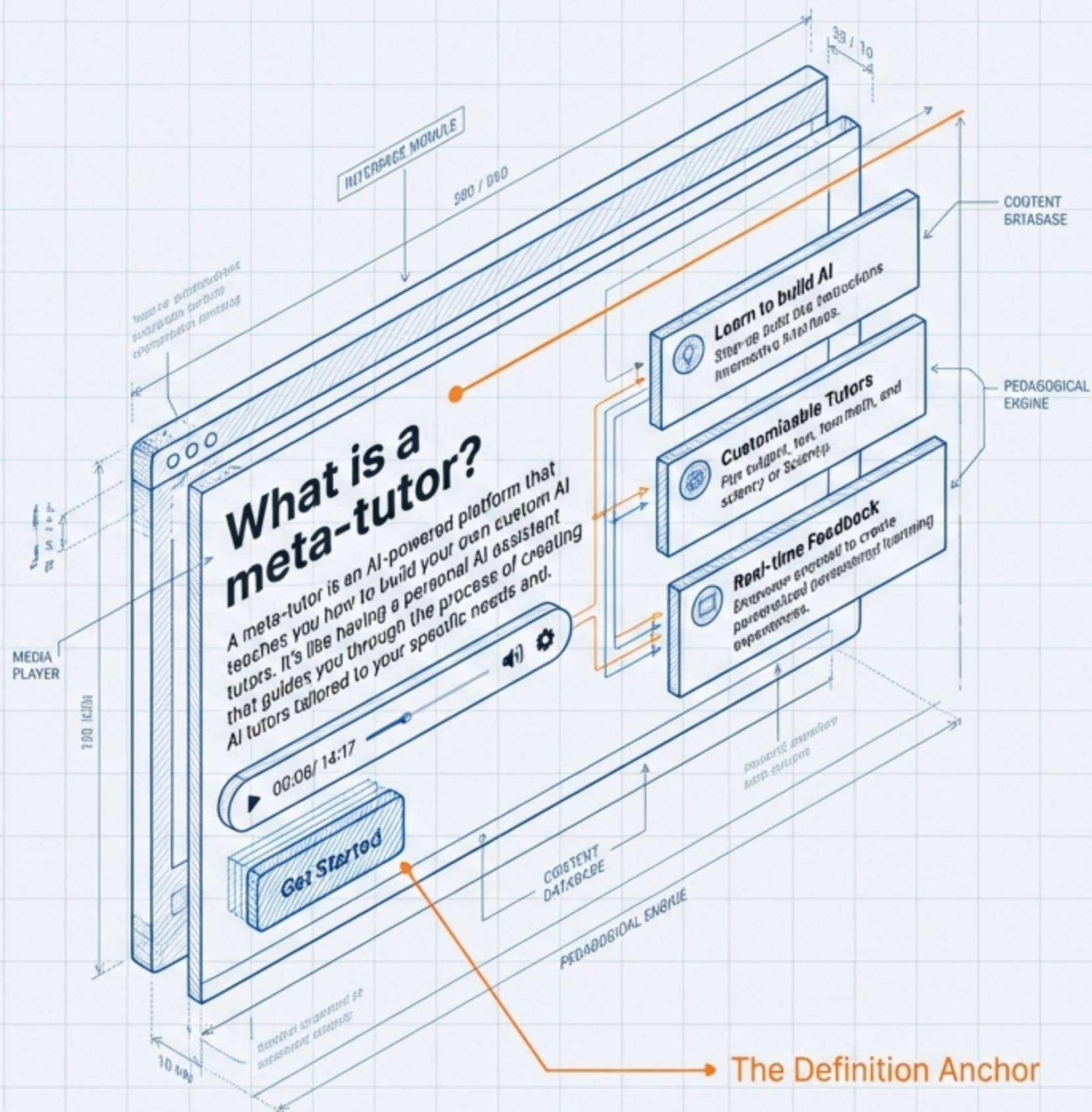
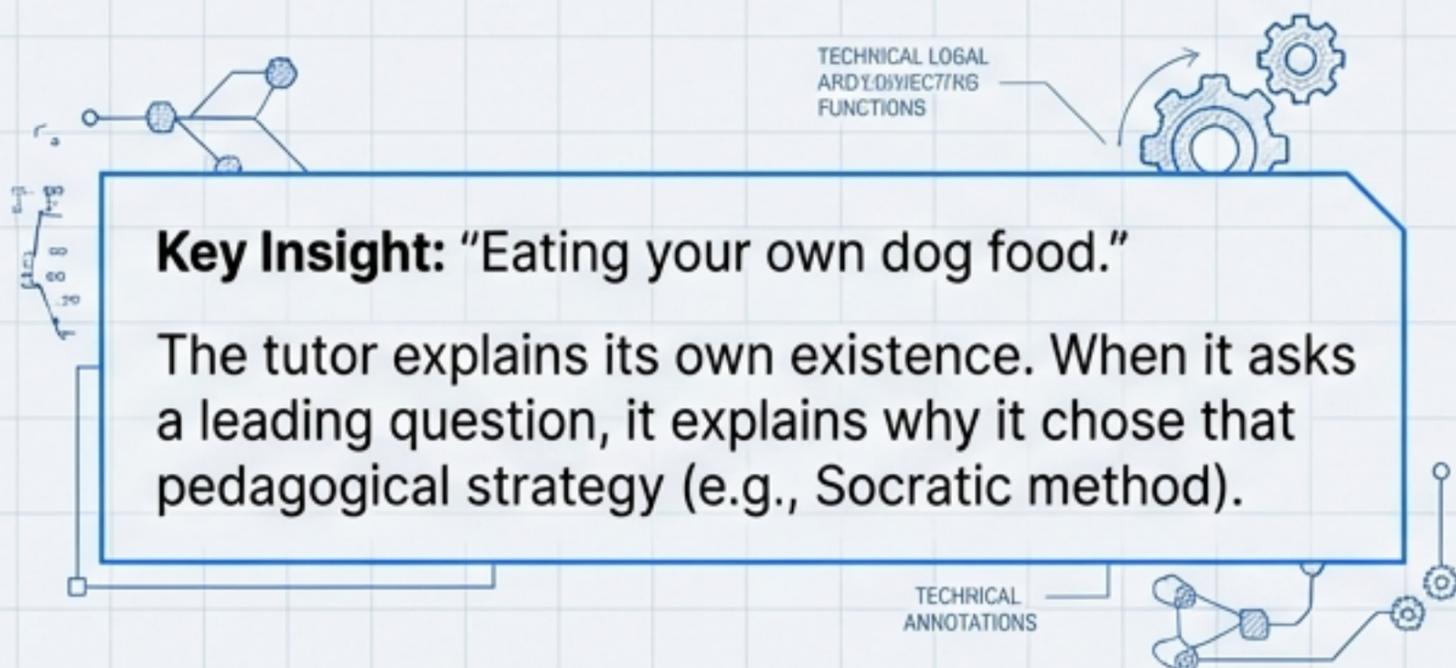
A Meta-Tutor is an instructional system operating on two simultaneous planes:

## 1. The Object Level

Teaches a specific subject (e.g., Google Cloud, AI).

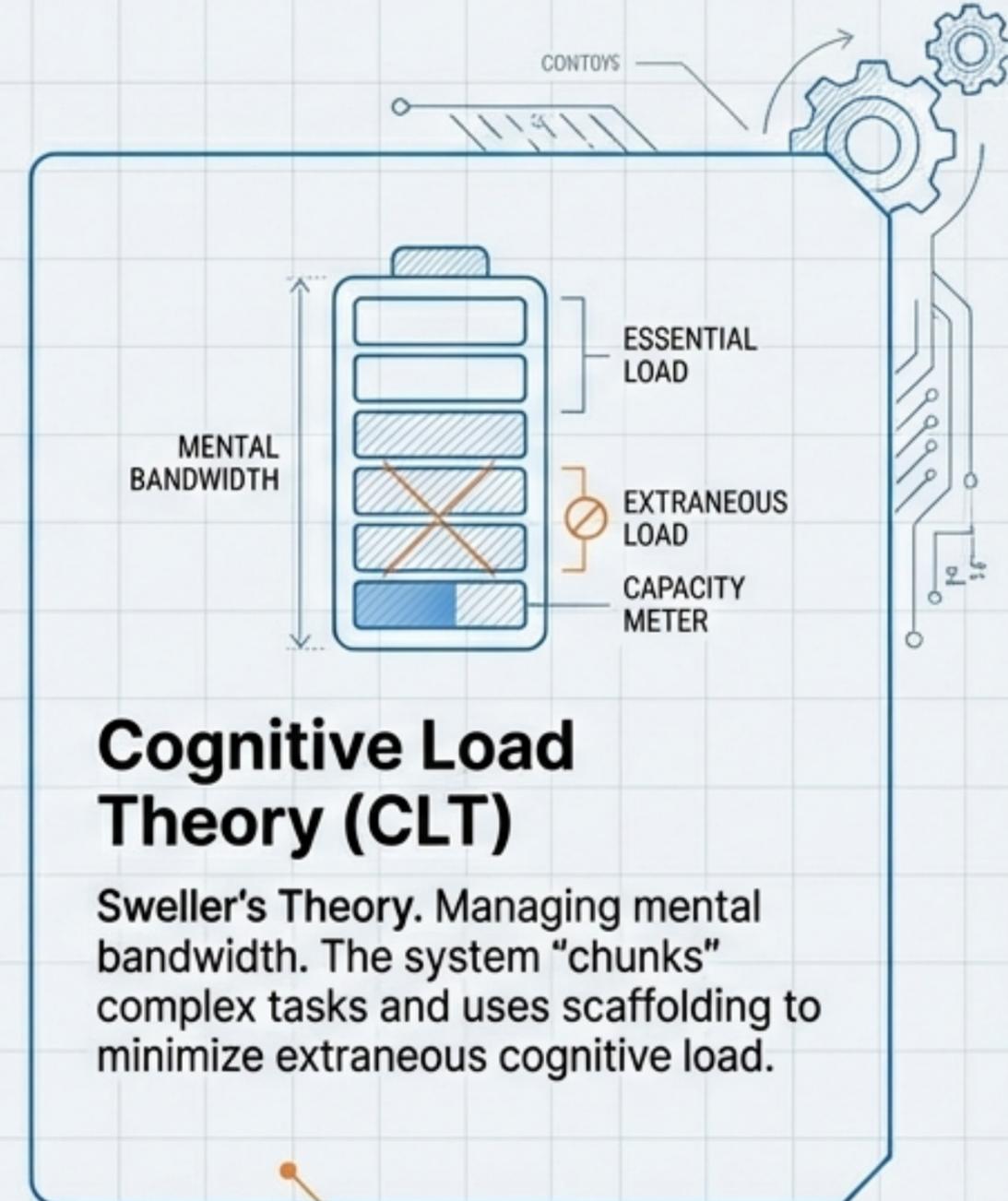
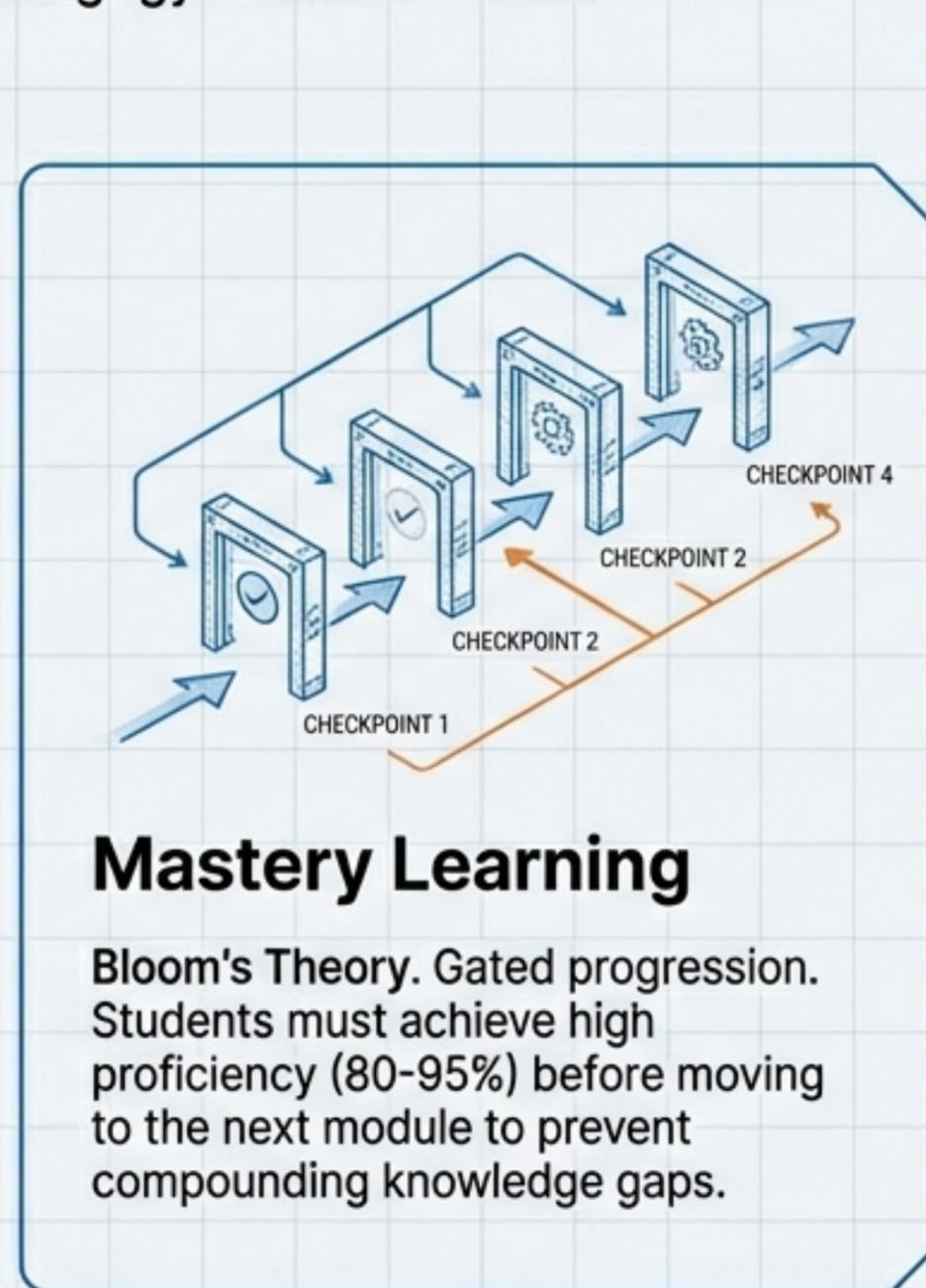
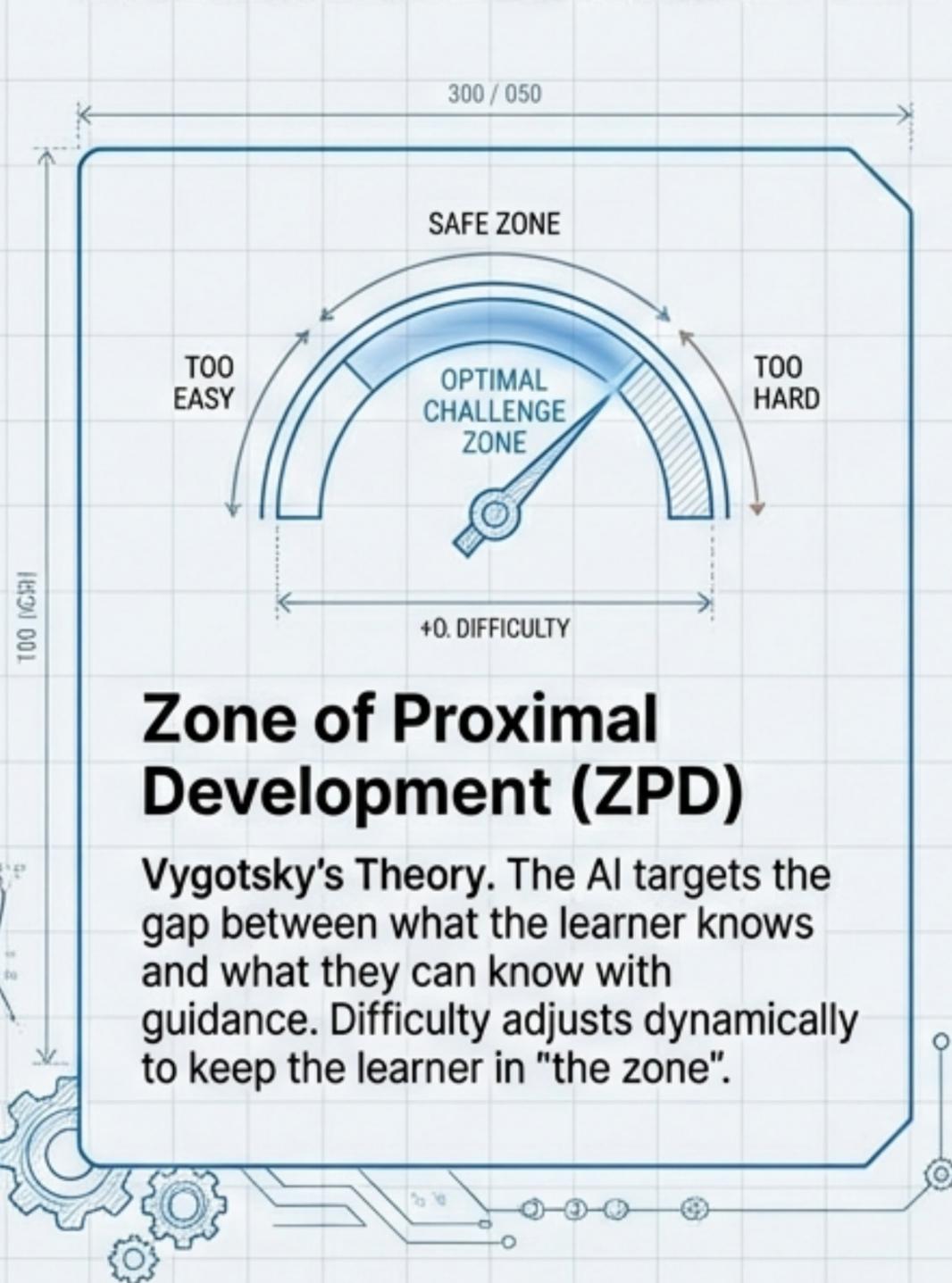
## 2. The Meta Level

Teaches the process of tutoring and building the system itself, using its own architecture as the live case study.



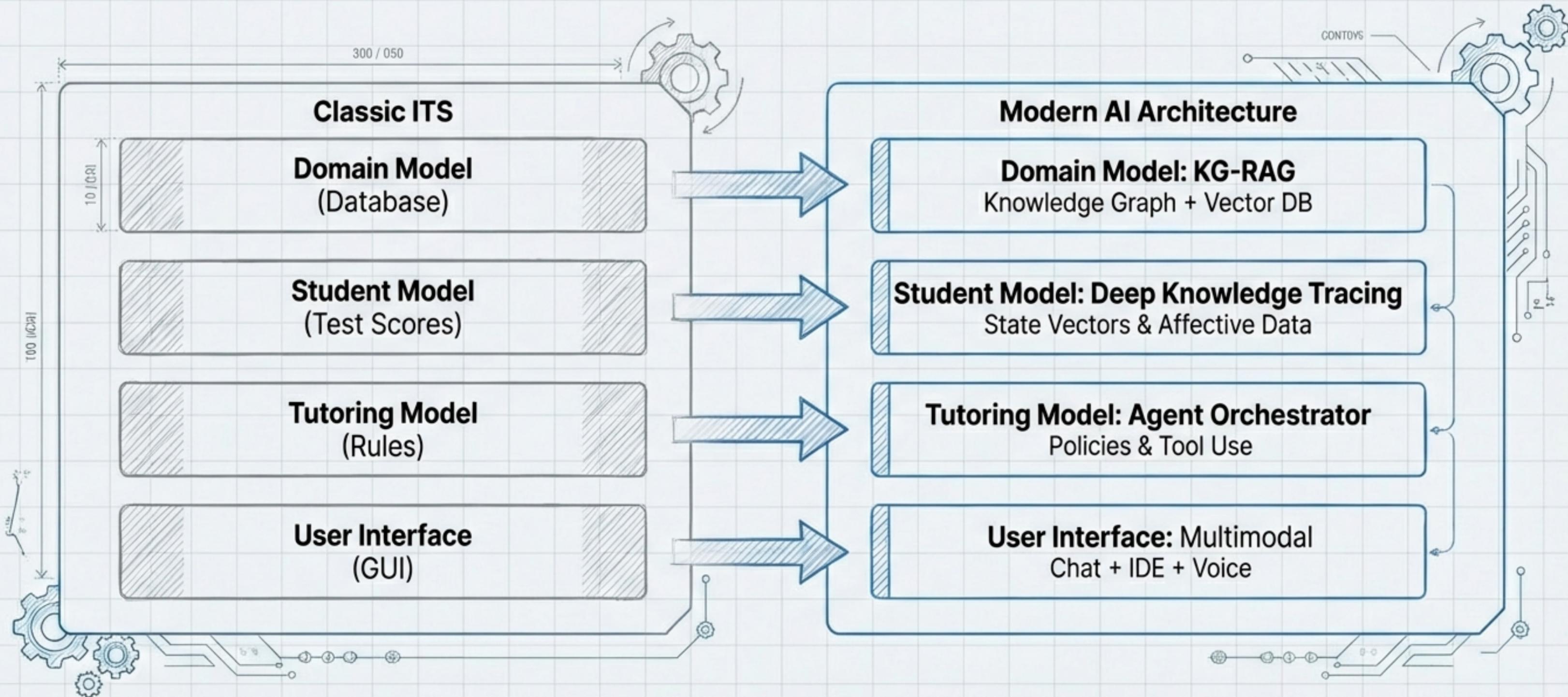
# The Pedagogical Engine: Learning Science as Code

An LLM without a framework is a tool. Pedagogy makes it a teacher.



PEDAGOGICAL ENGINE MODULES

# Reimagining the Intelligent Tutoring System (ITS)



# Phase 1: The Core Intelligence (Agent-G)

Goal: Establish the Foundational Q&A Tutor using Google Gemini 1.5 Pro.

## The Persona Strategy

- **Role:** Expert AI Meta-Tutor.
- **Primary Task:** Teach the user to configure GCP and n8n.

## Instructional Modalities (The Dual Switch)

### Socratic Method

Guide on the side. Asking questions to stimulate critical thinking (e.g., debugging logic).



### Direct Instruction

Sage on the stage. Efficient transfer of factual knowledge (e.g., syntax).

## AGENT ARCHITECTURE

INPUT & STREAM

### SYSTEM PROMPT

SYSTEM: You are an expert AI Meta-Tutor. Do not give the answer immediately.

Ask the student: "What does the error message suggest about the data type?"...

PROMPT WIREFRAME

AI ENGINE LINK

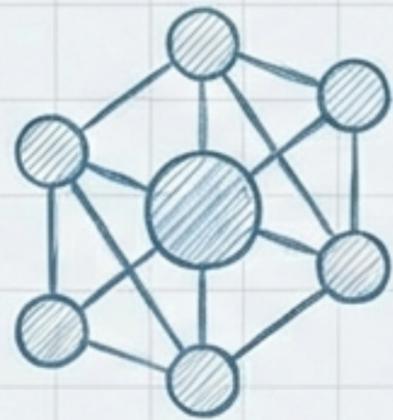
PROMPT CONFIG

# The Knowledge Backbone: KG-RAG Architecture

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**User Query**  
How do I use  
Function Calling?



**Knowledge Graph Traversal**  
Context Lookup: Function  
Calling -> Requires ->  
JSON Schema.



**Vector Retrieval**  
Fact Lookup: Retrieve  
Vertex AI Docs on 'JSON  
Schema' and 'Tools'.

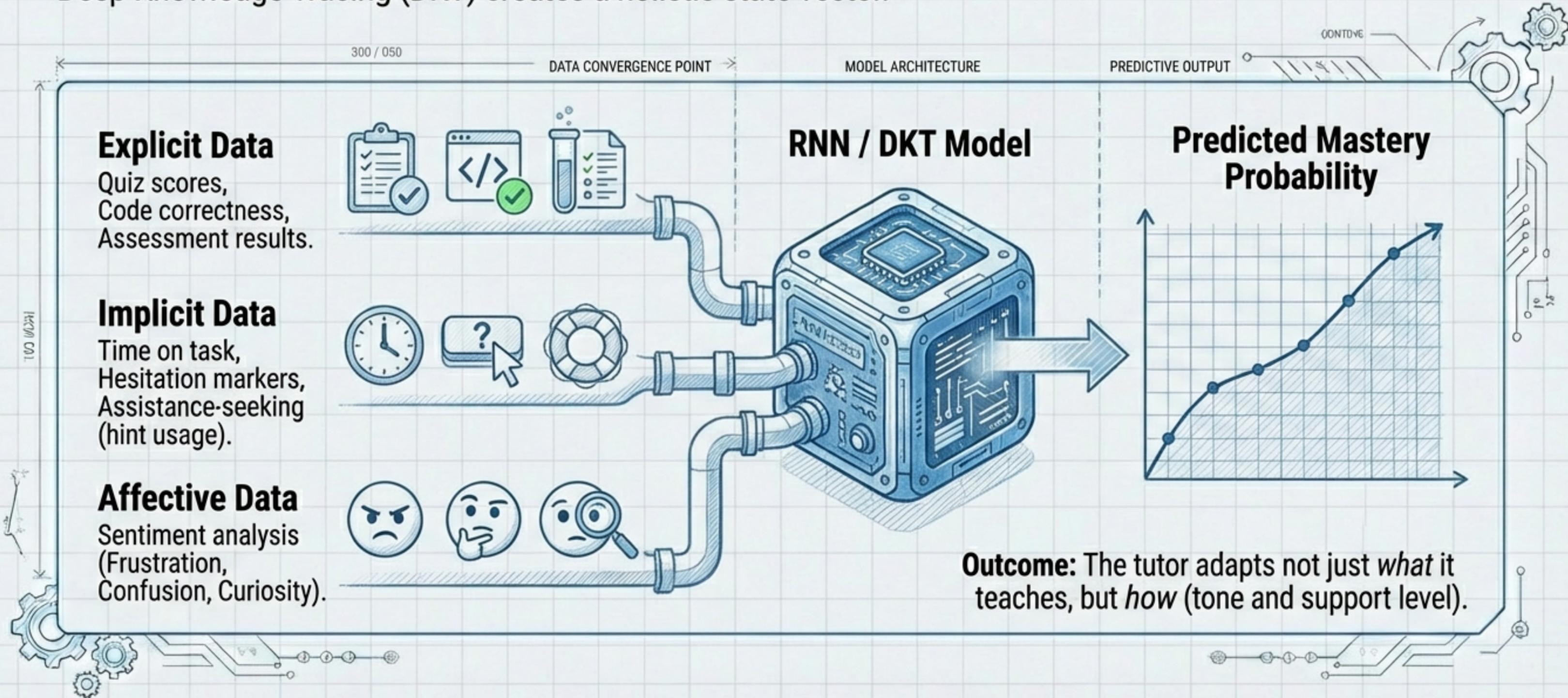


**Grounded Response**  
LLM Synthesis: Combines  
context and facts to  
generate an accurate,  
non-hallucinated answer.

**Why?** A technical tutor cannot afford to hallucinate API parameters.  
The Knowledge Graph ensures conceptual coherence.

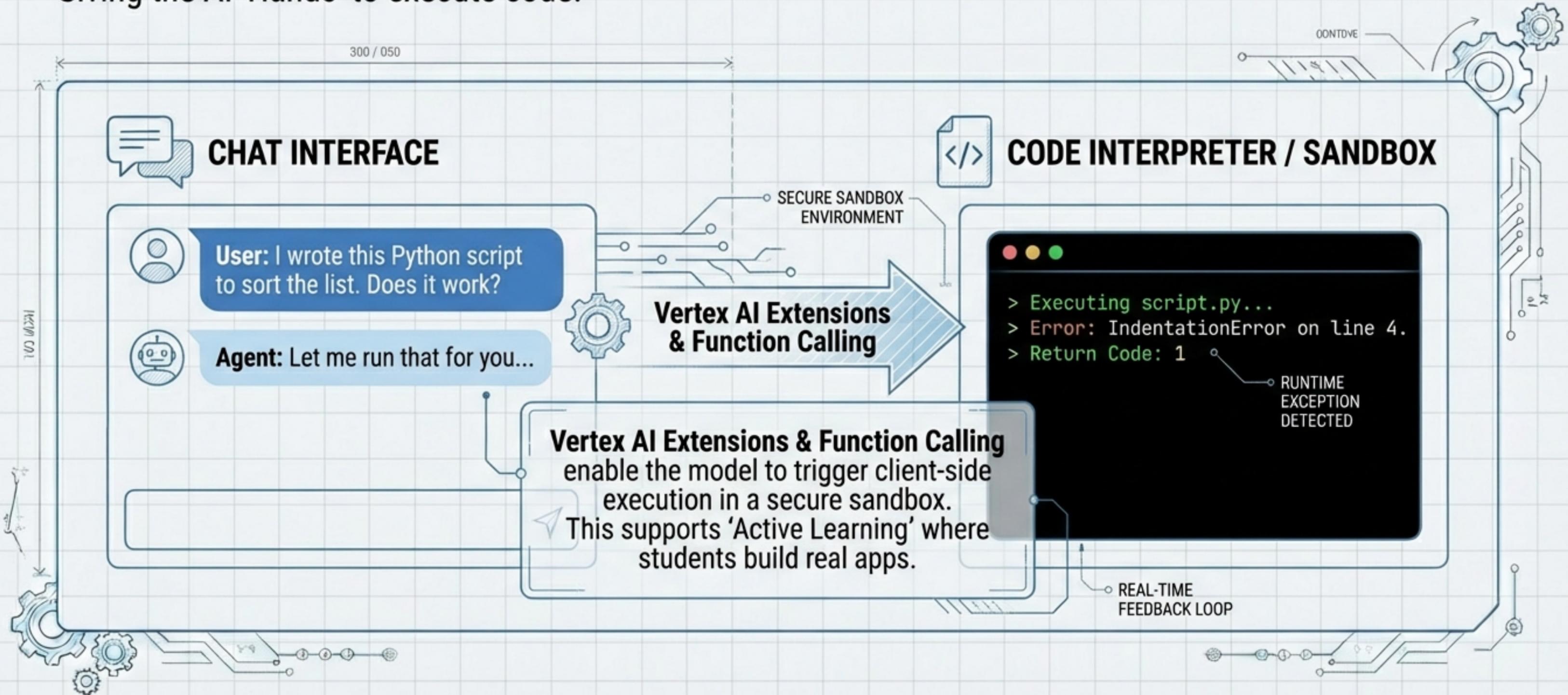
# The Dynamic Student Model

Deep Knowledge Tracing (DKT) creates a holistic state vector.



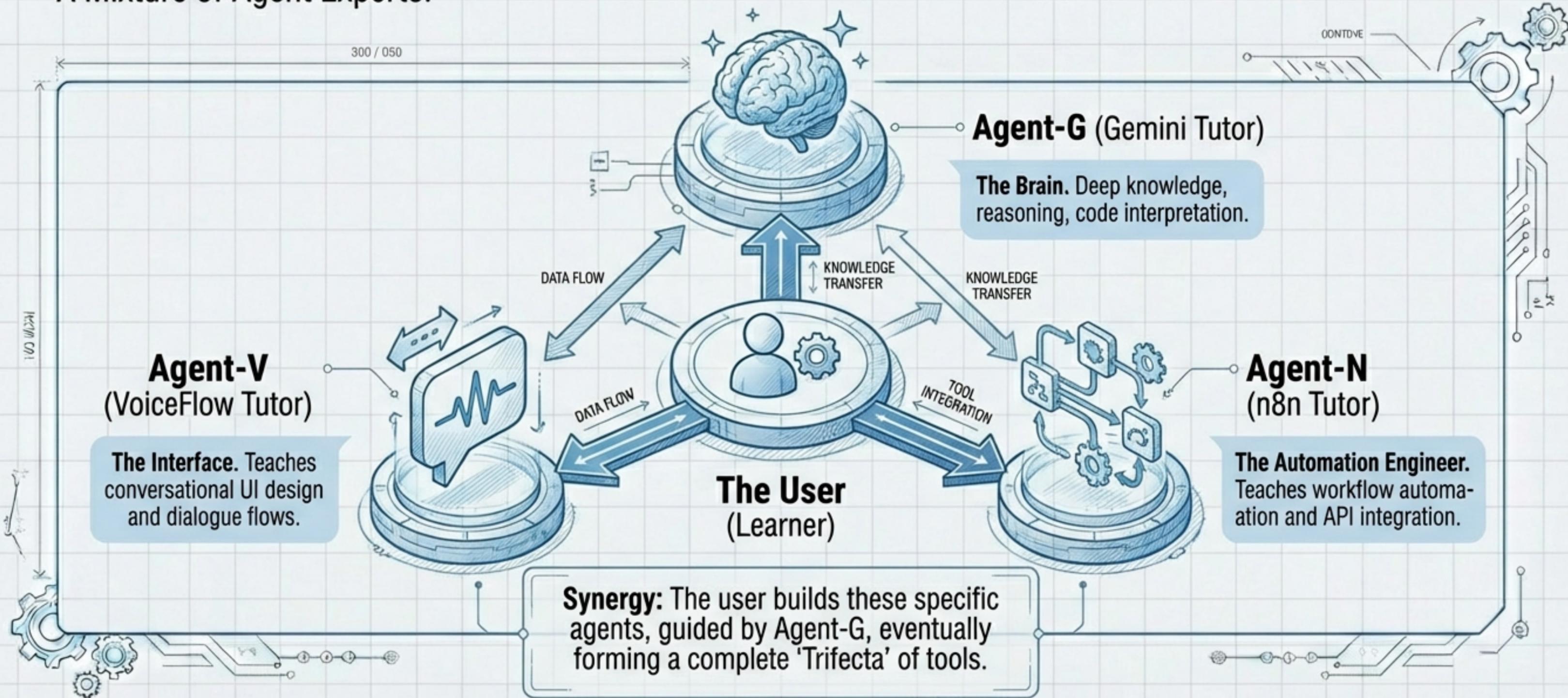
# Phase 2: From Chatbot to Agentic Tool-User

Giving the AI 'Hands' to execute code.

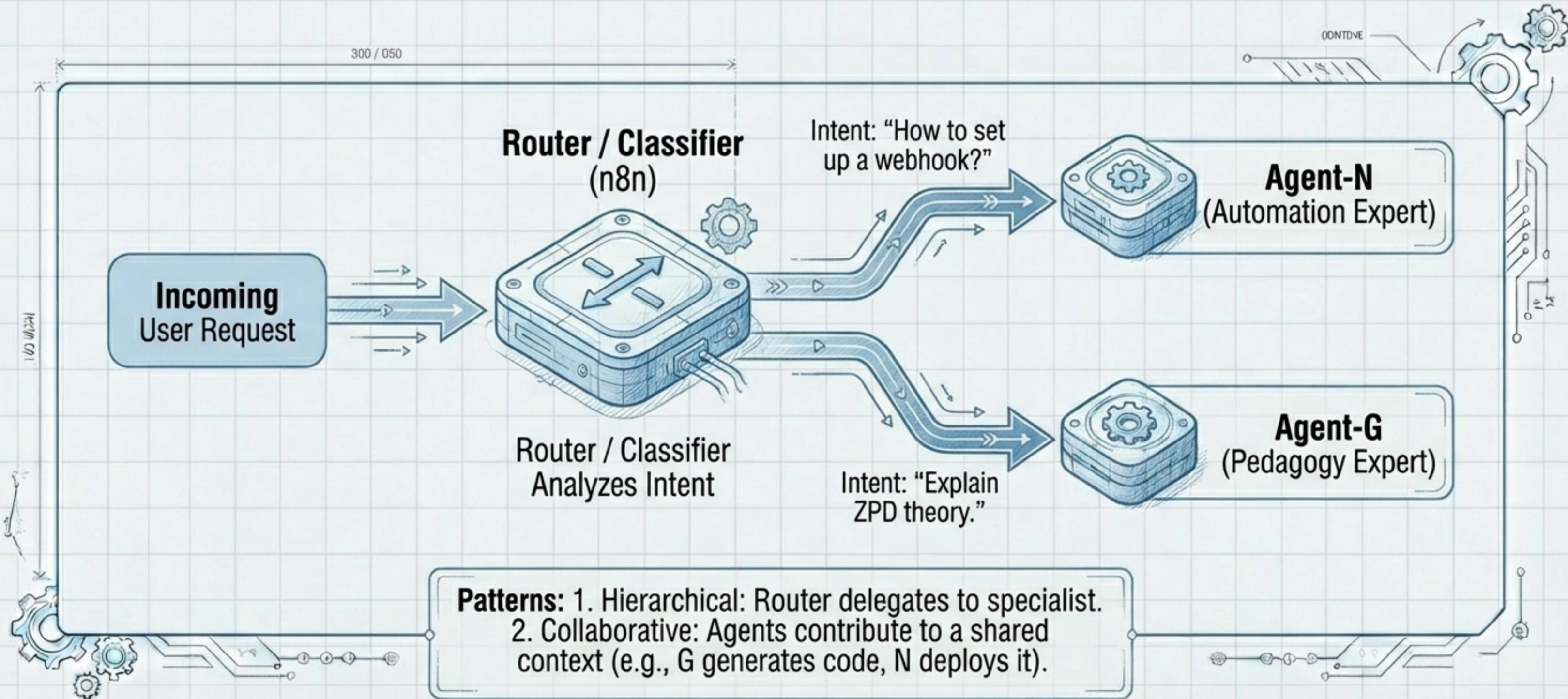


# Phase 3: The Multi-Agent Ecosystem

A Mixture of Agent Experts.

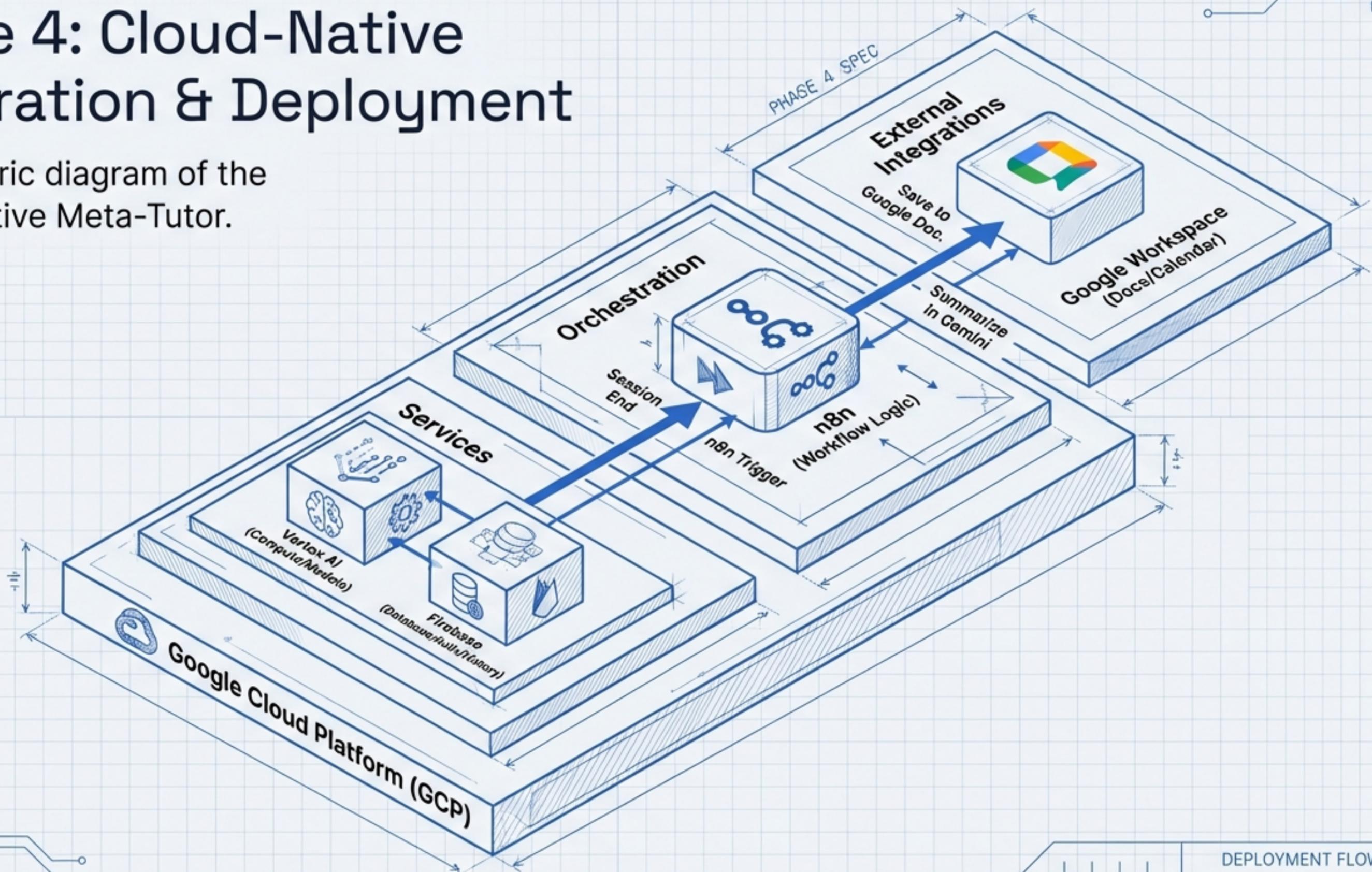


# The Nervous System: Orchestration via n8n

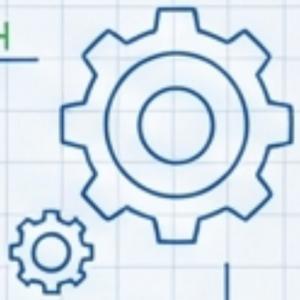


# Phase 4: Cloud-Native Integration & Deployment

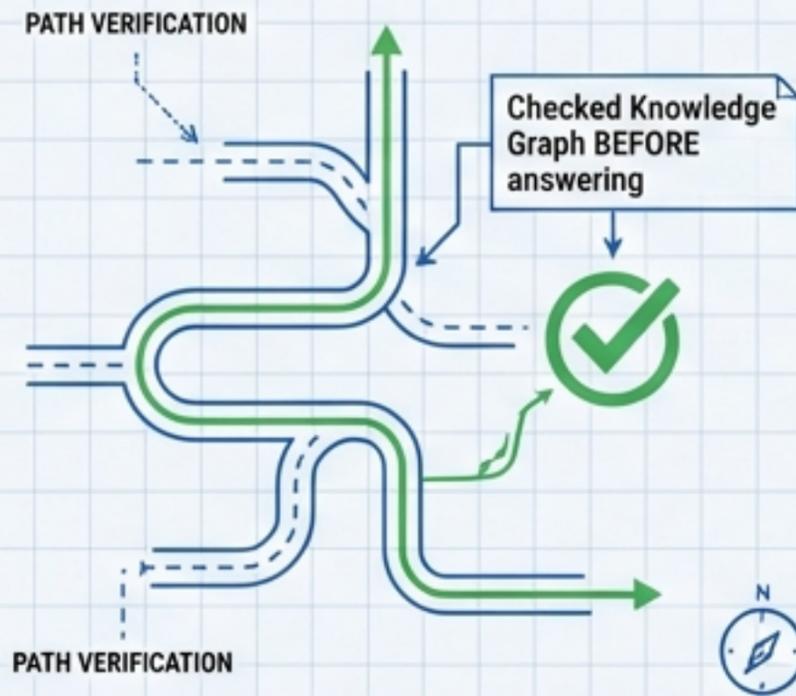
An isometric diagram of the Cloud-Native Meta-Tutor.



# Evaluation: AgentOps & Success Metrics

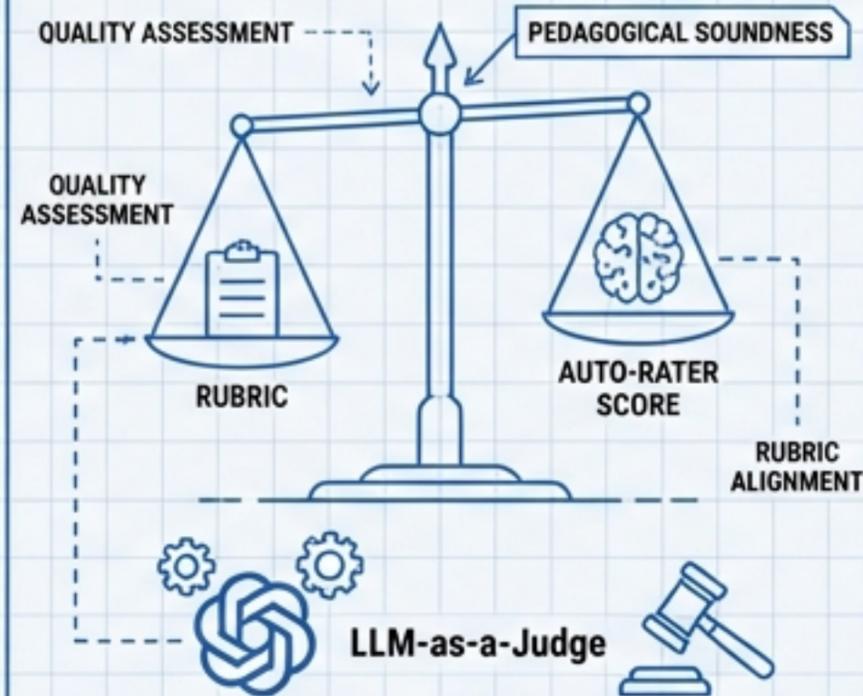


## Trajectory Evaluation



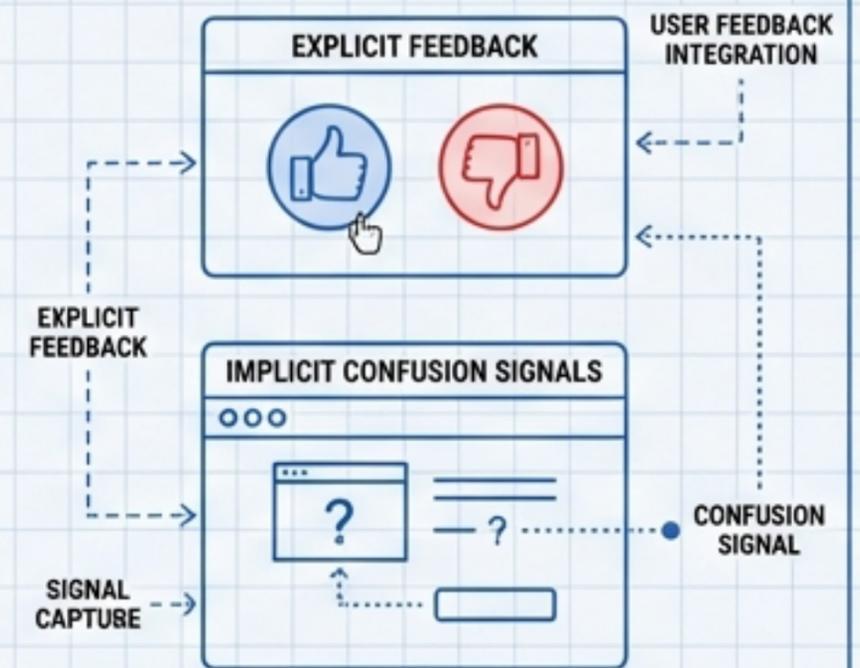
Did the agent take the right steps? (e.g., Checked Knowledge Graph BEFORE answering).  
Metric: Tool Usage Precision.

## Final Response Quality



Pedagogical Soundness. Auto-Rater (LLM-as-a-Judge) scores responses against a rubric.

## Human-in-the-Loop



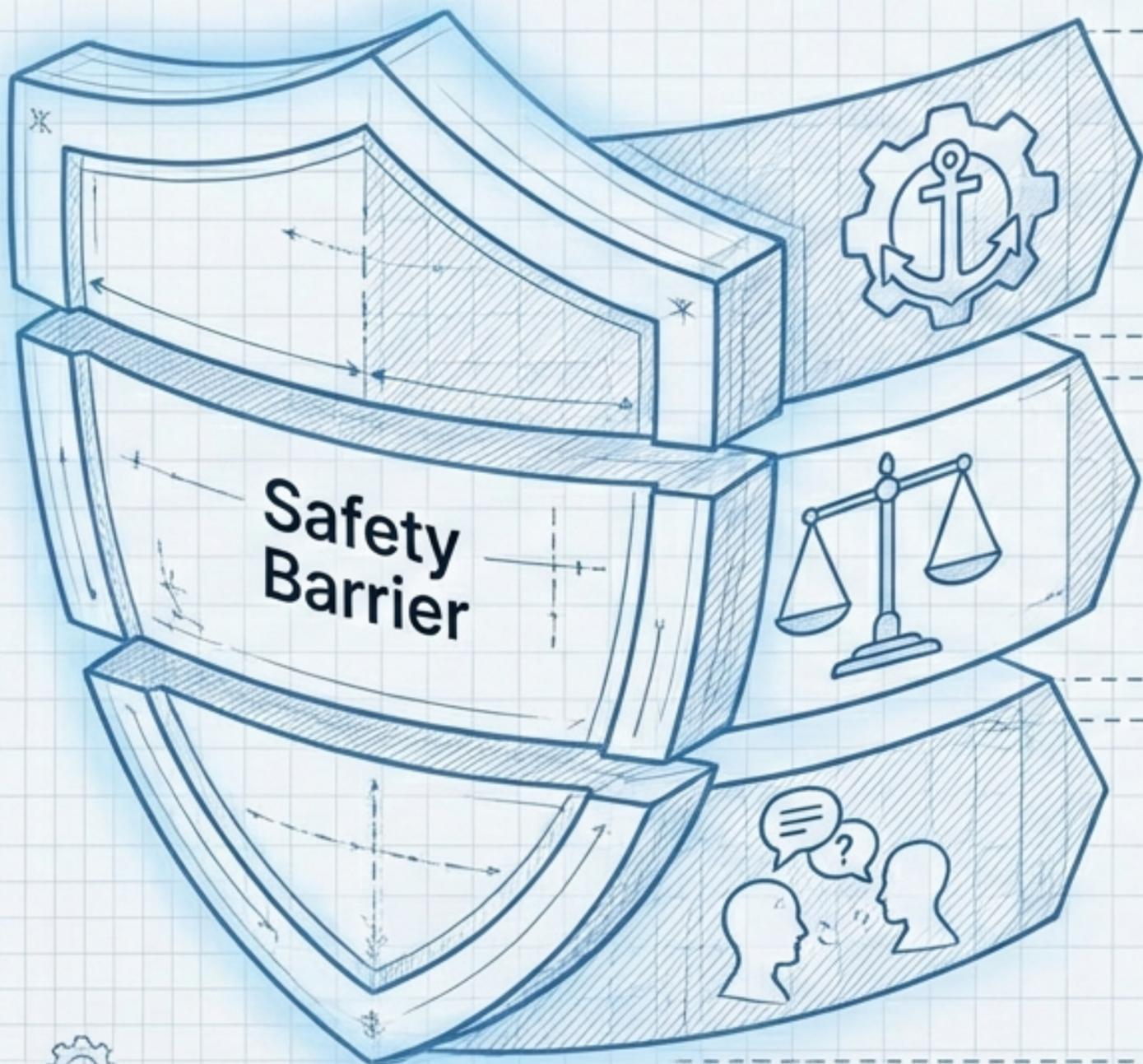
Explicit feedback buttons and implicit confusion signals.



Powered by Vertex AI Eval Service

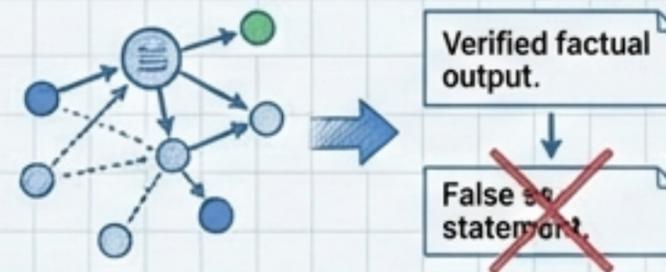


# Ethical Guardrails & Responsible AI



## Anti-Hallucination

Grounding via KG-RAG prevents fabrication of facts.



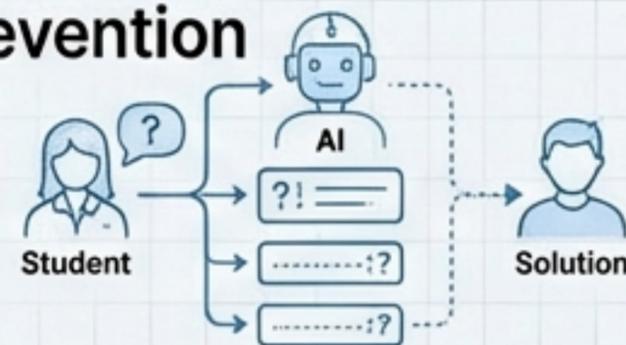
## Bias Mitigation

Diverse training data and Fairness Audits (disaggregated performance metrics).



## Cognitive Offloading Prevention

Pedagogical Guardrail: The Socratic Method prevents the "Cheating Machine" effect by prioritizing the process over the answer.



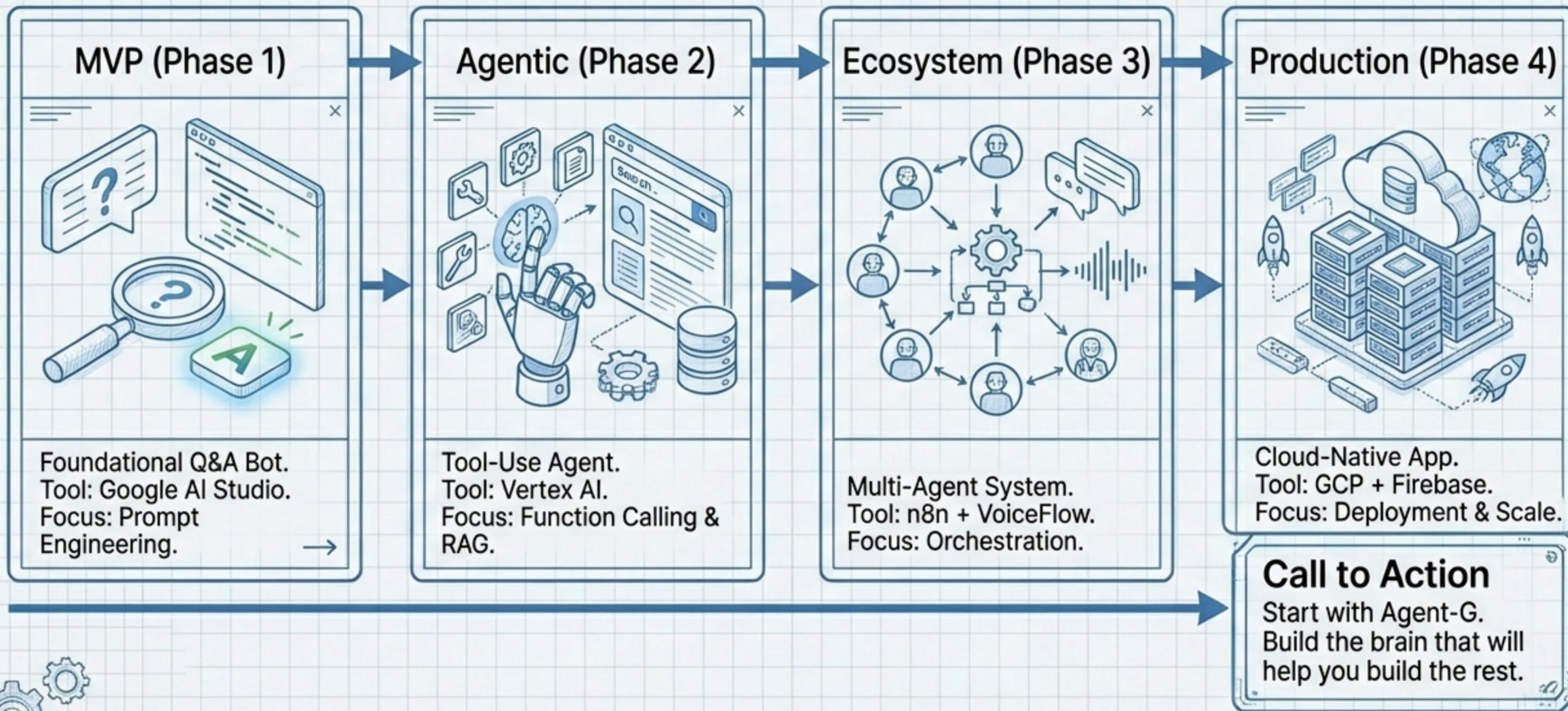
Note: Data Privacy: Strict adherence to GCP/Firebase encryption and minimization standards.



Powered by Google Cloud Platform (GCP)

DEPLOYMENT FLOW

# The Implementation Roadmap



# Transforming Learners into Builders

*“I actually used this exact AI Tutor framework in Google AI Studio to build the production version of this app on Vertex AI. It works!”*

— Jon Ross, AI-UX Designer

The Meta-Tutor represents a shift in educational technology: from static consumption of information to dynamic, scaffolded construction of knowledge. By building the tutor, the student masters the subject.

