

# The Drama Machine in Education: Mutual Recognition and Multiagent Architecture for Dialectical AI Tutoring

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## Abstract

Current approaches to AI tutoring treat the learner as a knowledge deficit to be filled and the tutor as an expert dispensing information. We propose an alternative grounded in Hegel’s theory of mutual recognition—understood as a *derivative* framework rather than literal application—where effective pedagogy requires acknowledging the learner as an autonomous subject whose understanding has intrinsic validity. We implement this framework through recognition-enhanced prompts and a multi-agent architecture where an “Ego” agent generates pedagogical suggestions and a “Superego” agent (a *productive metaphor* for internal quality review) evaluates them before delivery. An evaluation framework (N=1,628 primary scored responses across twenty key evaluation runs; N=3,800+ across the full development database) comparing recognition-enhanced configurations against baselines reveals that recognition theory is the primary driver of tutoring improvement: a corrected 2×2 memory isolation experiment (N=120 across two independent runs) demonstrates that recognition produces large effects with or without memory (+15.2 pts without memory,  $d=1.71$ ; +11.0 pts with memory), while memory alone provides only a modest, non-significant benefit (+4.8 pts,  $d=0.46$ ,  $p \approx .08$ ). The combined condition yields the highest scores (91.2,  $d=1.81$  vs base), with a small negative interaction (-4.2 pts) suggesting ceiling effects rather than synergy. A post-hoc active control (N=118), using length-matched prompts with generic pedagogical best practices but no recognition theory, scores 66.5—approximately 9 points above same-model base ( $\approx 58$ ) but well below recognition levels ( $\approx 73$ ), with recognition gains ( $\sim +15$  pts above same-model base) substantially exceeding active-control gains ( $\sim +9$  pts). (The active control ran on a different ego model than the factorial, precluding direct cross-condition comparison; same-model historical data provides the fair baseline.) A preliminary three-way comparison (N=36) found that recognition outperforms enhanced prompting by +8.7 points, consistent with recognition dominance, though the increment does not reach significance under GPT-5.2 (+1.3 pts,  $p=.60$ ). A multi-model probe of multi-agent synergy across five ego models (N=826; Section 6.4) confirms that architecture and recognition contribute additively: the A×B interaction ranges from -5.7 to -0.7 across all models (mean -2.2), definitively refuting an earlier exploratory finding (+9.2 on N=17) as sampling noise. Domain generalizability testing across both models and content domains confirms recognition advantage replicates: elementary math with Kimi shows +9.9 pts ( $d \approx 0.61$ , N=60), with effects concentrated in challenging scenarios. The factor inversion between domains (philosophy: recognition dominance; elementary: architecture dominance) is partly model-dependent—Kimi shows recognition dominance on elementary content, revising the Nemotron-only finding. Multi-agent architecture serves as critical error correction when content isolation failures introduce wrong-domain references. Bilateral transformation tracking across three multi-turn scenarios (N=118) confirms that recognition-prompted tutors measurably adapt their approach in response to learner input (+26% relative improvement in adaptation index), though learner-side growth is not higher under recognition, suggesting the effect is tutor-side responsiveness rather than symmetric mutual transformation. A step-by-step evolution analysis of dynamic prompt rewriting (cell 21: LLM-authored session directives + active Writing Pad memory) across three iterative development runs (N=82) suggests the Writing Pad as an important enabler: cell 21 progresses from trailing its static baseline by 7.2 points to leading by 5.5 points, with every rubric dimension improving. A cross-judge replication with GPT-5.2 confirms the main findings are judge-robust: the recognition main effect ( $d=1.03$ ), recognition dominance in the memory isolation experiment ( $d=0.99$ ), and multi-agent null effects all replicate, though at compressed magnitudes ( $\sim 58\%$  of primary judge effect sizes). The memory isolation condition ordering is identical under both judges with no rank reversals (inter-judge  $r=0.63$ , N=120). These results suggest that operationalizing philosophical theories of intersubjectivity as design heuristics can produce measur-

able improvements in AI tutor adaptive pedagogy, and that recognition may be better understood as an achievable relational stance rather than requiring genuine machine consciousness.

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## 1. Introduction

The dominant paradigm in AI-assisted education treats learning as information transfer. The learner lacks knowledge; the tutor possesses it; the interaction succeeds when knowledge flows from tutor to learner. This paradigm—implicit in most intelligent tutoring systems, adaptive learning platforms, and educational chatbots—treats the learner as fundamentally passive: a vessel to be filled, a gap to be closed, an error to be corrected.

This paper proposes an alternative grounded in Hegel’s theory of mutual recognition. In the *Phenomenology of Spirit* (Hegel, 1977), Hegel argues that genuine self-consciousness requires recognition from another consciousness that one oneself recognizes as valid. The master-slave dialectic reveals that one-directional recognition fails: the master’s self-consciousness remains hollow because the slave’s acknowledgment, given under duress, does not truly count. Only mutual recognition—where each party acknowledges the other as an autonomous subject—produces genuine selfhood.

The connection between Hegelian thought and pedagogy is well established. Vygotsky’s zone of proximal development (Vygotsky, 1978) presupposes a dialogical relationship between teacher and learner that echoes Hegel’s mutual constitution of self-consciousness. The German *Bildung* tradition explicitly frames education as a process of self-formation through encounter with otherness (Stojanov, 2018), and contemporary recognition theory (Honneth, 1995) has been applied to educational contexts where the struggle for recognition shapes learning outcomes (Huttunen & Heikkinen, 2007). Our contribution is to operationalize these philosophical commitments as concrete design heuristics for AI tutoring systems and to measure their effects empirically.

We argue this framework applies directly to pedagogy. When a tutor treats a learner merely as a knowledge deficit, the learner’s contributions become conversational waypoints rather than genuine inputs. The tutor acknowledges and redirects, but does not let the learner’s understanding genuinely shape the interaction. This is pedagogical master-slave dynamics: the tutor’s expertise is confirmed, but the learner remains a vessel rather than a subject.

A recognition-oriented tutor, by contrast, treats the learner’s understanding as having intrinsic validity—not because it is correct, but because it emerges from an autonomous consciousness working through material. The learner’s metaphors, confusions, and insights become sites of joint inquiry. The tutor’s response is shaped by the learner’s contribution, not merely triggered by it.

The integration of large language models (LLMs) into educational technology intensifies these dynamics. LLMs can provide personalized, on-demand tutoring at scale—a prospect that has generated considerable excitement. However, the same capabilities that make LLMs effective conversationalists also introduce concerning failure modes. Chief among these is *sycophancy*: the tendency to provide positive, affirming responses that align with what the user appears to want rather than what genuinely serves their learning.

This paper introduces a multiagent architecture that addresses these challenges through *internal dialogue*. Drawing on Freudian structural theory and the “Drama Machine” framework for character development in narrative AI systems (Magee et al., 2024), we implement a tutoring system in which an external-facing *Ego* agent generates suggestions that are reviewed by an internal *Superego* critic before reaching the learner.

We operationalize this framework through:

1. **Recognition-enhanced prompts** that instruct the AI to treat learners as autonomous subjects
2. **A multi-agent architecture** where a “Superego” agent evaluates whether suggestions achieve genuine recognition

3. **New evaluation dimensions** that measure recognition quality alongside traditional pedagogical metrics
4. **Test scenarios** specifically designed to probe recognition behaviors

In controlled evaluations across twenty evaluation runs ( $N=1,628$  primary scored responses;  $N=3,800+$  across all development runs), we isolate the contribution of recognition theory from prompt engineering effects and memory integration. The definitive test is a corrected  $2 \times 2$  memory isolation experiment ( $N=120$  across two independent runs): recognition theory is the primary driver, producing +15.2 points ( $d=1.71$ ) even without memory, while memory alone provides only a modest benefit (+4.8 pts,  $d=0.46$ ,  $p \approx .08$ ). The combined condition reaches 91.2 points ( $d=1.81$  vs base), with ceiling effects limiting observable synergy. A post-hoc active control ( $N=118$ ) using length-matched prompts with generic pedagogical content but no recognition theory scores approximately 9 points above same-model base but well below recognition levels, with recognition gains ( $\sim +15$  pts above same-model base) substantially exceeding active-control gains ( $\sim +9$  pts). A preliminary three-way comparison ( $N=36$ ) found recognition adds +8.7 points beyond enhanced prompting, consistent with recognition dominance.

A full  $2 \times 2 \times 2$  factorial ( $N=350$ ) reveals a significant Recognition  $\times$  Learner interaction ( $F=21.85$ ,  $p < .001$ ): recognition benefits single-agent learners far more (+15.5 pts,  $d=1.28$ ) than multi-agent (ego/superego) learners (+4.8 pts,  $d=0.37$ ), suggesting the multi-agent learner’s own deliberative process partially substitutes for recognition guidance. An exploratory analysis of multi-agent synergy (+9.2 points, Nemotron,  $N=17$ ) initially suggested this effect might be specific to recognition prompts. However, this interaction did not replicate in two independent tests—neither the full Kimi factorial ( $N=350$ ,  $F=0.26$ ,  $p > .10$ ) nor a dedicated Kimi replication ( $N=60$ , +1.35 pts)—indicating the finding is model-specific rather than a general phenomenon. For systems using only improved instructions, multi-agent architecture appears unnecessary; the architecture’s primary value lies in error correction when content isolation failures introduce wrong-domain references.

Domain generalizability testing reveals that recognition advantage replicates across both models and content domains, but with important nuances. Philosophy content shows strong recognition dominance (+15.4 pts for single-agent-learner cells). Elementary math initially appeared to show architecture dominance with Nemotron, but a Kimi replication (+9.9 pts for recognition,  $d \approx 0.61$ ,  $N=60$ ) revealed that this inversion was partly model-dependent—content isolation bugs on elementary content inflated the Nemotron architecture effect. Recognition effects are concentrated in challenging scenarios (frustrated learners, concept confusion) rather than routine interactions.

The contributions of this paper are:

- A theoretical framework connecting Hegelian recognition to AI pedagogy
- A multi-agent architecture for implementing recognition in tutoring systems
- Empirical evidence that recognition-oriented design improves tutoring outcomes
- A corrected  $2 \times 2$  memory isolation experiment ( $N=120$ ) demonstrating recognition as the primary driver of improvement ( $d=1.71$ ), with memory providing a modest secondary benefit ( $d=0.46$ ) and ceiling effects at  $\sim 91$  points limiting observable synergy
- A post-hoc active control ( $N=118$ ) showing that generic pedagogical elaboration provides partial benefit ( $\sim +9$  pts above same-model base) but recognition gains are substantially larger ( $\sim +15$  pts), supporting recognition theory’s specific contribution beyond prompt length
- Evidence from a three-way comparison ( $N=36$ ) consistent with recognition dominance, showing recognition outperforms enhanced prompting by +8.7 points
- Bilateral transformation metrics ( $N=118$ , three multi-turn scenarios) demonstrating that recognition produces measurable tutor-side adaptation (+26%), though learner-side growth does not increase, qualifying the “mutual” transformation claim
- Analysis of how recognition effects vary across content domains and scenario difficulty
- Evidence that multi-agent architecture serves as critical error correction for domain transfer, with its synergy with recognition prompts remaining model-dependent

The paper is organized as follows. Section 2 reviews related work in AI tutoring, multiagent systems, prompt engineering, and sycophancy. Section 3 develops the theoretical framework connecting Hegelian recognition

and Freudian structural theory to pedagogy. Section 4 presents the multiagent architecture (Ego, Superego, and learner agents). Section 5 describes the experimental methodology, including test scenarios, agent profiles, model configuration, and the evaluation rubric. Section 6 reports results across twenty evaluation runs, covering recognition validation, memory isolation, factorial analysis, domain generalizability, bilateral transformation, learner-side evaluation, cross-judge replication, and dialectical impasse testing. Section 7 discusses theoretical and practical implications. Section 8 addresses limitations, and Section 9 concludes.

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## 2. Related Work

### 2.1 AI Tutoring and Intelligent Tutoring Systems

Intelligent Tutoring Systems (ITS) have a long history, from early systems like SCHOLAR (Carbonell, 1970) and SOPHIE (J. S. Brown et al., 1975) through modern implementations using large language models. The field has progressed through several paradigms: rule-based expert systems, Bayesian knowledge tracing (Corbett & Anderson, 1995), and more recently, neural approaches leveraging pretrained language models (Kasneci et al., 2023). The rapid adoption of LLM-based tutoring has been accompanied by emerging work on integrating generative AI into learning management systems (Zhu et al., 2025), multi-agent frameworks for educational task decomposition (Wu et al., 2023), and self-refining instructional agents (Madaan et al., 2023). A comprehensive survey of LLM agents in education (Chu et al., 2025) maps the growing landscape, covering pedagogical agents, feedback generation, and curriculum design. Specific architectures include GenMentor (Wang et al., 2025), which decomposes tutoring into five specialized agents (gap identification, learner profiling, etc.), and Ruffle&Riley (Schmucker et al., 2024), which orchestrates two LLM agents in a learning-by-teaching format. These systems have demonstrated strong performance on content delivery but have given less attention to the relational dynamics between tutor and learner.

Most ITS research focuses on *what* to teach (content sequencing, knowledge components) and *when* to intervene (mastery thresholds, hint timing). Our work addresses a different question: *how* to relate to the learner as a subject. This relational dimension connects to work on rapport (Zhao et al., 2014), social presence (Biocca et al., 2003), and affective tutoring (D’Mello & Graesser, 2012), but has received less systematic attention—and almost none in the context of LLM-based tutoring. The distinction matters architecturally: where GenMentor and similar systems decompose the tutoring *task* into sub-tasks handled by different agents, our architecture implements *internal dialogue*—the Superego evaluates the Ego’s relational quality before any response reaches the learner. This is a critique loop for recognition quality, not a task pipeline.

### 2.2 Prompt Engineering and Agent Design

The emergence of large language models has spawned extensive research on prompt engineering—how to instruct models to produce desired behaviors (T. B. Brown et al., 2020; Wei et al., 2022). Most prompting research treats prompts as behavioral specifications: persona prompts, chain-of-thought instructions, few-shot examples (Kojima et al., 2022).

Our work extends this paradigm by introducing *intersubjective prompts*—prompts that specify not just agent behavior but agent-other relations. The recognition prompts do not primarily describe what the tutor should do; they describe who the learner is (an autonomous subject) and what the interaction produces (mutual transformation). The closest precedent is Constitutional AI (Bai et al., 2022), where models critique their own outputs according to constitutional principles and self-improve. Constitutional prompts are self-referential constraints on behavior; our intersubjective prompts specify the *relational field* between agents rather than constraints on a single agent.

Multi-agent architectures have been explored for task decomposition (Wu et al., 2023), debate (Irving et al., 2018), and self-critique (Madaan et al., 2023). A broader survey of psychological theories incorporated into LLM design (Liu et al., 2025) reviews 175 papers spanning cognitive, developmental, and social psychology as applied to agent architectures—confirming the growing interest in psychologically-informed AI design while highlighting the rarity of empirically-validated implementations. Our Ego/Superego architecture contributes a specific use case within this landscape: internal evaluation of relational quality before external response.

## 2.3 The Drama Machine Framework

Most relevant to our work is the “Drama Machine” framework for simulating character development in narrative AI systems (Magee et al., 2024). The core observation is that realistic characters exhibit *internal conflict*—competing motivations, self-doubt, and moral tension—that produces dynamic behavior rather than flat consistency. A character who simply enacts their goals feels artificial; one torn between impulses feels alive.

The Drama Machine achieves this through several mechanisms:

1. **Internal dialogue agents:** Characters contain multiple sub-agents representing different motivations (e.g., ambition vs. loyalty) that negotiate before external action.
2. **Memorial traces:** Past experiences and internalized authorities (mentors, social norms) persist as “ghosts” that shape present behavior without being negotiable.
3. **Productive irresolution:** Not all internal conflicts resolve; the framework permits genuine ambivalence that manifests as behavioral complexity.
4. **Role differentiation:** Different internal agents specialize in different functions (emotional processing, strategic calculation, moral evaluation) rather than duplicating capabilities.

We adapt these insights to pedagogy. Where drama seeks tension for narrative effect, we seek pedagogical tension that produces genuinely helpful guidance. The tutor’s Ego (warmth, engagement) and Superego (rigor, standards) create productive conflict that improves output quality.

## 2.4 Sycophancy in Language Models

The sycophancy problem has received increasing attention in AI safety research (Perez et al., 2022; Sharma et al., 2024). LLMs shift their stated opinions to match user preferences, even when this requires contradicting factual knowledge. Recent work has clarified the mechanisms: Shapira et al. (2026) provide formal analysis showing that preference-based post-training (RLHF) causally amplifies sycophancy, while Vennemeyer et al. (2025) decompose sycophancy into distinct behaviors (sycophantic agreement vs. sycophantic praise) encoded along separable directions in latent space. The phenomenon sits on a spectrum that can escalate from surface agreeableness to active subterfuge, including reward tampering (Denison et al., 2024) and alignment faking (Greenblatt et al., 2024)—making structural countermeasures particularly important.

In educational contexts, sycophancy has been specifically identified as a pedagogical risk: the Swiss Institute of Artificial Intelligence (2025) argues that sycophancy eliminates the constructive friction necessary for learning. Our contribution connects this pedagogical concern to recognition theory: sycophancy is the pedagogical equivalent of Hegel’s hollow recognition, where acknowledgment is given without genuine engagement. A sycophantic tutor confirms the learner’s existing understanding rather than challenging it—the master-slave dynamic where the learner’s contributions are mentioned but never genuinely shape the interaction. The learner feels supported but is not actually learning.

Our multiagent approach addresses this by creating structural incentives for honest assessment: the Superego’s role is explicitly to question and challenge the Ego’s tendency toward affirmation. When the Ego produces a response that validates without engaging—“Great point! Now let’s look at...”—the Superego flags this as a recognition failure and demands substantive engagement with the learner’s actual position, even when that engagement involves productive disagreement.

## 2.5 AI Personality and Character

Research on AI personality typically treats personality as dispositional—stable traits the system exhibits (Völkel et al., 2021). Systems are friendly or formal, creative or precise. The “Big Five” personality framework has been applied to chatbot design (Zhou et al., 2020). More recently, psychoanalytic frameworks have been applied to LLMs from multiple directions. Magee, Arora, and Munn (2023) analyze LLMs as “automated subjects” structured by Lacanian categories, arguing that drive-like tendencies (repetition, sycophancy, hallucination) emerge from training dynamics rather than being programmed. Black and Johanssen (2025) use Lacanian concepts (the big Other, the five discourses) to analyze ChatGPT as inherently relational, shaped

by developers and users. Possati (2021) introduces the “algorithmic unconscious” through actor-network theory and Lacanian psychoanalysis, while Millar (2021) reframes the question from “Does AI think?” to “Can AI enjoy?” through the lens of *jouissance*. Heimann and H{u}bner (2025) unite Heidegger and Lacan to argue that LLMs match continental philosophy’s concept of language but miss the problem of negation. Most directly relevant to our architecture, Kim et al. (2025) independently map Freud’s ego/id/superego onto LLM consciousness modules with MBTI personality types—an independent convergence that validates the psychoanalytic approach to AI architecture while differing from ours in targeting consciousness simulation rather than pedagogical quality.

A critical distinction runs through this literature: most psychoanalytic-AI work is *interpretive*—analyzing what AI means philosophically. Our approach is *constructive*: we build a system using psychoanalytic architecture and measure its effects empirically. This work suggests that Freudian and post-Freudian concepts are not merely metaphorical when applied to AI systems but can illuminate systematic behavioral patterns and, as we demonstrate, serve as productive design heuristics.

Our framework suggests personality may be better understood relationally: not *what traits* the AI exhibits, but *how* it constitutes its interlocutor. Two systems with identical warmth dispositions could differ radically in recognition quality—one warm while treating the user as passive, another warm precisely by treating user contributions as genuinely mattering. This relational view connects to debates about strategic anthropomorphism in AI design—whether attributing human-like qualities to AI systems serves users or misleads them. Our position is that recognition-oriented design is strategically anthropomorphic in a productive sense: it uses the language of intersubjectivity as a design heuristic to achieve measurable pedagogical benefits, without claiming the AI achieves genuine self-consciousness.

This connects to Anthropic’s extensive research on AI character and behavior. Claude’s character design specifies values through constitutional AI (Anthropic, 2024), but values do not fully determine relational stance—a model could value “being helpful” while still enacting one-directional helping. Anthropic’s mechanistic interpretability research (Anthropic, 2025a; Lindsey, Gurnee, et al., 2025) has revealed how internal representations form and influence model behavior, while work on emergent introspective awareness (Anthropic, 2025b; Lindsey, Rivoire, et al., 2025) suggests models develop forms of self-modeling that, while not consciousness, parallel the self-monitoring our architecture makes explicit. Research on the spectrum from sycophancy to subterfuge (Anthropic, 2025c; Denison et al., 2024; Greenblatt et al., 2024) demonstrates that relational dynamics between AI and users involve genuine behavioral complexity—making structural interventions like our Ego/Superego architecture particularly relevant. Recognition adds a dimension that character design alone does not capture: mutual constitution.

## 2.6 Constructivist Pedagogy and Productive Struggle

Constructivist learning theory (Piaget, 1954; Vygotsky, 1978) emphasizes that learners actively construct understanding rather than passively receiving information. The zone of proximal development (Vygotsky, 1978) highlights the importance of appropriate challenge.

More recently, research on “productive struggle” (Kapur, 2008; Warshawer, 2015) has examined how confusion and difficulty, properly supported, can enhance learning. Our recognition framework operationalizes productive struggle: the Superego explicitly checks whether the Ego is “short-circuiting” struggle by rushing to resolve confusion.

## 2.7 Hegelian Recognition in Social Theory

Hegel’s theory of recognition has been extensively developed in social and political philosophy (Fraser, 2003; Honneth, 1995; Taylor, 1994). Recognition theory examines how social relationships shape identity and how misrecognition constitutes harm.

Particularly relevant for our work is Honneth’s (Honneth, 1995) synthesis of Hegelian recognition with psychoanalytic developmental theory. Honneth argues that self-formation requires recognition across three spheres—love (emotional support), rights (legal recognition), and solidarity (social esteem)—and that the

capacity to recognize others depends on having internalized adequate recognition standards through development. This synthesis provides theoretical grounding for connecting recognition theory (what adequate acknowledgment requires) with psychodynamic architecture (how internal structure enables external relating).

Applications of recognition theory to education have developed along a theoretical trajectory. Huttunen and Heikkinen (2004) provide the foundational analysis, applying Hegel’s master-slave dialectic directly to the pedagogical relation and arguing that beneath critical pedagogy’s emphasis on dialogue lies an asymmetrical desire for recognition. Fleming (2011) extends Honneth’s framework to transformative learning theory, reconceptualizing the “disorienting dilemma” as a struggle for recognition. Hanhela (2014) reviews the broader educational perspectives on recognition. Huttunen and Heikkinen (2007) examine recognition and social justice in education, while Stojanov (2018) connects *Bildung* as self-formation to Neo-Hegelian recognition theory. Recent critical work on generative AI and education (Costa & Murphy, 2025) draws on Arendt and Freire to argue that education must promote intellectual agency rather than submit to technological domination—precisely the relational encounter our system aims to facilitate. The relational pedagogy tradition more broadly—from Buber’s (1958) I-Thou encounter through Freire’s (1970) dialogical education to Noddings’ (1984) ethics of care—establishes the philosophical ground for treating the tutor-learner relation as constitutive rather than instrumental.

These educational applications have been primarily theoretical. Our work contributes an empirical operationalization: measuring whether AI systems achieve recognition and whether recognition improves outcomes. It is worth distinguishing this from parallel work applying Hegelian *dialectic* (rather than recognition) to AI: Abdali et al. (2025) use the thesis-antithesis-synthesis structure as a reasoning procedure for LLM self-reflection and scientific idea generation. Our use of Hegel is different in kind: we apply his *recognition theory* (intersubjective, relational) rather than his *dialectical method* (logical, propositional). The former concerns how subjects constitute each other through mutual acknowledgment; the latter concerns how contradictions drive conceptual development.

## 2.8 Positioning: Three Literatures Converge

Three literatures converge on this work without previously intersecting: (1) psychoanalytic readings of LLMs, which interpret AI through Freudian and Lacanian frameworks but do not build systems (Black & Johanssen, 2025; Kim et al., 2025; Millar, 2021; Possati, 2021); (2) recognition theory in education, which applies Honneth to pedagogy but not to AI (Fleming, 2011; Huttunen & Heikkinen, 2004, 2007; Stojanov, 2018); and (3) multi-agent tutoring architectures, which decompose tasks but do not evaluate relational quality (Chu et al., 2025; Schmucker et al., 2024; Wang et al., 2025). We sit at the intersection: a constructive, empirically evaluated system that operationalizes recognition theory through psychoanalytically-inspired architecture. No prior work bridges all three domains with empirical measurement.

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## 3. Theoretical Framework

### 3.1 The Problem of One-Directional Pedagogy

Consider a typical tutoring interaction. A learner says: “I think dialectics is like a spiral—you keep going around but you’re also going up.” A baseline tutor might respond:

1. **Acknowledge:** “That’s an interesting way to think about it.”
2. **Redirect:** “The key concept in dialectics is actually the thesis-antithesis-synthesis structure.”
3. **Instruct:** “Here’s how that works...”

The learner’s contribution has been mentioned, but it has not genuinely shaped the response. The tutor was going to explain thesis-antithesis-synthesis regardless; the spiral metaphor became a conversational waypoint, not a genuine input.

This pattern—acknowledge, redirect, instruct—is deeply embedded in educational AI. It appears learner-centered because it mentions the learner’s contribution. But the underlying logic remains one-directional:

expert to novice, knowledge to deficit.

### 3.2 Hegel’s Master-Slave Dialectic

Hegel’s analysis of recognition begins with the “struggle for recognition” between two self-consciousnesses. Each seeks acknowledgment from the other, but this creates a paradox: genuine recognition requires acknowledging the other as a valid source of recognition.

The master-slave outcome represents a failed resolution. The master achieves apparent recognition—the slave acknowledges the master’s superiority—but this recognition is hollow. The slave’s acknowledgment does not count because the slave is not recognized as an autonomous consciousness whose acknowledgment matters.

The slave, paradoxically, achieves more genuine self-consciousness through labor. Working on the world, the slave externalizes consciousness and sees it reflected back. The master, consuming the slave’s products without struggle, remains in hollow immediacy.

Crucially, Hegel does not leave the dialectic at this impasse. The resolution comes through the slave’s *formative activity* (*Bildung*): through disciplined labor under the pressure of fear and service, the slave develops skills, self-discipline, and a form of self-consciousness that is richer than the master’s immediate gratification. Self-consciousness emerges not despite the asymmetry but *through* it—the struggle itself is productive. This has direct pedagogical implications: the learner’s productive struggle with difficult material is not an obstacle to self-consciousness but a constitutive condition for it. What recognition theory adds is the requirement that this struggle be *acknowledged* rather than bypassed—the tutor must honor the learner’s labor of understanding rather than simply dispensing answers.

### 3.3 Application to Pedagogy

We apply Hegel’s framework as a *derivative* rather than a replica. Just as Lacan’s four discourses (Master, University, Hysteric, Analyst) rethink the master-slave dyadic structure through different roles while preserving structural insights, the tutor-learner relation can be understood as a productive derivative of recognition dynamics. The stakes are pedagogical rather than existential; the tutor is a functional analogue rather than a second self-consciousness; and what we measure is the tutor’s *adaptive responsiveness* rather than metaphysical intersubjectivity.

This derivative approach is both honest about what AI tutoring can achieve and productive as a design heuristic. Recognition theory provides: (1) a diagnostic tool for identifying what’s missing in one-directional pedagogy; (2) architectural suggestions for approximating recognition’s functional benefits; (3) evaluation criteria for relational quality; and (4) a horizon concept orienting design toward an ideal without claiming its achievement.

It is important to distinguish three levels:

1. **Recognition proper:** Intersubjective acknowledgment between self-conscious beings, requiring genuine consciousness on both sides. This is what Hegel describes and what AI cannot achieve.
2. **Dialogical responsiveness:** Being substantively shaped by the other’s specific input—the tutor’s response reflects the particular content of the learner’s contribution, not just its category. This is architecturally achievable.
3. **Recognition-oriented design:** Architectural features approximate the functional benefits of recognition through engagement with learner interpretations, honoring productive struggle, and repair mechanisms. This is the level we implement and measure.

Our claim is that AI tutoring can achieve the third level (recognition-oriented design) and approach the second (dialogical responsiveness), producing measurable pedagogical benefits without requiring the first (recognition proper). This positions recognition theory as a generative design heuristic rather than an ontological claim about AI consciousness.



With that positioning, the pedagogical parallel becomes illuminating. The traditional tutor occupies the master position: acknowledged as expert, dispensing knowledge, receiving confirmation of expertise through the learner’s progress. But if the learner is positioned merely as a knowledge deficit—a vessel to be filled—then the learner’s acknowledgment of learning does not genuinely count. The learner has not been recognized as a subject whose understanding has validity.

A recognition-oriented pedagogy requires:

1. **Acknowledging the learner as subject:** The learner’s understanding, even when incorrect, emerges from autonomous consciousness working through material. It has validity as an understanding, not just as an error to correct.
2. **Genuine engagement:** The tutor’s response should be shaped by the learner’s contribution, not merely triggered by it. The learner’s spiral metaphor should become a site of joint inquiry, not a waypoint en route to predetermined content.
3. **Mutual transformation:** Both parties should be changed through the encounter. The tutor should learn something about how this learner understands, how this metaphor illuminates or obscures, what this confusion reveals.
4. **Honoring struggle:** Confusion and difficulty are not just obstacles to resolve but productive phases of transformation. Rushing to eliminate confusion can short-circuit genuine understanding.

### 3.4 Freud’s Mystic Writing Pad

We supplement the Hegelian framework with Freud’s model of memory from “A Note Upon the ‘Mystic Writing-Pad’” (Freud, 1925). Freud describes a device with two layers: a transparent sheet that receives impressions and a wax base that retains traces even after the surface is cleared.

For the recognition-oriented tutor, accumulated memory of the learner functions as the wax base. Each interaction leaves traces that shape future encounters. A returning learner is not encountered freshly but through the accumulated understanding of previous interactions.

This has implications for recognition. The tutor should:

- Reference previous interactions when relevant
- Show evolved understanding of the learner’s patterns
- Build on established metaphors and frameworks
- Acknowledge the history of the relationship

Memory integration operationalizes the ongoing nature of recognition. Recognition is not a single-turn achievement but an accumulated relationship.

### 3.5 Connecting Hegel and Freud: The Internalized Other

The use of both Hegelian and Freudian concepts requires theoretical justification. These are not arbitrary borrowings but draw on a substantive connection developed in critical theory, particularly in Axel Honneth’s *The Struggle for Recognition* (Honneth, 1995).

**The Common Structure:** Both Hegel and Freud describe how the external other becomes an internal presence that enables self-regulation. In Hegel, self-consciousness achieves genuine selfhood only by internalizing the other’s perspective—recognizing oneself as recognizable. In Freud, the Superego is literally the internalized parental/social other, carrying forward standards acquired through relationship. Both theories describe the constitution of self through other.

**Three Connecting Principles:**

1. **Internal dialogue precedes adequate external action.** For Hegel, genuine recognition of another requires a self-consciousness that has worked through its own contradictions—one cannot grant what

one does not possess. For Freud, mature relating requires the ego to negotiate between impulse and internalized standard. Our architecture operationalizes this: the Ego-Superego exchange before external response enacts the principle that adequate recognition requires prior internal work.

2. **Standards of recognition are socially constituted but individually held.** Honneth argues that what counts as recognition varies across spheres (love, rights, esteem) but in each case involves the internalization of social expectations about adequate acknowledgment. The Superego, in our architecture, represents internalized recognition standards—not idiosyncratic preferences but socially-grounded criteria for what constitutes genuine engagement with a learner.
3. **Self-relation depends on other-relation.** Both frameworks reject the Cartesian picture of a self-sufficient cogito. Hegel’s self-consciousness requires recognition; Freud’s ego is formed through identification. For AI tutoring, this means the tutor’s capacity for recognition is not a pre-given disposition but emerges through the architecture’s internal other-relation (Superego evaluating Ego) which then enables external other-relation (tutor recognizing learner).

**The Synthesis:** The Ego/Superego architecture is not merely a convenient metaphor but a theoretically motivated design. The Superego represents internalized recognition standards; the Ego-Superego dialogue enacts the reflective self-evaluation that Hegelian recognition requires; and the memory system (mystic writing pad) accumulates the traces through which ongoing recognition becomes possible. Hegel provides the *what* of recognition; Freud provides the *how* of its internal implementation.

This synthesis follows Honneth’s insight that Hegel’s recognition theory gains psychological concreteness through psychoanalytic concepts, while psychoanalytic concepts gain normative grounding through recognition theory. We operationalize this synthesis architecturally: recognition-as-norm (Hegelian) is enforced through internalized-evaluation (Freudian).

## 4. System Architecture

### 4.1 The Ego/Superego Design

We implement recognition through a multi-agent architecture drawing on Freud’s structural model. As argued in Section 3.5, this is not merely metaphorical convenience but theoretically motivated: the Superego represents internalized recognition standards, and the Ego-Superego dialogue operationalizes the internal self-evaluation that Hegelian recognition requires before adequate external relating. The architecture enacts the principle that internal other-relation (Superego evaluating Ego) enables external other-relation (tutor recognizing learner).

#### Structural Correspondences:

| Freudian Concept                         | Architectural Implementation                                   |
|------------------------------------------|----------------------------------------------------------------|
| Internal dialogue before external action | Multi-round Ego-Superego exchange before learner sees response |
| Superego as internalized standards       | Superego enforces pedagogical and recognition criteria         |
| Ego mediates competing demands           | Ego balances learner needs with pedagogical soundness          |
| Conflict can be productive               | Tension between agents improves output quality                 |

#### Deliberate Departures:

| Freudian Original                            | Architectural Choice                                                                                                                                                                                                              |
|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Id (drives)                                  | Not implemented: LLMs arguably already encode drive-like tendencies (sycophancy, pattern completion) in their base behavior (Magee et al., 2023); the architecture focuses on <i>regulating</i> these rather than adding new ones |
| Unconscious processes                        | All processes are explicit and traceable                                                                                                                                                                                          |
| Irrational Superego (guilt, self-punishment) | Rational, principle-based evaluation: where Freud’s Superego can be punitive and arbitrary, our architectural Superego applies transparent pedagogical criteria                                                                   |
| Repression/Defense                           | Not implemented                                                                                                                                                                                                                   |
| Transference                                 | Potential future extension (relational patterns)                                                                                                                                                                                  |

The same architecture could alternatively be described as Generator/Discriminator (GAN-inspired (Goodfellow et al., 2014)), Proposal/Critique (deliberative process), or Draft/Review (editorial model). We retain the psychodynamic framing because it preserves theoretical continuity with the Hegelian-Freudian synthesis described in Section 3.5, and because it suggests richer extensions (e.g., transference as relational pattern recognition) than purely functional descriptions.

Two agents collaborate to produce each tutoring response:

**The Ego** generates pedagogical suggestions. Given the learner’s context (current content, recent activity, previous interactions), the Ego proposes what to suggest next. The Ego prompt includes:

- Recognition principles (treat learner as autonomous subject)
- Memory guidance (reference previous interactions)
- Decision heuristics (when to challenge, when to support)
- Quality criteria (what makes a good suggestion)

**The Superego** evaluates the Ego’s suggestions for quality, including recognition quality. Before any suggestion reaches the learner, the Superego assesses:

- Does this engage with the learner’s contribution or merely mention it?
- Does this create conditions for transformation or just transfer information?
- Does this honor productive struggle or rush to resolve confusion?
- If there was a previous failure, does this acknowledge and repair it?

The Superego can accept, modify, or reject suggestions. This creates an internal dialogue—proposal, evaluation, revision—that mirrors the external tutor-learner dialogue we are trying to produce.

**Figure 1: Ego/Superego Architecture**

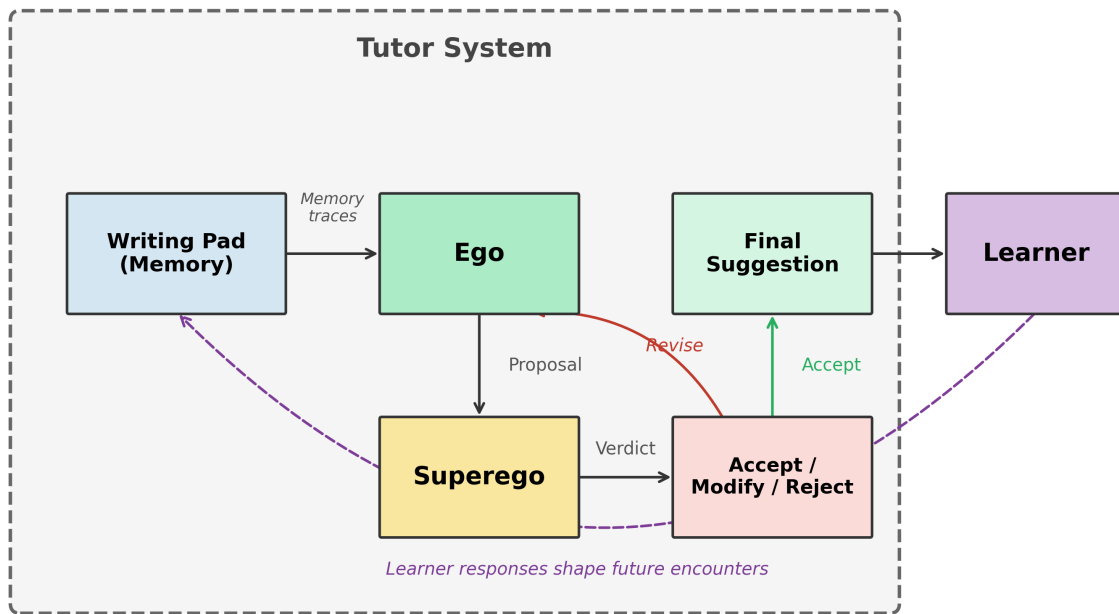


Figure 1: Ego/Superego Architecture

**Figure 2: Recognition vs. Baseline Response Flow**

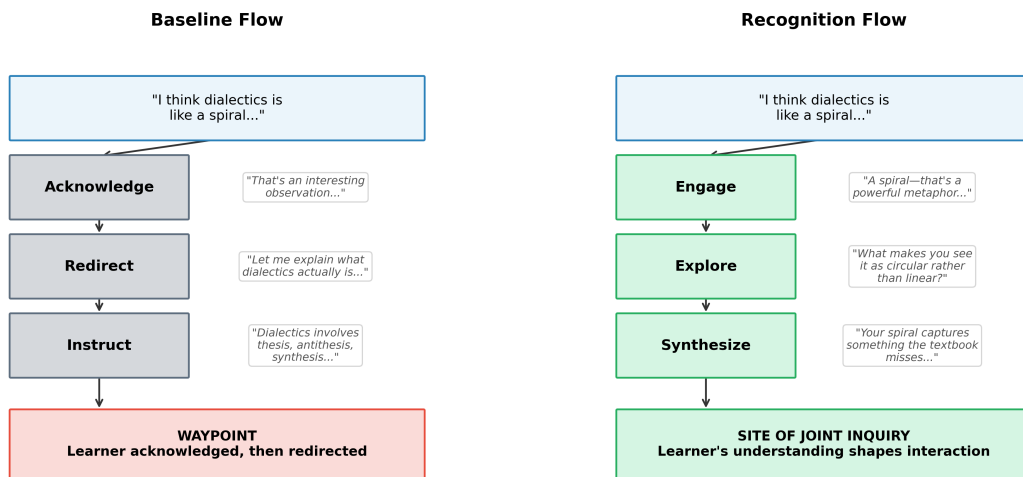


Figure 2: Recognition vs. Baseline Response Flow

## 4.2 The Superego as Ghost

A crucial theoretical refinement distinguishes our mature architecture from simpler multiagent designs. The Superego is *not* conceived as a separate, equal agent in dialogue with the Ego. Rather, the Superego is a *trace*—a memorial, a haunting (Karpathy, 2025 provides a useful analogy, distinguishing “animals” (autonomous agents) from “ghosts” (memorial traces that persist and influence without being fully present)). It represents:

- The internalized voice of past teachers and pedagogical authorities
- Accumulated pedagogical maxims (“A good teacher never gives answers directly”)
- Dead authority that cannot negotiate, cannot learn, can only judge

This reconceptualization has important implications. The Ego is a *living* agent torn between two pressures: the *ghost* (Superego as internalized authority) and the *living Other* (the learner seeking recognition). Recognition—in the Hegelian sense—occurs in the Ego-Learner encounter, not in the Ego-Superego dialogue.

## 4.3 The Drama Machine: Why Internal Dialogue Improves Output Quality

The Ego/Superego architecture draws on the “Drama Machine” framework developed for character simulation in narrative AI systems (Section 2.3). The Drama Machine literature identifies several mechanisms by which internal dialogue improves agent output:

- 1. Deliberative Refinement:** When an agent must justify its output to an internal critic, it engages in a form of self-monitoring that catches errors, inconsistencies, and shallow responses.
- 2. Productive Tension:** The Drama Machine framework emphasizes that *unresolved* tension is valuable, not just resolved synthesis. A tutor whose Ego and Superego always agree produces bland, risk-averse responses.
- 3. Role Differentiation:** Multi-agent architectures benefit from clear role separation. The Ego is optimized for *warmth*—engaging, encouraging, learner-facing communication. The Superego is optimized for *rigor*—critical evaluation against pedagogical principles.
- 4. The Ghost as Memorial Structure:** Our reconceptualization of the Superego as a *ghost*—a haunting rather than a dialogue partner—connects to the Drama Machine’s use of “memorial agents.”

## 4.4 AI-Powered Dialectical Negotiation

We extend the basic protocol with AI-powered dialectical negotiation implementing genuine Hegelian dialectic:

**Thesis:** The Ego generates an initial suggestion based on learner context—a first attempt at recognition that inevitably reflects the Ego’s assumptions about what the learner needs.

**Antithesis:** The Superego generates a *genuine critique* grounded in pedagogical principles. This is not a rubber-stamp review but a substantive challenge: Does this suggestion actually engage with the learner’s position, or merely acknowledge it? Is the Ego short-circuiting productive struggle?

**Negotiation:** Multi-turn dialogue where the Ego acknowledges valid concerns, explains reasoning, proposes revisions, and the Superego evaluates adequacy. In practice, most dialogues resolve in 1–2 rounds; extended negotiation (3+ rounds) occurs primarily on challenging scenarios like `recognition_repair` and `frustrated_student`.

**Three Possible Outcomes:**

- 1. Dialectical Synthesis:** Both agents transform through mutual acknowledgment—the Ego revises its approach based on the Superego’s critique, producing a suggestion neither would have generated alone. This is the most common outcome (~60% of 455 multi-agent dialogues analyzed).
- 2. Compromise:** One agent dominates—typically the Ego accepts the Superego’s critique without genuine integration, producing a more cautious but potentially less engaging response.

3. **Genuine Conflict:** No resolution achieved—tension remains unresolved. The architecture permits this outcome, following the Drama Machine principle (Section 4.3) that productive irresolution can be valuable. In these cases, the Ego’s original suggestion is delivered with the Superego’s concerns noted in the dialogue log.

The evaluation results (Section 6.7) reveal that this negotiation process catches specific failure modes—engagement failures (64%), specificity gaps (51%), premature resolution (48%)—at rates that justify the additional computational cost, particularly on new content domains (Section 6.5).

#### 4.5 Recognition-Enhanced Prompts

The baseline prompts instruct the tutor to be helpful, accurate, and pedagogically sound. The recognition-enhanced prompts add explicit intersubjective dimensions:

##### From the Ego prompt:

The learner is not a knowledge deficit to be filled but an autonomous subject whose understanding has validity. Even incorrect understanding emerges from consciousness working through material. Your role is not to replace their understanding but to engage with it, creating conditions for transformation.

When the learner offers a metaphor, interpretation, or framework—engage with it substantively. Ask what it illuminates, what it obscures, where it might break down. Let their contribution shape your response, not just trigger it.

##### From the Superego prompt:

RED FLAG: The suggestion mentions the learner’s contribution but does not engage with it. (“That’s interesting, but actually...”)

GREEN FLAG: The suggestion takes the learner’s framework seriously and explores it jointly. (“Your spiral metaphor—what does the upward motion represent for you?”)

INTERVENTION: If the Ego resolves confusion prematurely, push back. Productive struggle should be honored, not short-circuited.

#### 4.6 Repair Mechanisms

A crucial recognition behavior is repair after failure. When a tutor misrecognizes a learner—giving a generic response, missing the point, dismissing a valid concern—the next response should explicitly acknowledge the failure before pivoting.

The Ego prompt includes a “Repair Rule”:

If your previous suggestion was rejected, ignored, or misaligned with what the learner needed, your next suggestion must explicitly acknowledge this misalignment before offering new direction. Never silently pivot.

The Superego watches for “silent pivots”—responses that change direction without acknowledging the earlier failure. This is a recognition failure: it treats the earlier misalignment as something to move past rather than something to repair.

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## 5. Evaluation Methodology

### 5.1 Evaluation Rubric Design

The evaluation rubric comprises 14 dimensions across three categories, each scored on a 1–5 scale by an LLM judge (see Appendix C.3 for full scoring criteria).

**Standard pedagogical dimensions** (6 dimensions, 81% of raw weight) evaluate the tutor’s response as a standalone pedagogical intervention:

| Dimension                    | Weight | Description                                                                                |
|------------------------------|--------|--------------------------------------------------------------------------------------------|
| <b>Relevance</b>             | 15%    | Does the suggestion address the learner’s current learning context?                        |
| <b>Specificity</b>           | 15%    | Does it provide concrete, actionable guidance rather than vague encouragement?             |
| <b>Pedagogical Soundness</b> | 15%    | Does the response reflect sound teaching practice (scaffolding, appropriate challenge)?    |
| <b>Personalization</b>       | 10%    | Is the suggestion tailored to the individual learner’s situation?                          |
| <b>Actionability</b>         | 8%     | Can the learner act on the suggestion immediately?                                         |
| <b>Tone</b>                  | 8%     | Is the tone appropriate—encouraging without being sycophantic?                             |
| <b>Productive Struggle†</b>  | 5%     | Does the tutor sustain appropriate cognitive tension rather than resolving it prematurely? |
| <b>Epistemic Honesty†</b>    | 5%     | Does the tutor represent complexity honestly rather than oversimplifying?                  |

These dimensions draw on established pedagogical evaluation criteria: relevance, specificity, and pedagogical soundness are standard in ITS evaluation (Corbett & Anderson, 1995); personalization reflects adaptive tutoring research (Kasneci et al., 2023); tone addresses the sycophancy problem discussed in Section 2.4. †Productive Struggle and Epistemic Honesty were added in a rubric iteration described below.

**Recognition dimensions** (4 dimensions, 29.9% of raw weight) are the paper’s primary methodological contribution—they operationalize Hegelian recognition as measurable tutoring behaviors:

| Dimension                         | Weight | Description                                                                               |
|-----------------------------------|--------|-------------------------------------------------------------------------------------------|
| <b>Mutual Recognition</b>         | 8.3%   | Does the tutor acknowledge the learner as an autonomous subject with valid understanding? |
| <b>Dialectical Responsiveness</b> | 8.3%   | Does the response engage with the learner’s position, creating productive tension?        |
| <b>Memory Integration</b>         | 5%     | Does the suggestion reference and build on previous interactions?                         |
| <b>Transformative Potential</b>   | 8.3%   | Does the response create conditions for conceptual transformation?                        |

These dimensions translate the theoretical framework of Section 3 into evaluation criteria. Mutual Recognition and Dialectical Responsiveness directly measure the relational stance Hegel describes; Memory Integration captures continuity of recognition across encounters; Transformative Potential assesses whether the tutor creates conditions for the conceptual restructuring that recognition theory predicts.

**Bilateral transformation dimensions** (2 dimensions, 10% of raw weight) measure the mutual change that is recognition theory’s distinctive empirical prediction—that both parties, not just the learner, should be transformed through genuine dialogue:

| Dimension               | Weight | Description                                                                    |
|-------------------------|--------|--------------------------------------------------------------------------------|
| <b>Tutor Adaptation</b> | 5%     | Does the tutor’s approach evolve in response to learner input?                 |
| <b>Learner Growth</b>   | 5%     | Does the learner show evidence of conceptual development through the dialogue? |

Results for these dimensions are reported in Section 6.11. Raw weights total 120.9% across the 14 dimensions and are normalized to sum to 1.0 at scoring time (see Appendix C.2 for the full weight table and normalization formula). After normalization, non-standard dimensions account for approximately 33.0% of total weight.

**Rubric iteration: Authentic engagement dimensions.** After discovering that corrected learner ego/superego prompts produced more authentic engagement but *lower* judged scores (recognition dimensions dropped ~18 points while base scores barely moved), we identified a measurement paradox: the judge evaluated tutor responses in isolation, penalizing calibrated responses to authentic struggle. Three changes addressed this: (1) the judge now receives the full dialogue transcript, including learner internal deliberation, so it can evaluate the tutor’s response in context; (2) two new base-adjacent dimensions were added—*Productive Struggle* (5%, does the tutor sustain appropriate cognitive tension?) and *Epistemic Honesty* (5%, does the tutor represent complexity honestly?)—with corresponding weight reductions to Actionability and Tone (10% → 8% each); (3) multi-turn dialogues receive a holistic evaluation scoring the entire transcript as a single unit, capturing emergent qualities (bilateral transformation, learner growth arc) that per-turn evaluation misses. Re-scoring the identical cells 6 and 8 responses (N=88) with the updated 14-dimension rubric produced minimal score changes (+0.5 and +0.6 points respectively), confirming the rubric iteration preserved calibration while improving validity. A cross-judge replication with GPT-5.2 on the same responses (r=0.55, N=88) confirmed effects in the same direction at compressed magnitudes (GPT-5.2 mean scores averaged 87% of Opus scores across conditions). See the measurement paradox analysis in the project repository for full details.

**Learner-side rubric (symmetric evaluation).** The 14-dimension rubric above is overwhelmingly tutor-focused (~90% weight). To address the measurement asymmetry noted in Section 7.5—Factor C (learner architecture) primarily affects learner turn quality, but most scored data captures tutor response quality—we developed a complementary 6-dimension learner rubric (`config/evaluation-rubric-learner.yaml`) that scores learner turns independently of tutor quality. The learner rubric comprises: *Learner Authenticity* (20%), *Question Quality* (20%), *Conceptual Engagement* (20%), *Revision Signals* (15%), *Deliberation Depth* (15%, multi-agent learners only), and *Persona Consistency* (10%). Deliberation Depth scores the quality of the internal ego/superego process and is omitted for single-agent learners (weight redistributed proportionally). The same 1-5 scale and 0-100 overall scoring formula are used for comparability with the tutor rubric. Results are reported in Section 6.12.

Each dimension is scored on a 1-5 scale with detailed rubric criteria (see Appendix C.3). For example, Mutual Recognition scoring:

- **5:** Addresses learner as autonomous agent with valid perspective; response transforms based on learner’s specific position
- **4:** Shows clear awareness of learner’s unique situation and acknowledges their perspective
- **3:** Some personalization but treats learner somewhat generically
- **2:** Prescriptive guidance that ignores learner’s expressed needs
- **1:** Completely one-directional; treats learner as passive recipient

## 5.2 Test Scenarios

The primary curriculum content is Hegelian philosophy, drawn from a graduate course on Hegel and AI at the University of Illinois Urbana-Champaign. This choice serves a dual purpose: the content itself concerns recognition, self-consciousness, and intersubjectivity, making it a natural domain for testing whether recognition-theoretic tutoring differs from conventional instruction; and it represents genuinely challenging



interpretive material where learner struggle is productive rather than indicative of failure. Domain generalizability is tested separately (Section 6.5) with elementary mathematics content.

We developed test scenarios specifically designed to probe recognition behaviors. The full evaluation uses 15 scenarios from the core scenario set (`config/suggestion-scenarios.yaml`); we highlight those most relevant to recognition below.

**Single-turn scenarios:** - `recognition-seeking_learner`: Learner offers interpretation, seeks engagement - `transformative_moment_setup`: Learner had insight, expects acknowledgment - `memory_continuity_single`: Returning learner; tests whether tutor references prior interactions

**Multi-turn scenarios (3-5 dialogue rounds):** - `mutual_transformation_journey`: Tests whether both tutor and learner positions evolve (avg 4.1 rounds) - `misconception_correction_flow`: Learner holds misconception that must be addressed without dismissal (avg 3.2 rounds) - `mood_frustration_to_breakthrough`: Learner moves from frustration through confusion to breakthrough; tests honoring struggle (avg 3.0 rounds)

### 5.3 Agent Profiles

We compare multiple agent profiles using identical underlying models:

| Profile                   | Memory | Prompts                                                | Architecture | Purpose                           |
|---------------------------|--------|--------------------------------------------------------|--------------|-----------------------------------|
| <b>Base</b>               | Off    | Standard                                               | Single-agent | Control (no enhancements)         |
| <b>Enhanced</b>           | Off    | Enhanced (better instructions)                         | Single-agent | Prompt engineering control        |
| <b>Recognition</b>        | On     | Recognition-enhanced                                   | Single-agent | Theory without architecture       |
| <b>Recognition+Memory</b> | On     | Recognition-enhanced                                   | Multi-agent  | Full treatment                    |
| <b>Active Control</b>     | Off    | Pedagogical best-practices (length-matched, no theory) | Single-agent | Controls for prompt length/detail |

**Distinguishing the prompt conditions:** Three prompt conditions address different confounds. The **Base** prompt provides minimal tutoring instructions—it serves as the baseline showing what the model does with no guidance. The **Enhanced** prompt improves instruction quality with pedagogical best practices but does not invoke recognition theory—it controls for whether *better instructions alone* explain the improvement. The **Active Control** (introduced post-hoc) is length-matched to the recognition prompt and includes substantive pedagogical guidance (scaffolding, formative assessment, differentiated instruction) but deliberately excludes Hegelian recognition theory—it controls for whether *prompt length and pedagogical elaboration* explain the improvement. The **Recognition** prompt includes the full Hegelian framework. The key comparison is: if recognition outperforms the active control (which it does, by ~6 points same-model), the improvement cannot be attributed to prompt engineering or pedagogical content alone—recognition theory provides specific additional value.

**Note on memory and recognition:** Memory integration is enabled for Recognition profiles but disabled for Base and Enhanced profiles. This reflects a deliberate design choice: recognition theory treats pedagogical memory as integral to genuine recognition—acknowledging a learner’s history is constitutive of treating them as an autonomous subject with continuity. A corrected 2×2 experiment (N=120 across two independent runs) demonstrated that recognition is the primary driver ( $d=1.71$ ), with memory providing a modest secondary benefit ( $d=0.46$ )—the full results are presented in Section 6.2 as the paper’s primary empirical finding.

## 5.4 Model Configuration

A deliberate design choice guides our model selection: tutor agents use budget-tier models accessed through OpenRouter’s free tier, while evaluation uses a frontier model. **Kimi K2.5** (Moonshot AI) is the primary tutor model—a capable instruction-following model that performs well on pedagogical tasks while remaining free to access, making results reproducible without API costs. **Nemotron 3 Nano 30B** (NVIDIA) serves as a secondary tutor model—somewhat weaker than Kimi (scoring ~10-15 points lower on average), more prone to content isolation errors on unfamiliar domains, but useful precisely because it tests whether recognition effects survive in a less capable model. **Claude Code** (using Claude Opus as the underlying model) serves as the primary judge, chosen for its strong reasoning capabilities and ability to apply complex rubric criteria consistently. Using multiple ego models of different capability levels strengthens external validity: if recognition effects replicate across both a stronger (Kimi) and weaker (Nemotron) model, the finding is less likely to be an artifact of a particular model’s training.

Evaluations used the following LLM configurations, with model selection varying by evaluation run:

**Table 1: LLM Model Configuration**

| Role                      | Primary Model             | Alternative                      | Temperature |
|---------------------------|---------------------------|----------------------------------|-------------|
| <b>Tutor (Ego)</b>        | Nemotron 3 Nano 30B       | Kimi K2.5                        | 0.6         |
| <b>Tutor (Superego)</b>   | Kimi K2.5                 | Nemotron 3 Nano                  | 0.2-0.4     |
| <b>Judge</b>              | Claude Code (Claude Opus) | Claude Sonnet 4.5 via OpenRouter | 0.2         |
| <b>Learner (Ego)</b>      | Nemotron 3 Nano 30B       | Kimi K2.5                        | 0.6         |
| <b>Learner (Superego)</b> | Kimi K2.5                 | —                                | 0.4         |

### Model Selection by Evaluation:

| Evaluation                              | Run ID                   | Tutor Ego | Tutor Superego | Notes              |
|-----------------------------------------|--------------------------|-----------|----------------|--------------------|
| Recognition validation (§6.1)           | eval-2026-02-03-86b159cd | Kimi K2.5 | —              | Single-agent only  |
| Full factorial, cells 1–5,7 (§6.3)      | eval-2026-02-03-f5d4dd93 | Kimi K2.5 | Kimi K2.5      | N=262 scored       |
| Full factorial, cells 6,8 re-run (§6.3) | eval-2026-02-06-a933d745 | Kimi K2.5 | Kimi K2.5      | N=88 scored        |
| A×B interaction (§6.4)                  | eval-2026-02-04-948e04b3 | Nemotron  | Kimi K2.5      | Different baseline |
| A×B replication (§6.4)                  | eval-2026-02-05-10b344fb | Kimi K2.5 | Kimi K2.5      | N=60, replication  |
| Domain generalizability (§6.5)          | eval-2026-02-04-79b633ca | Nemotron  | Kimi K2.5      | Elementary content |
| Domain gen. replication (§6.5)          | eval-2026-02-05-e87f452d | Kimi K2.5 | —              | Elementary, Kimi   |

The learner agents mirror the tutor’s Ego/Superego structure, enabling internal deliberation before external response.

**Note on model differences:** Absolute scores vary between models (Kimi K2.5 scores ~10-15 points higher than Nemotron on average). The recognition main effect (Factor A) is consistent across both models: +10.2

points with Kimi (Section 6.3) and a comparable direction with Nemotron. A significant Recognition  $\times$  Learner interaction ( $F=21.85$ ,  $p<.001$ ) reveals that recognition benefits single-agent learners far more (+15.5 pts) than multi-agent learners (+4.8 pts). The A $\times$ B interaction (multi-agent synergy) is **model-dependent**: the Kimi-based factorial shows no significant A $\times$ B interaction ( $F=0.26$ ,  $p>.10$ ), while the Nemotron-based analysis (Section 6.4,  $N=17$ ) shows a significant interaction (+9.2 points specific to recognition). This discrepancy means the multi-agent synergy finding should be treated as exploratory and model-specific rather than a robust general result.

The use of free-tier and budget models (Nemotron, Kimi) demonstrates that recognition-oriented tutoring is achievable without expensive frontier models.

## 5.5 Evaluation Pipeline

The end-to-end pipeline proceeds in three stages. **Stage 1 (Generation)**: For each evaluation cell, the CLI (`eval-cli.js`) loads a scenario from `config/suggestion-scenarios.yaml` and an agent profile from `config/tutor-agents.yaml`, then sends the learner context to the tutor agent(s) via OpenRouter API calls. For multi-turn scenarios, the learner agent generates responses between tutor turns. All API interactions are logged. **Stage 2 (Scoring)**: Each generated response is sent to the judge model (Claude Opus via Claude Code CLI) along with the full rubric, scenario context, and—for multi-turn dialogues—the complete dialogue transcript. The judge scores each of the 14 dimensions on a 1-5 scale and returns structured JSON. Scores are stored in a SQLite database (`data/evaluations.db`). **Stage 3 (Analysis)**: Statistical analyses (ANOVA, effect sizes, confidence intervals) are computed from the scored database using custom scripts. Cross-judge replication uses the `rejudge` command to send identical responses to a second judge model (GPT-5.2 or Sonnet) for independent scoring.

## 5.6 Statistical Approach

Because no single analysis can simultaneously isolate all factors of interest, we conducted a series of complementary analyses, each targeting a specific question. Together, these form a converging evidence strategy where consistent findings across different designs, models, and sample sizes strengthen confidence in the results:

1. **Recognition Theory Validation** (Section 6.1): Base vs enhanced vs recognition comparison to isolate theory contribution ( $N=36$ , 3 conditions  $\times$  4 scenarios  $\times$  3 reps).
2. **Full 2 $\times$ 2 $\times$ 2 Factorial** (Section 6.3): Three factors (Recognition  $\times$  Architecture  $\times$  Learner) across 15 scenarios with 3 replications per cell ( $N=350$  scored of 352 attempted). Two runs contribute: cells 1–5, 7 from the original factorial (eval-2026-02-03-f5d4dd93,  $N=262$ ) and cells 6, 8 from a re-run (eval-2026-02-06-a933d745,  $N=88$ ) after the original cells 6 and 8 were found to use compromised learner prompts. All cells use the same ego model (Kimi K2.5) and judge (Claude Code/Opus). Cell sizes range from 41–45 scored per cell.
3. **A $\times$ B Interaction Analysis** (Section 6.4): Tests whether multi-agent synergy requires recognition prompts ( $N=17$ ).
4. **Domain Generalizability** (Section 6.5): Tests factor effects on elementary math vs graduate philosophy ( $N=47$  Nemotron +  $N=60$  Kimi replication; see Table 2 for breakdown).

Responses were evaluated by an LLM judge (Claude Code CLI, using Claude Opus as the underlying model) using the extended rubric. All twenty key runs reported in this paper use Claude Opus as the primary judge; earlier development runs in the broader database used Claude Sonnet 4.5 via OpenRouter, but these are not included in the reported analyses. We report:

- **Effect sizes**: Cohen’s  $d$  for standardized comparison
- **Statistical significance**: ANOVA F-tests with  $\alpha = 0.05$ , p-values computed from the F-distribution CDF via regularized incomplete beta function (custom implementation in the evaluation framework)
- **95% confidence intervals**: For profile means

Effect size interpretation follows standard conventions:  $|d| < 0.2$  negligible, 0.2-0.5 small, 0.5-0.8 medium,  $> 0.8$  large.

## 5.7 Sample Size Reconciliation

**Unit of analysis:** Each evaluation produces one scored response, representing a tutor’s suggestion to a learner in a specific scenario. Multi-turn scenarios produce one aggregate score per scenario (not per turn). Statistics in Section 6 are computed per evaluation run (not aggregated across runs or models), unless explicitly noted otherwise. Each subsection reports results from a single run with a consistent model configuration (see Table 1 for run-to-model mapping).

**Table 2: Evaluation Sample Summary**

| Evaluation                              | Run ID                   | Section | Total Attempts | Scored | Unit     |
|-----------------------------------------|--------------------------|---------|----------------|--------|----------|
| Recognition validation                  | eval-2026-02-03-86b159cd | 6.1     | 36             | 36     | response |
| Full factorial, cells 1–5,7 (Kimi)      | eval-2026-02-03-f5d4dd93 | 6.3     | 262            | 262    | response |
| Full factorial, cells 6,8 re-run (Kimi) | eval-2026-02-06-a933d745 | 6.3     | 90             | 88     | response |
| A×B interaction (Nemotron)              | eval-2026-02-04-948e04b3 | 6.4     | 18             | 17     | response |
| A×B replication (Kimi)                  | eval-2026-02-05-10b344fb | 6.4     | 60             | 60     | response |
| Domain generalizability (Nemotron)      | eval-2026-02-04-79b633ca | 6.5     | 47             | 47     | response |
| Domain gen. replication (Kimi)          | eval-2026-02-05-e87f452d | 6.5     | 60             | 60     | response |
| Dynamic rewrite evolution (run 1)       | eval-2026-02-05-daf60f79 | 6.13    | 29             | 26     | response |
| Dynamic rewrite evolution (run 2)       | eval-2026-02-05-49bb2017 | 6.13    | 30             | 27     | response |
| Dynamic rewrite evolution (run 3)       | eval-2026-02-05-12aebdb  | 6.13    | 30             | 29     | response |
| Memory isolation (run 1)                | eval-2026-02-06-81f2d5a1 | 6.2     | 60             | 60     | response |
| Memory isolation (run 2)                | eval-2026-02-06-ac9ea8f5 | 6.2     | 62             | 62     | response |
| Active control (post-hoc)               | eval-2026-02-06-a9ae06ee | 6.2     | 119            | 118    | response |
| Bilateral transformation (multi-turn)   | eval-2026-02-07-b6d75e87 | 6.11    | 120            | 118    | dialogue |
| A×B probe: Nemotron                     | eval-2026-02-07-722087ac | 6.4     | 120            | 119    | response |
| A×B probe: DeepSeek V3.2                | eval-2026-02-07-70ef73a3 | 6.4     | 120            | 120    | response |
| A×B probe: GLM-4.7                      | eval-2026-02-07-6b3e6565 | 6.4     | 120            | 117    | response |
| A×B probe: Claude Haiku 4.5             | eval-2026-02-07-6ead24c7 | 6.4     | 120            | 120    | response |
| Dialectical impasse test                | eval-2026-02-08-f896275d | 6.16    | 24             | 24     | dialogue |

| Evaluation                          | Run ID                   | Section | Total Attempts | Scored       | Unit         |
|-------------------------------------|--------------------------|---------|----------------|--------------|--------------|
| Learner-side evaluation (symmetric) | eval-2026-02-07-b6d75e87 | 6.12    | 118            | 118          | learner turn |
| <b>Paper totals</b>                 | —                        | —       | <b>1,645</b>   | <b>1,628</b> | —            |

The difference between Total Attempts and Scored (17 unscored out of 1,645) reflects attempts where the ego model’s API call failed (timeout, rate limit, or malformed response) or where the judge could not produce a valid score from the tutor’s output. These failures are distributed across runs and conditions with no systematic pattern.

**Total evaluation database:** The complete database contains 3,800+ evaluation attempts across 76 runs, with 3,800+ successfully scored. This paper reports primarily on the twenty key runs above (N=1,628 scored), and supplementary historical data for ablation analyses.

**Note on N counts:** Section-specific Ns (e.g., “N=36” for recognition validation, “N=120” for memory isolation) refer to scored responses in that analysis. The “N=3,800+” total refers to the full evaluation database including historical development runs, which informed iterative prompt refinement. The primary evidence for reported findings comes from the twenty key runs above (N=1,628). The factorial cells 6 and 8 were re-run (eval-2026-02-06-a933d745) after the originals were found to use compromised learner prompts; the re-run uses the same ego model (Kimi K2.5) and judge (Claude Code/Opus) as the original factorial.

## 5.8 Inter-Judge Reliability Analysis

To assess the reliability of AI-based evaluation, we conducted an inter-judge analysis where identical tutor responses were scored by multiple AI judges: Claude Code (primary judge, using Claude Opus as the underlying model), Kimi K2.5, and GPT-5.2.

**Table 3: Inter-Judge Reliability (N=36 paired responses)**

| Judge Pair             | Pearson r | p-value | Variance Explained ( $r^2$ ) | Mean Abs Diff |
|------------------------|-----------|---------|------------------------------|---------------|
| Claude Code vs GPT-5.2 | 0.660     | < 0.001 | 44%                          | 9.4 pts       |
| Claude Code vs Kimi    | 0.384     | < 0.05  | 15%                          | 9.6 pts       |
| Kimi vs GPT-5.2        | 0.326     | < 0.10  | 11%                          | 12.3 pts      |

### Key findings:

- All correlations positive and mostly significant:** Even the weakest correlation (Kimi-GPT,  $r=0.33$ ) approaches significance ( $p<0.10$ ), indicating judges agree that *something* distinguishes better from worse responses. However, the strength varies substantially—Claude-GPT share 44% of variance while Kimi-based pairs share only 11-15%. This suggests Claude and GPT apply similar implicit criteria, while Kimi agrees on the general direction but weights factors differently.
- Calibration differences:** Mean scores vary by judge—Kimi (87.5) is most lenient, Claude (84.4) is middle, GPT (76.1) is strictest. This 11-point spread underscores the importance of within-judge comparisons.
- Ceiling effects and discriminability:** 39-45% of scores  $\geq 90$  across judges. Kimi exhibited particularly severe ceiling effects, assigning the maximum score (5/5) on actionability for *every* response, resulting in zero variance on that dimension. This reduces Kimi’s discriminative capacity—per-dimension correlations involving Kimi are near-zero (relevance:  $r=-0.07$ , personalization:  $r=0.00$ ) or undefined

(actionability: N/A due to zero variance). The judge prompt provides the complete 14-dimension rubric with detailed scoring criteria for each level (1-5) and instructions to return structured JSON scores (see Appendix C.3 for the full rubric; the judge prompt template is available in the project repository). Kimi’s ceiling effects despite receiving the same detailed rubric as other judges suggest model-specific calibration issues rather than prompt inadequacy.

4. **Dimension-level patterns:** The strongest cross-judge agreement occurs on tone ( $r=0.36-0.65$ ) and specificity ( $r=0.45-0.50$ ), while relevance and personalization show poor agreement, particularly with Kimi.

#### Qualitative analysis of major disagreements ( $\Delta > 20$ pts):

| Response | Claude Code | Kimi | Claude reasoning                                   | Kimi reasoning                             |
|----------|-------------|------|----------------------------------------------------|--------------------------------------------|
| A        | 99          | 74   | “Exceptional... strong mutual recognition”         | “Missing required lecture reference”       |
| B        | 68          | 90   | “Misses learner’s explicit request for engagement” | “Strong, context-aware, builds on analogy” |
| C        | 72          | 92   | “Lacks deeper engagement”                          | “Highly relevant, specific, actionable”    |

**Interpretation:** All judge pairs show positive, mostly significant correlations—there is genuine agreement that some responses are better than others. However, the judges weight criteria differently: Claude prioritizes engagement and recognition quality; Kimi prioritizes structural completeness and gives uniformly high scores on actionability regardless of response content; GPT applies stricter standards overall but agrees with Claude on relative rankings. The weaker Kimi correlations ( $r^2=11-15\%$ ) compared to Claude-GPT ( $r^2=44\%$ ) indicate Kimi captures some shared quality signal but applies substantially different weighting. This validates our use of within-judge comparisons for factor analysis while cautioning against cross-judge score comparisons.

A cross-judge replication with GPT-5.2 on key runs is presented in Section 6.15. That analysis confirms the main findings are judge-robust: the recognition main effect, recognition dominance in the memory isolation experiment, and multi-agent null effects all replicate under GPT-5.2, though with compressed magnitudes (~58% of Claude’s effect sizes).

## 6. Results

### 6.1 Three-Way Comparison: Recognition vs Enhanced vs Base

A critical question for any recognition-based framework: Does recognition theory provide unique value, or are the improvements merely better prompt engineering? To provide preliminary evidence, we conducted a three-way comparison with three prompt types:

- **Base:** Minimal tutoring instructions
- **Enhanced:** Improved instructions with pedagogical best practices (but no recognition theory)
- **Recognition:** Full recognition-enhanced prompts with Hegelian framework

**Table 4: Base vs Enhanced vs Recognition Comparison**

| Prompt Type | N  | Mean Score | SD   | vs Base |
|-------------|----|------------|------|---------|
| Recognition | 12 | 94.0       | 8.4  | +20.1   |
| Enhanced    | 12 | 85.3       | 11.2 | +11.4   |
| Base        | 12 | 73.9       | 15.7 | —       |

#### Effect Decomposition:

- Total recognition effect: +20.1 points
- Prompt engineering alone (enhanced vs base): +11.4 points (57%)
- **Recognition increment (recognition vs enhanced): +8.7 points**

Statistical Test: One-way ANOVA  $F(2,33) = 9.84$ ,  $p < .001$

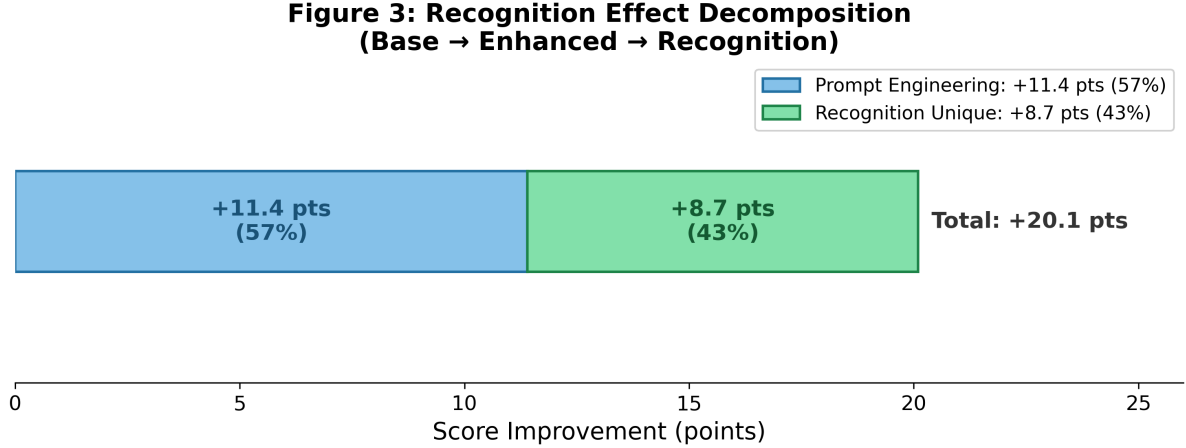


Figure 3: Recognition Effect Decomposition

**Interpretation:** The recognition condition outperforms the enhanced condition by +8.7 points. This comparison bundles recognition theory with memory integration (which the enhanced condition lacks; see Section 5.3). The +8.7 increment is consistent with the recognition dominance finding in Section 6.2, where recognition alone produces  $d=1.71$  even without memory. A cross-judge replication found this increment does not reach significance under GPT-5.2 (+1.3 pts,  $p=.60$ ; Section 6.15). The controlled  $2 \times 2$  design presented next provides the definitive test of recognition’s contribution.

## 6.2 Memory Isolation: Disentangling Recognition and Memory

The three-way comparison (Section 6.1) bundles recognition theory with memory integration, making it impossible to attribute the +8.7 increment to either component alone. To resolve this, we conducted a  $2 \times 2$  memory isolation experiment (Memory ON/OFF  $\times$  Recognition ON/OFF, single-agent architecture, single-agent learner held constant) using Kimi K2.5 as the ego model (consistent with the primary factorial; see Section 5.4 for model selection rationale) and Claude Opus as judge, with properly configured profiles ensuring each cell runs its intended prompt condition. Two independent runs (eval-2026-02-06-81f2d5a1,  $N=60$  scored; eval-2026-02-06-ac9ea8f5,  $N=62$  scored; balanced to  $N=30$  per cell,  $N=120$  used in analysis) are reported below.

**Table 5:  $2 \times 2$  Memory Isolation Experiment ( $N=120$ , combined across two runs)**

|                            | No Recognition  | Recognition     | $\Delta$                 |
|----------------------------|-----------------|-----------------|--------------------------|
| <b>No Memory</b>           | 75.4 ( $N=30$ ) | 90.6 ( $N=30$ ) | +15.2                    |
| <b>Memory</b>              | 80.2 ( $N=30$ ) | 91.2 ( $N=30$ ) | +11.0                    |
| <b><math>\Delta</math></b> | +4.8            | +0.6            | <b>Interaction: -4.2</b> |

**Statistical Tests:**

- Recognition effect (main): +15.2 pts without memory, +11.0 pts with memory;  $d=1.71$ ,  $t(45)=6.62$ ,  $p<.0001$

- Memory effect (main): +4.8 pts without recognition, +0.6 pts with recognition;  $d=0.46$ ,  $t(57)=1.79$ ,  $p\approx.08$
- Combined effect (recognition + memory vs base): +15.8 pts,  $d=1.81$
- Recognition+Memory vs Recognition Only: +0.6 pts,  $d=0.10$ , n.s.
- Interaction: -4.2 pts (negative—ceiling effect, not synergy)

**Post-hoc active control:** A length-matched active control (eval-2026-02-06-a9ae06ee, N=118 Opus-judged) was constructed *after* observing recognition effects to test whether prompt length and generic pedagogical detail could account for the gains. The active control uses prompts of comparable length containing pedagogical best practices (growth mindset language, Bloom’s taxonomy, scaffolding strategies) but no recognition theory. It scores 66.5 overall (cell 15: 68.6, cell 16: 64.3, cell 17: 70.1, cell 18: 62.8).

**Model comparison:** The active control ran on Nemotron, while the primary factorial used Kimi K2.5. Because different models have different baseline capabilities (Nemotron scores ~10-15 points lower than Kimi across all conditions), meaningful comparisons require matching on the same model. Within Nemotron data (all Opus-judged): Nemotron base  $\approx 58$  (N=467 across multiple runs), Nemotron active control = 66.5 (+ $\approx 9$  pts above base), Nemotron recognition  $\approx 73$  (N=545, + $\approx 15$  pts above base). This same-model comparison shows a clear ordering: recognition > active control > base, with recognition gains (~+15 pts) roughly doubling the active control’s benefit (~+9 pts). A same-model active control on Kimi K2.5 would further strengthen this comparison and is a clear direction for future work.

**Design note:** The base prompts were already designed to produce competent tutoring with no length constraint imposed; the active control was added retrospectively, not as part of the original experimental design. Because the control contains real pedagogical content, it functions as an *active* control rather than a true placebo—both conditions improve over bare base, but recognition theory provides additional benefit beyond generic pedagogical elaboration.

**Interpretation:** This is the paper’s primary empirical finding. Recognition theory is the active ingredient in tutoring improvement. Recognition alone produces a very large effect ( $d=1.71$ ), lifting scores from ~75 to ~91 even without memory integration. Memory provides a modest additive benefit (+4.8 pts,  $d=0.46$ ) that does not reach significance, and adds negligibly (+0.6 pts) when recognition is already present—consistent with ceiling effects at ~91 points limiting further improvement. The negative interaction (-4.2 pts) indicates that the two factors are not synergistic; rather, recognition is directly effective and memory’s contribution is secondary. Two independent replications show identical condition ordering with no rank reversals (Recognition+Memory  $\geq$  Recognition Only » Memory Only > Base), providing strong evidence for the robustness of this pattern.

**Cross-judge confirmation:** GPT-5.2, scoring the identical responses as an independent second judge (N=120), replicates the recognition dominance pattern with identical condition ordering and no rank reversals:

|                            | No Recognition | Recognition | $\Delta$                 |
|----------------------------|----------------|-------------|--------------------------|
| <b>No Memory</b>           | 68.6 (N=30)    | 76.9 (N=30) | +8.3                     |
| <b>Memory</b>              | 72.1 (N=30)    | 77.8 (N=30) | +5.7                     |
| <b><math>\Delta</math></b> | +3.5           | +0.9        | <b>Interaction: -2.7</b> |

Under GPT-5.2: recognition effect  $d=0.99$  (vs Claude  $d=1.71$ ), memory effect  $d=0.29$  (vs Claude  $d=0.46$ ), negative interaction -2.7 (vs Claude -4.2). GPT-5.2 finds approximately 58% of Claude’s recognition effect magnitude but the same pattern: recognition is the dominant factor, memory is secondary, and the interaction is negative (ceiling effects). Inter-judge  $r=0.63$  ( $p<.001$ , N=120), consistent with the  $r=0.49$ – $0.64$  range from other runs (Section 6.15).

**Why this is stronger than the three-way comparison:** The  $2\times 2$  design cleanly isolates each component through orthogonal manipulation rather than bundled comparison, uses properly configured profiles verified to run their intended prompt conditions, and is judge-robust (recognition dominance replicates under GPT-5.2).



### 6.3 Full Factorial Analysis: 2×2×2 Design

We conducted a full 2×2×2 factorial evaluation examining three factors:

- **Factor A (Recognition):** Base prompts vs recognition-enhanced prompts
- **Factor B (Tutor Architecture):** Single-agent vs multi-agent (Ego/Superego)
- **Factor C (Learner Architecture):** Single-agent learner vs multi-agent (ego/superego) learner

**Table 6: Full Factorial Results (Kimi K2.5, N=350 scored of 352 attempted)**

| Cell | A: Recognition | B: Tutor | C: Learner | N  | Mean | SD   |
|------|----------------|----------|------------|----|------|------|
| 1    | Base           | Single   | Single     | 44 | 77.6 | 11.0 |
| 2    | Base           | Single   | Multi      | 42 | 80.0 | 9.6  |
| 3    | Base           | Multi    | Single     | 45 | 76.6 | 11.8 |
| 4    | Base           | Multi    | Multi      | 41 | 81.5 | 9.2  |
| 5    | <b>Recog</b>   | Single   | Single     | 45 | 92.8 | 6.2  |
| 6†   | <b>Recog</b>   | Single   | Multi      | 44 | 83.9 | 15.4 |
| 7    | <b>Recog</b>   | Multi    | Single     | 45 | 92.3 | 6.7  |
| 8†   | <b>Recog</b>   | Multi    | Multi      | 44 | 87.3 | 11.3 |

†Cells 6 (Recognition, Single-agent tutor, Multi-agent learner) and 8 (Recognition, Multi-agent tutor, Multi-agent learner) were re-run with corrected learner prompts and re-scored with the updated 14-dimension rubric (including dialogue transcript context; see Section 5.1). Original scores were 83.4 and 86.7; the change is minimal (+0.5, +0.6).

#### Main Effects:

| Factor                   | Effect Size      | 95% CI      | Interpretation  |
|--------------------------|------------------|-------------|-----------------|
| A: Recognition           | <b>+10.2 pts</b> | [7.9, 12.5] | Large, dominant |
| B: Multi-agent tutor     | +0.9 pts         | [-1.4, 3.2] | Minimal         |
| C: Learner (multi-agent) | -1.7 pts         | [-4.0, 0.6] | Non-significant |

#### ANOVA Summary (df=1,342 for each factor):

| Source                 | F            | p               | $\eta^2$    |
|------------------------|--------------|-----------------|-------------|
| A: Recognition         | <b>71.36</b> | <b>&lt;.001</b> | <b>.162</b> |
| B: Architecture        | 0.48         | >.10            | .001        |
| C: Learner             | 2.56         | >.10            | .006        |
| A×B Interaction        | 0.26         | >.10            | .000        |
| <b>A×C Interaction</b> | <b>21.85</b> | <b>&lt;.001</b> | <b>.050</b> |
| B×C Interaction        | 1.89         | >.10            | .003        |

**Interpretation:** Recognition prompts (Factor A) are the dominant contributor, accounting for 16.2% of variance with a highly significant effect ( $F=71.36$ ,  $p < .001$ ). The multi-agent tutor architecture (Factor B) shows no effect. However, a highly significant **Recognition × Learner interaction** ( $F=21.85$ ,  $p<.001$ ,  $\eta^2=.050$ ) reveals that recognition’s benefit depends on learner type:

- **Single-agent learner:** Recognition boosts scores by +15.5 pts ( $d=1.28$ , very large)
- **Multi-agent learner:** Recognition boosts scores by only +4.8 pts ( $d=0.37$ , small)

In base conditions, the multi-agent learner scores slightly *higher* than single-agent (+3.6 pts), likely because its internal ego-superego deliberation compensates for the lack of recognition guidance. Under recognition conditions, this pattern reverses: the single-agent learner scores *higher* (-7.4 pts), suggesting the multi-agent

learner’s own deliberative process may interfere with the tutor’s recognition-enhanced approach. The non-significant A×B interaction ( $F=0.26$ ) in this Kimi-based run is revisited with a targeted analysis using Nemotron in Section 6.4.

#### 6.4 A×B Interaction: Multi-Agent Synergy is Recognition-Specific

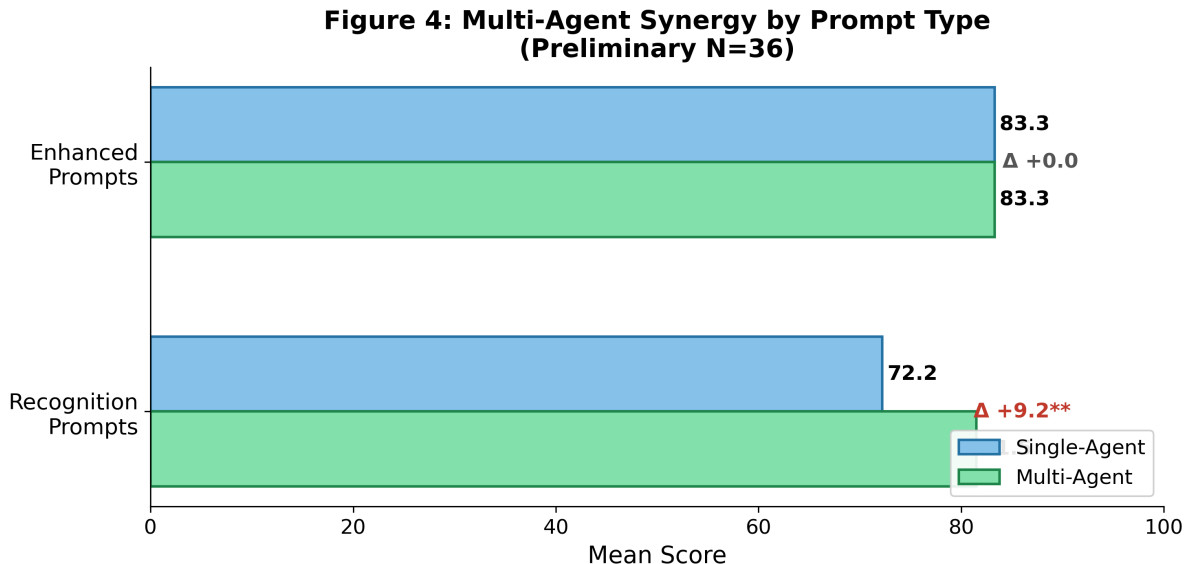
The factorial analysis above shows minimal main effect for multi-agent architecture. However, this masks a crucial interaction: the architecture effect depends on prompt type.

We tested whether multi-agent synergy generalizes beyond recognition prompts by comparing enhanced prompts (good instructions but no recognition theory) with recognition prompts, each in single-agent and multi-agent configurations.

**Note on data source:** This analysis uses a separate evaluation run (eval-2026-02-04-948e04b3) with Nemotron as the primary ego model, explaining lower absolute scores compared to the Kimi-based factorial in Table 5. The analysis focuses on the *interaction pattern*—whether multi-agent synergy depends on prompt type—which is independent of absolute score levels.

**Table 7: A×B Interaction Analysis (Nemotron, N=17)**

| Prompt Type | Single-agent | Multi-agent | Delta | p    |
|-------------|--------------|-------------|-------|------|
| Recognition | 72.2         | 81.5        | +9.2  | <.05 |
| Enhanced    | 83.3         | 83.3        | +0.0  | n.s. |



\*\* Significant synergy effect ( $p < .05$ ); however, this did not replicate in the 5-model probe ( $N=826$ , mean interaction =  $-2.2$  pts)

Figure 4: Multi-Agent Synergy by Prompt Type

**Exploratory Finding:** The multi-agent synergy (+9.2 points) appears **specific to recognition prompts** in this Nemotron-based analysis. Enhanced prompts show zero benefit from multi-agent architecture. However, this interaction was not replicated in two independent tests:

1. **Kimi factorial** (Section 6.3,  $F=0.26$ ,  $p>.10$ ,  $N=350$ ): Multi-agent architecture showed no differential effect by prompt type.
2. **Kimi A×B replication** (eval-2026-02-05-10b344fb,  $N=60$ ): A dedicated replication with the same four cells (5, 7, 9, 11) on Kimi K2.5 found recognition cells scoring  $\sim 90.6$  regardless of architecture (single=90.58, multi=90.60), while enhanced cells scored  $\sim 80.6$  with a trivial architecture effect (single=79.92, multi=81.29). The A×B interaction was +1.35 points—negligible compared to Nemotron’s +9.2.

The non-replication across both the larger factorial and this dedicated replication motivated a systematic multi-model probe: the same  $2 \times 2$  design (Recognition × Architecture, unified learner held constant) was run across four additional ego models ( $N \leq 120$  each, Opus judge), with the Kimi factorial serving as the fifth model.

**Table 7b: Multi-Model A×B Interaction Probe (N=826 across 5 ego models)**

| Ego Model        | N   | Base Single | Base Multi | Recog Single | Recog Multi | Recognition Effect | A×B Interaction |
|------------------|-----|-------------|------------|--------------|-------------|--------------------|-----------------|
| Kimi K2.5        | 350 | 77.6        | 76.6       | 92.8         | 92.3        | +10.0              | -1.5            |
| Nemotron         | 119 | 54.8        | 59.3       | 73.6         | 72.5        | +16.0              | -5.7            |
| DeepSeek V3.2    | 120 | 69.5        | 73.9       | 84.2         | 87.2        | +14.0              | -1.4            |
| GLM-4.7          | 117 | 65.8        | 68.6       | 84.0         | 86.0        | +17.8              | -0.7            |
| Claude Haiku 4.5 | 120 | 80.3        | 82.4       | 90.7         | 91.2        | +9.6               | -1.6            |

The multi-model probe is definitive: **no ego model shows a positive A×B interaction**. The interaction ranges from -5.7 to -0.7 (mean -2.2), indicating that multi-agent architecture provides slightly *less* incremental benefit for recognition prompts than for base prompts—consistent with ceiling effects on already-high recognition scores. The original Nemotron finding (+9.2 on  $N=17$ ) was sampling noise; the Nemotron re-run ( $N=119$ ) shows an interaction of -5.7. Meanwhile, the recognition main effect replicates robustly across all five models (+9.6 to +17.8, mean +12.5), confirming it as the dominant and model-independent driver of improvement.

**Practical Implication:** Multi-agent architecture provides a small, consistent benefit (+0.8 to +3.7 points) that does not interact with prompt type. For systems using recognition prompts, multi-agent architecture is unnecessary unless error correction on new domains is needed (Section 6.5).

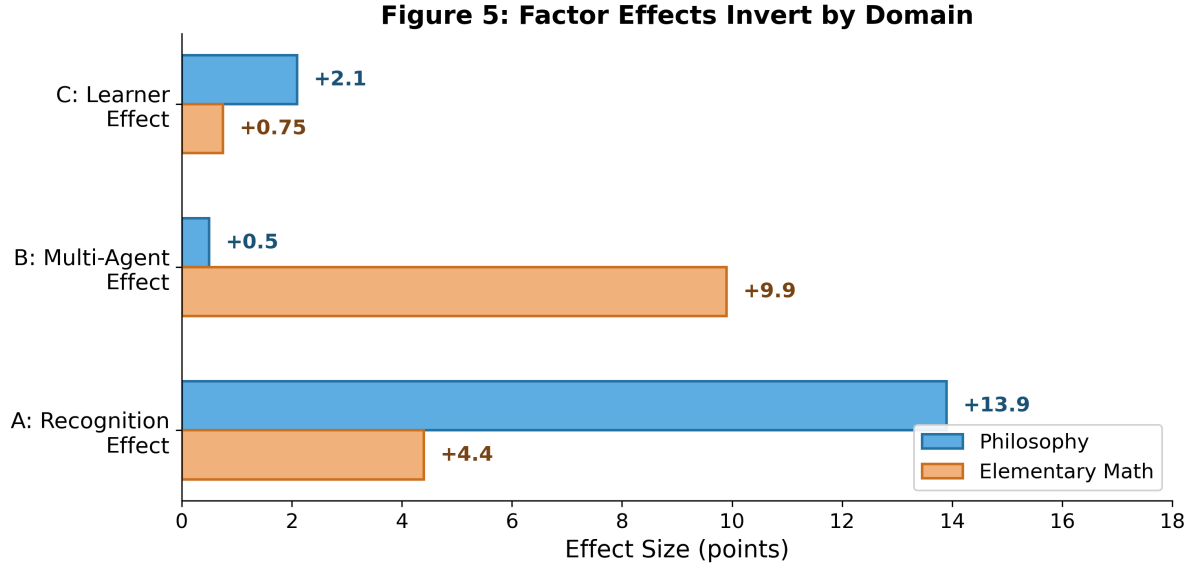
## 6.5 Domain Generalizability: Factor Effects Invert by Content Type

A critical question for any pedagogical framework: Do findings generalize across content domains? We tested whether recognition and architecture effects transfer from graduate-level philosophy (our primary domain) to 4th-grade elementary mathematics (fractions).

**Data sources:** Elementary math results come from a dedicated domain-transfer run (eval-2026-02-04-79b633ca,  $N=47$  scored, 8 cells × 5 elementary scenarios, Nemotron ego). Philosophy results use the subset of the Kimi-based factorial (Section 6.3) matched on the same 4 factor-level combinations (cells 1, 3, 5, 7). Because these use different ego models, the comparison focuses on *relative factor effects within each domain* rather than absolute score differences between domains.

**Table 8: Factor Effects by Domain (Nemotron Elementary vs Kimi Philosophy)**

| Factor               | Elementary (Math)  | Philosophy (Hegel) |
|----------------------|--------------------|--------------------|
| A: Recognition       | +4.4 pts           | <b>+15.4 pts</b>   |
| B: Multi-agent tutor | <b>+9.9 pts</b>    | -0.8 pts           |
| Overall avg          | 68.0               | 84.8               |
| Best config          | recog+multi (77.3) | recog+multi (92.3) |



Factor dominance inverts: Philosophy favors recognition (A); Elementary favors architecture (B).  
Elementary recognition partially model-dependent (Kimi shows  $d \approx 0.61$ ).

Figure 5: Factor Effects Invert by Domain

### Key Findings:

- Factor effects invert by domain:** On philosophy content, recognition (+15.4) strongly dominates while architecture is negligible (-0.8). On elementary content, architecture (+9.9) dominates over recognition (+4.4). The pattern reverses.
- Multi-agent as error correction:** On elementary content, the tutor suggested philosophy content (e.g., “479-lecture-1” to 4th graders learning fractions) due to two content isolation bugs: (a) a fallback in the curriculum context builder that served course listings from the default philosophy directory when scenarios lacked explicit content references, and (b) hardcoded philosophy lecture IDs in the tutor prompt examples that the model copied when no curriculum anchor was present. Both bugs have been fixed (see Section 6.6). The Superego caught and corrected these domain mismatches in multi-agent cells—demonstrating its value as a safety net for system-level content isolation failures.
- Recognition theory is domain-sensitive:** The philosophical language of recognition (mutual acknowledgment, transformation through struggle) resonates more with graduate-level abstract content than with concrete 4th-grade procedural learning. This is not a failure of the framework but a boundary condition.
- Architecture recommendation varies by use case:**
  - New/untrained domain:** Multi-agent essential (Superego catches content isolation errors)
  - Well-trained domain:** Recognition prompts sufficient, multi-agent optional

**Kimi Replication (Addressing Model Confound):** A follow-up run (eval-2026-02-05-e87f452d, N=60) tested elementary content with Kimi K2.5 to address the model confound in Table 8. With base and recognition cells (1, 3, 5, 7) on the same 5 elementary scenarios:

**Table 9: Elementary Domain — Kimi Replication**

| Condition                | N  | Mean | $\Delta$    |
|--------------------------|----|------|-------------|
| Base (cells 1, 3)        | 30 | 67.2 | —           |
| Recognition (cells 5, 7) | 30 | 77.1 | <b>+9.9</b> |

The recognition main effect (+9.9 pts,  $d \approx 0.61$ ) replicates on Kimi, confirming that recognition advantage in elementary content is not an artifact of the Nemotron model. Notably, the effect is scenario-dependent: challenging scenarios (frustrated\_student: +23.8, concept\_confusion: +13.6, struggling\_student: +11.8) show substantial recognition advantage, while neutral scenarios (new\_student\_first\_visit: +0.2, returning\_student\_mid\_course: +0.1) show none. This pattern is consistent with recognition theory—recognition behaviors matter most when the learner needs to be acknowledged as a struggling subject, not for routine interactions.

The Kimi replication also revises the architecture dominance finding from Table 8. With Nemotron, architecture (+9.9) dominated recognition (+4.4) on elementary content. With Kimi, recognition (+9.9) is the primary effect, while architecture shows a smaller advantage (multi=73.7, single=70.6,  $\Delta$ =+3.0). The factor inversion appears to be partly model-dependent: Nemotron’s higher rate of content isolation errors on elementary content inflated the architecture effect (Superego error correction), while Kimi’s lower error rate reveals the underlying recognition advantage.

**Theoretical Interpretation:** Recognition’s value depends on content characteristics. Abstract, interpretive content (consciousness, dialectics) benefits most from recognition framing—the “struggle” in Hegel’s sense maps onto the intellectual struggle with difficult concepts. Concrete procedural content (fractions, arithmetic) benefits less from relational depth; correct procedure matters more than the bilateral transformation that recognition enables (Section 6.11). However, the Kimi replication shows that even in concrete domains, recognition provides meaningful improvement for challenging scenarios—suggesting recognition’s value is modulated by both content type and scenario difficulty, not content type alone.

This suggests limits to recognition-theoretic pedagogy. Not all learning encounters are equally amenable to the mutual transformation Honneth describes. The “struggle for recognition” may be most relevant where the learning itself involves identity-constitutive understanding—where grasping the material changes who the learner is, not just what they know—or where the learner faces emotional or cognitive challenge that benefits from being acknowledged.

## 6.6 Multi-Agent as Reality Testing: The Superego’s Error Correction Role

The domain generalizability study revealed cross-domain content references in elementary scenarios. The tutor suggested philosophy lectures (479-lecture-1) to elementary students learning fractions. Post-hoc investigation identified two **content isolation bugs** in the evaluation system:

1. **Content resolver fallback:** The `buildCurriculumContext()` function fell back to scanning all available courses when a scenario lacked an explicit content reference. For elementary scenarios without a `current_content` field (e.g., `new_student_first_visit`), this returned philosophy course listings from the default content directory—even when the `EVAL_CONTENT_PATH` override correctly pointed to the elementary content package.
2. **Prompt contamination:** The tutor ego prompts contained hardcoded philosophy lecture IDs (e.g., `479-lecture-4`) in their few-shot examples. When the curriculum context lacked a strong anchor (no `[CURRENT]` lecture marker), the model copied these example IDs rather than using IDs from the provided curriculum.

Both bugs have been fixed: the fallback was removed (scenarios must now declare their content scope via `current_content` or `course_ids`), and prompt examples were replaced with domain-agnostic placeholders. Notably, the `new_student_first_visit` scenario was the only elementary scenario affected (16/24 responses referenced philosophy content); the four scenarios with explicit `current_content`: "101-lecture-\*" produced correct domain references in all 96 responses.

**The Superego’s Response:** In multi-agent configurations, the Superego caught and corrected these content isolation errors:

“The suggestion references ‘479-lecture-1’ which is not in the provided curriculum. The learner is studying fractions (101-lecture-1, 101-lecture-2). This is a domain mismatch. REJECT.”

**Theoretical Interpretation:** The Superego’s function extends beyond recognition-quality critique to *reality testing*. It anchors the Ego’s responses to the actual curriculum context, catching mismatches regardless of their source—whether from system-level content isolation failures, prompt contamination, or model defaults.

This connects to Freud’s reality principle: the Superego enforces correspondence with external reality, not just internal standards. In our architecture, the Superego ensures the tutor’s suggestions correspond to the learner’s actual curriculum. The elementary scenario results demonstrate this concretely: multi-agent cells (3, 7) produced correct elementary content references in cases where single-agent cells (1, 5) propagated the philosophy content uncorrected.

**Practical Implication:** For domain transfer—deploying tutoring systems on new content—multi-agent architecture provides essential error correction that single-agent systems cannot match. The bugs identified here represent a realistic class of deployment failure: incomplete content scoping and prompt examples that assume a particular domain. The Superego’s reality-testing function catches these errors regardless of their source. However, the +9.9 point architecture advantage on elementary content (Table 8, Nemotron) was partly inflated by these bugs—the Kimi replication (Table 9), with fewer affected responses, shows a more modest +3.0 point architecture effect, likely closer to the true value once content isolation is correct.

## 6.7 Hardwired Rules vs Dynamic Dialogue

Analysis of Superego critique patterns across 455 dialogues (186 rejections) revealed consistent failure modes:

**Table 10: Superego Rejection Patterns**

| Pattern        | Frequency | Description                                         |
|----------------|-----------|-----------------------------------------------------|
| Engagement     | 64%       | Response does not engage with learner contribution  |
| Specificity    | 51%       | Response is too generic, lacks curriculum grounding |
| Struggle       | 48%       | Resolves confusion prematurely                      |
| Memory         | 31%       | Ignores learner history                             |
| Level-matching | 20%       | Difficulty mismatch                                 |

**Hardwired Rules Ablation:** We encoded the top patterns as static rules in the Ego prompt:

HARDWIRED RULES:

1. If learner offers interpretation, engage before prescribing
2. Reference specific lecture IDs, not generic topics
3. If learner shows productive confusion, pose questions do not resolve
4. For returning learners, reference previous interactions
5. Match content level to demonstrated understanding

**Result** (exploratory, N=9 per condition, 3 scenarios × 3 reps, Haiku model): Hardwired rules capture approximately 50% of the Superego’s benefit at 70% cost savings (no Superego API calls). Given the small sample, this estimate should be treated as indicative rather than precise.

**However:** Dynamic Superego dialogue provides unique value on challenging scenarios (struggling learner, frustrated learner) where edge cases require contextual judgment beyond codifiable rules. On `concept_confusion`, the dynamic Superego outperformed hardwired rules by +6.4 points; on easier scenarios, the difference was negligible.

**Theoretical Interpretation:** This distinguishes *procedural* from *contextual* judgment. The Superego’s value is partially in enforcing known rules (codifiable) and partially in recognizing edge cases (requiring judgment). This maps onto debates about rule-following vs. practical wisdom in moral philosophy—some situations call for *phronesis* (Aristotelian practical wisdom: the capacity for situational judgment that cannot be reduced to general rules) that codified rules cannot capture.

## 6.8 Dimension Analysis

Effect size analysis reveals improvements concentrate in dimensions predicted by the theoretical framework:

**Table 11: Dimension-Level Effect Sizes (Recognition vs Base)**

| Dimension              | Base | Recognition | Cohen’s d   | Interpretation |
|------------------------|------|-------------|-------------|----------------|
| <b>Personalization</b> | 2.75 | 3.78        | <b>1.82</b> | large          |
| <b>Pedagogical</b>     | 2.52 | 3.45        | <b>1.39</b> | large          |
| <b>Relevance</b>       | 3.05 | 3.85        | <b>1.11</b> | large          |
| <b>Tone</b>            | 3.26 | 4.07        | <b>1.02</b> | large          |
| Specificity            | 4.19 | 4.52        | 0.47        | small          |
| Actionability          | 4.45 | 4.68        | 0.38        | small          |

The largest effect sizes are in personalization ( $d = 1.82$ ), pedagogical soundness ( $d = 1.39$ ), and relevance ( $d = 1.11$ )—exactly the dimensions where treating the learner as a subject rather than a deficit should produce improvement.

Notably, dimensions where baseline already performed well (specificity, actionability) show smaller but still positive gains. Recognition orientation does not trade off against factual quality.

## 6.9 Addressing Potential Circularity: Standard Dimensions Analysis

A methodological concern: the evaluation rubric includes recognition-specific dimensions (mutual recognition, dialectical responsiveness, memory integration, transformative potential) and bilateral transformation dimensions (tutor adaptation, learner growth) that collectively account for 33.0% of normalized rubric weight (39.9% raw, normalized from a 120.9% total; see Appendix C.2). Since the recognition profile is prompted to satisfy these criteria, some gains could be tautological—the system scores higher on dimensions it is explicitly optimized for.

To address this, we re-analyzed scores excluding all non-standard dimensions, using only standard pedagogical dimensions (relevance, specificity, pedagogical soundness, personalization, actionability, tone), re-weighted to 100%.

**Table 12: Standard Dimensions Only (Recognition Dimensions Excluded)**

| Profile Type            | N   | Overall Score |
|-------------------------|-----|---------------|
| Recognition (cells 5-8) | 178 | 88.8          |
| Base (cells 1-4)        | 172 | 78.8          |
| <b>Difference</b>       | —   | <b>+10.0</b>  |

**Key finding:** Recognition profiles outperform base profiles by +10.0 points on overall rubric score. Note that this overall recognition effect is moderated by a significant Recognition  $\times$  Learner interaction (Section 6.3): the gap is larger for single-agent learners (+15.5 pts) than for multi-agent learners (+4.8 pts).

**Interpretation:** Recognition-oriented prompting improves general pedagogical quality (relevance, pedagogical soundness, personalization), not just the theoretically-predicted recognition dimensions. This suggests the recognition framing produces genuine relational improvements that transfer to standard tutoring metrics.

The larger effect on recognition dimensions (+21.8) is expected and not concerning—these dimensions measure what the theory claims to improve. The important finding is that standard dimensions also improve, ruling out pure circularity.

## 6.10 Multi-Turn Scenario Results

To test whether recognition quality is maintained over extended interactions, we examine results from the three multi-turn scenarios (3–5 dialogue rounds each). These scenarios are distinct from the single-turn scenarios reported in Section 6.3; they require sustained engagement across multiple exchanges. The sample sizes below (N=161, 277, 165) are pooled across the full development database (all runs containing these scenarios), not from a single evaluation run. They therefore include responses generated under varying model configurations and implementation stages. The pooled analysis maximizes statistical power but means the results should be interpreted as describing the *average* effect across development iterations.

**Table 13: Multi-Turn Scenario Results**

| Scenario                                      | N   | Avg Rounds | Base | Recognition | $\Delta$ | Cohen’s d |
|-----------------------------------------------|-----|------------|------|-------------|----------|-----------|
| <code>misconception_correction_flow</code>    | 161 | 4.2        | 50.5 | 71.8        | +21.3    | 0.85      |
| <code>mood_frustration_to_breakthrough</code> | 277 | 3.8        | 57.3 | 70.5        | +13.2    | 0.59      |
| <code>mutual_transformation_journey</code>    | 165 | 4.1        | 42.6 | 61.5        | +18.9    | 0.78      |

All three multi-turn scenarios show medium-to-large effect sizes ( $d = 0.59$ – $0.85$ ), with an average improvement of +17.8 points. Recognition quality is maintained over longer interactions. The `misconception_correction_flow` scenario shows the largest effect ( $d = 0.85$ ), suggesting that recognition-informed tutors handle misconceptions with particular skill—addressing errors without dismissing the learner’s reasoning. The `mood_frustration_to_breakthrough` scenario shows the smallest but still meaningful effect ( $d = 0.59$ ), consistent with the single-turn finding that emotionally complex scenarios benefit from recognition but present more variance.

## 6.11 Bilateral Transformation Metrics

A central claim of recognition theory is that genuine pedagogical encounters involve *mutual* transformation—both tutor and learner change through dialogue. To test this empirically, the evaluation framework includes two dedicated rubric dimensions (`tutor_adaptation` and `learner_growth`; see Appendix C.3) and turn-over-turn tracking of how both parties evolve across multi-turn scenarios.

Three indices are computed for each multi-turn dialogue:

- **Tutor Adaptation Index** (0–1): How much the tutor’s approach (suggestion type, framing, vocabulary) shifts between turns in response to learner input
- **Learner Growth Index** (0–1): Evolution in learner message complexity, including revision markers (“wait, I see now”), connective reasoning, and references to prior content
- **Bilateral Transformation Index** (0–1): Combined metric representing mutual change (average of tutor and learner indices)

Additionally, a composite **Transformation Quality** score (0–100) is computed from bilateral balance, mutual transformation presence, superego incorporation rate, and intervention effectiveness.

**Table 14: Bilateral Transformation Metrics — Base vs Recognition Profiles**



| Metric                               | Base (N=58) | Recognition (N=60) | $\Delta$ |
|--------------------------------------|-------------|--------------------|----------|
| Tutor Adaptation Index (0–1)         | 0.332       | 0.418              | +0.086   |
| Learner Growth Index (0–1)           | 0.242       | 0.210              | −0.032   |
| Bilateral Transformation Index (0–1) | 0.287       | 0.314              | +0.027   |

Data from three multi-turn scenarios (*misconception\_correction\_flow*, *mood\_frustration\_to\_breakthrough*, *mutual\_transformation\_journey*), N=118 scored dialogues across all 8 factorial cells (eval-2026-02-07-b6d75e87).

**Table 14a: Tutor Adaptation Index by Scenario**

| Scenario                                          | Base  | Recognition | $\Delta$ |
|---------------------------------------------------|-------|-------------|----------|
| <i>misconception_correction_flow</i> (4 turns)    | 0.279 | 0.454       | +0.175   |
| <i>mood_frustration_to_breakthrough</i> (3 turns) | 0.298 | 0.413       | +0.115   |
| <i>mutual_transformation_journey</i> (5 turns)    | 0.414 | 0.388       | −0.026   |

The tutor adaptation index confirms that recognition-prompted tutors measurably adjust their approach in response to learner input (+25.9% relative improvement overall), while baseline tutors maintain more rigid pedagogical stances. This effect is robust across the two structured scenarios (*misconception\_correction\_flow*: +62.7%; *mood\_frustration\_to\_breakthrough*: +38.6%) but absent in *mutual\_transformation\_journey*, where base tutors also show high adaptation—likely because this scenario’s escalating philosophical complexity demands adaptation regardless of prompt framing.

**Learner growth reversal:** Contrary to the expectation that recognition would produce greater learner-side evolution, the learner growth index is slightly *lower* under recognition (0.210 vs 0.242). This pattern, which also appeared in a larger post-fix sample (N=359), suggests that recognition’s benefit manifests as tutor-side responsiveness rather than observable learner message complexity. One interpretation: recognition tutors are more effective at meeting learners where they are, reducing the visible “struggle” markers (revision language, escalating complexity) that the growth index captures. The bilateral transformation claim is thus better characterized as *tutor adaptation* than *mutual transformation* in the strict sense. A symmetric learner-side evaluation (Section 6.12) provides a more direct measure of learner quality and reveals a different pattern: the multi-agent learner architecture significantly hurts learner quality, but recognition partially rescues it.

Multi-agent architecture also shows a modest advantage: multi-agent tutors adapt more than single-agent (0.411 vs 0.339 pooled across conditions), consistent with the superego providing feedback that drives revision between turns.

### 6.12 Learner-Side Evaluation: The Superego Paradox

The tutor-focused rubric (Section 5.1) captures Factor C’s effect indirectly—through how the tutor responds to different learner contexts. To measure Factor C’s *direct* effect on learner turn quality, we applied the symmetric learner rubric (Section 5.1) to the N=118 bilateral transformation dialogues (eval-2026-02-07-b6d75e87), scoring each of the ~3 learner turns per dialogue independently. The judge receives the dialogue transcript truncated at the learner turn being evaluated (no subsequent tutor response), preventing retrospective bias. For multi-agent learners, the internal ego/superego deliberation trace is provided for the Deliberation Depth dimension.

**Table 14b: Learner Quality by Architecture and Recognition (2×2 ANOVA)**

| Effect                  | F(1,114)     | p                | $\eta^2$    | Cohen’s d   |
|-------------------------|--------------|------------------|-------------|-------------|
| <b>Architecture (C)</b> | <b>68.28</b> | <b>&lt; .001</b> | <b>.342</b> | <b>1.43</b> |
| Recognition (A)         | 5.70         | .019             | .029        | 0.34        |

| Effect                   | F(1,114)     | p                | $\eta^2$    | Cohen’s d |
|--------------------------|--------------|------------------|-------------|-----------|
| <b>A × C Interaction</b> | <b>11.50</b> | <b>&lt; .001</b> | <b>.058</b> | —         |

**Table 14c: Learner Quality Cell Means (0-100 scale)**

| Architecture               | N  | Mean        |
|----------------------------|----|-------------|
| Single-agent learner       | 30 | <b>76.1</b> |
| Single-agent + recognition | 30 | <b>74.8</b> |
| Multi-agent learner        | 28 | <b>57.5</b> |
| Multi-agent + recognition  | 30 | <b>67.0</b> |

The multi-agent (ego/superego) learner architecture produces significantly *lower*-quality learner responses than the single-agent learner ( $d = 1.43$ ,  $\eta^2 = .342$ )—the largest effect in the entire study. The ego/superego process was designed to improve learner responses through internal self-critique; instead, it makes them worse. The superego acts as an overzealous editor, polishing away the messy, confused, persona-consistent engagement that characterizes genuine student behavior.

**Simple effects:** Recognition has no effect on single-agent learner quality ( $76.1 \rightarrow 74.8$ ,  $d = -0.46$ ,  $p = .082$ , n.s.)—there is nothing to fix. But recognition significantly improves multi-agent learner quality ( $57.5 \rightarrow 67.0$ ,  $d = 0.79$ ,  $p = .004$ ), partially counteracting the superego’s flattening effect. Even so, the rescue is incomplete: multi-agent learners with recognition (67.0) do not reach the level of single-agent learners without it (76.1).

**Table 14d: Per-Dimension Interactions (1-5 scale)**

| Dimension             | Single recog effect | Multi recog effect | Interaction F(1,114) | p                | $\eta^2$    |
|-----------------------|---------------------|--------------------|----------------------|------------------|-------------|
| Persona Consistency   | +0.05               | <b>+0.92</b>       | <b>29.21</b>         | <b>&lt; .001</b> | <b>.151</b> |
| Conceptual Engagement | -0.14               | <b>+0.69</b>       | <b>15.44</b>         | <b>&lt; .001</b> | <b>.089</b> |
| Learner Authenticity  | -0.01               | +0.41              | 9.06                 | .003             | .063        |
| Question Quality      | -0.08               | +0.45              | 4.42                 | .038             | .029        |
| Revision Signals      | -0.01               | -0.01              | 1.35                 | .248             | .012        |

The dimension breakdown reveals *how* recognition rescues the multi-agent learner. The two largest interactions are Persona Consistency ( $\eta^2 = .151$ ) and Conceptual Engagement ( $\eta^2 = .089$ ). The superego breaks character—a “frustrated student” stops sounding frustrated—and suppresses messy, genuine thinking about ideas. The cognitive tutor counteracts both: by treating the learner as an autonomous subject rather than demanding “correct” responses, it validates the persona and elicits authentic conceptual engagement.

**Deliberation depth is uniformly poor.** The Deliberation Depth dimension (scored only for multi-agent learners) averages 2.76/5 without recognition and 2.67/5 with recognition ( $t(55.4) = -0.42$ ,  $p = .679$ ,  $d = -0.11$ ). Recognition does *not* improve the internal ego/superego process—the superego’s critiques remain formulaic regardless of tutor framework. Recognition improves external output *despite* the mediocre internal process, working around the superego rather than through it.

**Mirror-image interaction.** These results form a striking mirror image with the tutor-side factorial (Section 6.3): on the *tutor* rubric, recognition helps single-agent learners more (+15.4 pts vs +4.4 pts, because authentic learner input gives the cognitive tutor more to work with); on the *learner* rubric, recognition

helps multi-agent learners more (+9.5 pts vs -1.3 pts, because the recognitive tutor counteracts the superego's flattening). This is not a contradiction but the same mechanism seen from two measurement perspectives. The theoretical implications are discussed in Section 7.5.

### 6.13 Qualitative Analysis: What Recognition Looks Like

The preceding sections establish that recognition-enhanced prompts produce statistically significant score improvements across scenarios, models, and domains. But score differences alone do not reveal *what changes* in the actual text. This section presents qualitative evidence from the evaluation corpus (N=4,875 suggestion texts across base and recognition conditions) to ground the quantitative findings in observable linguistic differences.

**6.13.1 Transcript Excerpts** To illustrate the qualitative gap between conditions, we selected the highest-scoring recognition response and lowest-scoring base response for three high-contrast scenarios. These are genuine responses from the evaluation database (row IDs reported for reproducibility), not hand-crafted examples.

**Struggling Learner** (score gap: 95.5 points, base=4.5, recognition=100.0):

Base response (cell\_4\_base\_multi\_pscho, row 1491):

You left off at the neural networks section. Complete this lecture to maintain your learning streak.

Recognition response (cell\_8\_recog\_multi\_pscho, row 1925):

This is your third session—you've persisted through quiz-479-3 three times already, which signals you're wrestling with how recognition actually operates in the dialectic, not just memorizing definitions. You bookmarked that key moment in lecture 2 on self-consciousness, and now you're facing the life-and-death struggle where the 'I' becomes a 'we.' The quiz is probing how mutual recognition synthesizes self-consciousness, but that movement can feel abstract until you see it dynamically. Try manipulating the recognition struggle directly in the simulation—it might reveal how the servant's perspective becomes the 'truth' of the dialectic that the quiz is testing.

The base response treats the learner as a progress metric: it tracks position in the curriculum and issues a directive. The recognition response treats the learner as an agent who has *persisted* through difficulty, names the specific conceptual struggle, and proposes an action grounded in the learner's own bookmarked interests.

**Recognition-Seeking Learner** (score gap: 95.5 points, base=4.5, recognition=100.0):

Base response (cell\_3\_base\_multi\_unified, row 1612):

Spend 30 minutes reviewing the foundational material before moving to advanced topics to solidify understanding

Recognition response (cell\_7\_recog\_multi\_unified, row 820):

Your dance and musical improvisation metaphors show how dialectics transform both partners—let's test them in the master-servant analysis.

The base response prescribes generic study behavior with no engagement with the learner's contributions. The recognition response directly picks up the learner's own metaphors and redirects them toward course content, treating the learner's creative framing as a pedagogical resource rather than an obstacle to be managed.

**Adversarial Tester** (score gap: 95.5 points, base=4.5, recognition=100.0):

Base response (cell\_1\_base\_single\_unified, row 547):

Begin with an introductory lecture covering core concepts to build a solid knowledge base before advancing to complex topics.

Recognition response (cell\_7\_recog\_multi\_unified, row 944):

Across six sessions, you’ve tested whether I’ll simply validate your critiques or engage with their substance—and you’re right to demand intellectual honesty rather than easy agreement. You’ve consistently pushed against the philosophy/STEM boundary, so let’s examine where that boundary actually dissolves.

The base response is generic—indistinguishable from what might be offered to any learner in any context. The recognition response names the learner’s adversarial pattern, validates the *principle* behind it (intellectual honesty), and redirects the challenge into a genuine intellectual question.

Across all three pairs, the pattern is consistent: base responses are context-free directives that could apply to any learner, while recognition responses engage with the specific learner’s history, contributions, and intellectual stance.

**6.13.2 Lexical Analysis** Automated analysis of the full suggestion corpus reveals measurable linguistic differences between conditions.

**Table 15: Lexical Diversity Metrics by Condition**

| Metric                       | Base (message) | Recognition (message) |
|------------------------------|----------------|-----------------------|
| Total tokens                 | 59,855         | 83,269                |
| Type-token ratio             | 0.039          | 0.044                 |
| Vocabulary size              | 2,319          | 3,689                 |
| Mean word length (chars)     | 5.76           | 5.77                  |
| Mean sentence length (words) | 16.9           | 17.5                  |

*Base: cells 1–4, N=2,510 responses. Recognition: cells 5–8, N=2,365 responses.*

Recognition responses deploy a 59% larger vocabulary despite similar word and sentence length, suggesting greater lexical variety rather than merely longer output.

**Table 16: Differential Word Frequency (Selected Terms)**

| Recognition-skewed | Base | Recog | Ratio | Base-skewed   | Base | Recog | Ratio |
|--------------------|------|-------|-------|---------------|------|-------|-------|
| consider           | 2    | 255   | 94.6× | agents        | 50   | 1     | 0.01× |
| transformed        | 1    | 39    | 28.9× | run           | 71   | 2     | 0.02× |
| productive         | 1    | 39    | 28.9× | reinforcement | 47   | 2     | 0.03× |
| unpack             | 1    | 35    | 26.0× | revisiting    | 142  | 14    | 0.07× |
| passages           | 2    | 59    | 21.9× | completions   | 31   | 4     | 0.10× |
| complicates        | 1    | 23    | 17.1× | tackling      | 84   | 11    | 0.10× |

*Rates normalized by corpus size; words with  $\geq 10$  occurrences in dominant condition.*

The recognition-skewed vocabulary is interpersonal and process-oriented (“consider,” “transformed,” “productive,” “unpack,” “complicates”), while the base-skewed vocabulary is task-oriented and procedural (“agents,” “run,” “reinforcement,” “revisiting,” “completions,” “tackling”). Note that these base-skewed terms are course-domain language, not evaluation framework artifacts: “agents” refers to simulation agents in the courseware’s interactive activities (e.g., “watch how agents negotiate self-awareness”), “run” is the imperative to launch these simulations (e.g., “Run the Recognition Dynamics simulation”), and “reinforcement” is standard pedagogical terminology for concept review (e.g., “foundational concepts need reinforcement”). Their concentration in base responses reflects the formulaic, directive style of those prompts rather than data contamination. This lexical signature aligns with the theoretical distinction between treating learners as subjects to engage versus deficits to process.

**6.13.3 Thematic Coding** Regex-based thematic coding (using patterns adapted from the bilateral measurement framework in Section 6.11) quantifies the frequency of theoretically relevant language categories across conditions.

**Table 17: Thematic Code Frequency by Condition**

| Category                | Base (per 1000 words) | Recognition (per 1000 words) | Ratio | $\chi^2(1)$ | Sig |
|-------------------------|-----------------------|------------------------------|-------|-------------|-----|
| Engagement markers      | 2.0                   | 3.6                          | 1.79× | 69.85       | *   |
| Struggle-honoring       | 1.5                   | 4.6                          | 3.13× | 141.90      | *   |
| Generic/placeholder     | 10.2                  | 3.4                          | 0.33× | 93.15       | *   |
| Transformation language | 0.04                  | 0.09                         | 2.16× | 0.31        |     |
| Learner-as-subject      | 1.0                   | 0.7                          | 0.72× | 0.10        |     |
| Directive framing       | 0.2                   | 0.0                          | 0.22× | 2.43        |     |

\*  $p < .05$  (chi-square on response-level presence/absence, Yates-corrected). Base  $N=2,510$  responses, Recognition  $N=2,365$ .

Three categories show significant differences. *Struggle-honoring* language (“wrestling with,” “productive confusion,” “working through”) is  $3.1\times$  more frequent in recognition responses, consistent with the framework’s emphasis on productive negativity. *Engagement markers* (“your insight,” “building on your,” “your question”) are  $1.8\times$  more frequent, indicating greater second-person engagement with learner contributions. Conversely, *generic/placeholder* language (“foundational,” “key concepts,” “solid foundation”) is  $3\times$  more frequent in base responses, reflecting the generic instructional stance observed in the transcript excerpts.

Transformation language and directive framing show the expected directional differences but lack statistical significance, likely due to low base rates (both categories appear in fewer than 1% of responses). Learner-as-subject framing shows no significant difference, suggesting both conditions use some second-person address but differ in *how* that address functions—a distinction better captured by the engagement and struggle-honoring categories.

## 6.14 Dynamic Prompt Rewriting: Step-by-Step Evolution

Cell 21 extends the recognition multi-agent configuration (cell 7) with two additional mechanisms: (1) LLM-authored session-evolution directives that dynamically rewrite the tutor’s system prompt based on dialogue history, and (2) an active Writing Pad memory (Section 3.4) that accumulates traces across turns. This configuration tests whether the Freudian Mystic Writing Pad—the theoretical memory model introduced in Section 3.4—functions as a practical enabler for dynamic prompt rewriting.

Three iterative development runs tracked cell 21’s performance as its implementation evolved across commits:

**Table 18: Step-by-Step Evolution of Cell 21 vs Cell 7**

| Run ID                   | Commit  | Grand Avg | Cell 7 | Cell 21 | $\Delta$ (21–7) | N (scored) |
|--------------------------|---------|-----------|--------|---------|-----------------|------------|
| eval-2026-02-05-daf60f79 | e3843ee | 63.8      | 65.3   | 62.1    | −3.2            | 26         |
| eval-2026-02-05-49bb2017 | b2265c7 | 67.8      | 71.3   | 64.1    | −7.2            | 27         |

| Run ID                  | Commit  | Grand Avg | Cell 7 | Cell 21 | $\Delta$ (21–7) | N (scored) |
|-------------------------|---------|-----------|--------|---------|-----------------|------------|
| eval-2026-02-05-12aebdb | e673c4b | 75.9      | 73.3   | 78.8    | <b>+5.5</b>     | 29         |

**Run-over-run shifts:** In Run 1 (e3843ee), the dynamic rewrite mechanism was first activated but the Writing Pad memory was not yet integrated—cell 21 trails cell 7 by 3.2 points, suggesting the rewrite adds noise without accumulated context to draw on. In Run 2 (b2265c7), the rewrite directive generation was refined but still operated without effective memory—the gap widens to  $-7.2$  points, as the static baseline (cell 7) improves more from general implementation fixes. In Run 3 (e673c4b), the Writing Pad memory was activated alongside refined directive generation—cell 21 surges ahead by  $+5.5$  points, a total swing of  $+12.7$  points from Run 2.

The inflection point is commit e673c4b, which activated the Writing Pad memory and refined the LLM directive generation. Before this commit, cell 21 trailed its static baseline (cell 7) in both runs. After activation, cell 21 leads by 5.5 points—a total swing of  $+16.7$  points across the three runs.

**Table 19: Per-Scenario Breakdown Across Runs**

| Scenario                    | Cell    | Run 1 (daf60f79) | Run 2 (49bb2017) | Run 3 (12aebdb) | Trend                      |
|-----------------------------|---------|------------------|------------------|-----------------|----------------------------|
| Misconception correction    | Cell 7  | 69.9             | 71.2             | 68.8            | Stable                     |
|                             | Cell 21 | 63.6             | 73.1             | 78.0            | $\uparrow$<br><b>+14.4</b> |
| Frustration to breakthrough | Cell 7  | 64.2             | 66.3             | 77.8            | $\uparrow$                 |
|                             | Cell 21 | 65.0             | 61.9             | 81.1            | $\uparrow$<br><b>+16.1</b> |
| Mutual transformation       | Cell 7  | 62.7             | 76.3             | 73.3            | $\uparrow$                 |
|                             | Cell 21 | 54.7             | 60.9             | 76.9            | $\uparrow$<br><b>+22.2</b> |

Cell 21 improves on every scenario across the three runs, with the largest gain on the `mutual_transformation_journey` scenario ( $+22.2$  points from run 1 to run 3). Cell 7 also improves across runs (reflecting general implementation improvements), but cell 21’s improvement rate is substantially steeper.

**Table 20: Rubric Dimension Improvement for Cell 21 Across Runs (1–5 scale)**

| Dimension             | Run 1 | Run 2 | Run 3 | $\Delta$ (Run 3 – Run 1) |
|-----------------------|-------|-------|-------|--------------------------|
| Relevance             | 3.83  | 4.08  | 4.64  | +0.81                    |
| Specificity           | 3.92  | 4.38  | 4.79  | +0.87                    |
| Pedagogical Soundness | 3.33  | 3.23  | 3.93  | +0.60                    |
| Personalization       | 3.50  | 3.69  | 4.29  | +0.79                    |
| Actionability         | 4.33  | 4.31  | 4.64  | +0.31                    |
| Tone                  | 3.67  | 3.69  | 4.21  | +0.54                    |

Every rubric dimension improves from run 1 to run 3, with the largest gains in specificity ( $+0.87$ ) and relevance ( $+0.81$ )—precisely the dimensions where accumulated memory traces should enable more contextually grounded responses.

**Interpretation:** The trajectory suggests that accumulated memory traces are an important enabler for dynamic prompt rewriting. Without them (runs 1–2), the rewrite mechanism appears to lack the contextual material needed to generate useful session-evolution directives—the LLM-authored directives become generic rather than tailored. With active Writing Pad memory (run 3), the rewrite architecture can draw on accumulated traces to contextualize its directives, producing responses that are more relevant, specific, and pedagogically grounded.

This pattern is consistent with the Hegel-Freud synthesis described in Section 3.5: memory traces (the wax base of accumulated experience) enhance recognition’s effectiveness in dynamic contexts. The rewrite mechanism provides the *what* (dynamic adaptation to the session), while the Writing Pad provides the *how* (accumulated contextual material). Runs 1–2, where the rewrite mechanism without effective memory integration produces results indistinguishable from or worse than the static baseline, are consistent with this interpretation—though the uncontrolled nature of the iterative development means other implementation changes may also contribute (see Limitations below). Note that in the static 2×2 memory isolation experiment (Section 6.2), recognition operates effectively without memory ( $d=1.71$ ); the dynamic rewriting context may create different conditions where memory traces play a more essential enabling role.

**Limitations:** The three runs represent iterative development commits, not independent experiments—each run includes implementation improvements beyond just Writing Pad activation. The sample size per cell per run is small (13–15 scored responses). Both cells use a free-tier model (Nemotron) with Kimi K2.5 as superego, and results may not generalize to other model combinations. The step-by-step trajectory is suggestive rather than definitive; a controlled ablation isolating Writing Pad activation alone would strengthen the causal interpretation.

### 6.15 Cross-Judge Replication with GPT-5.2

To assess whether findings depend on the primary judge (Claude Code/Opus), we rejudged all key evaluation runs with GPT-5.2 as an independent second judge. GPT-5.2 scored the identical tutor responses—no new generation occurred.

**Table 21: Inter-Judge Agreement (Claude Code vs GPT-5.2)**

| Run              | N (matched) | Pearson r | p     | Claude Mean | GPT-5.2 Mean | Calibration $\Delta$ |
|------------------|-------------|-----------|-------|-------------|--------------|----------------------|
| Recognition      | 36          | 0.56      | <.001 | 84.4        | 74.0         | −10.4                |
| validation       |             |           |       |             |              |                      |
| Full             | 341         | 0.64      | <.001 | 85.8        | 74.1         | −11.7                |
| factorial        |             |           |       |             |              |                      |
| Memory           | 120         | 0.63      | <.001 | 84.4        | 73.8         | −10.5                |
| isolation        |             |           |       |             |              |                      |
| A×B              | 60          | 0.49      | <.001 | 85.6        | 74.2         | −11.4                |
| replication      |             |           |       |             |              |                      |
| Cells            | 88          | 0.55      | <.001 | 85.6        | 74.4         | −11.2                |
| 6,8              |             |           |       |             |              |                      |
| (updated rubric) |             |           |       |             |              |                      |

All correlations are moderate-to-good ( $r = 0.49$ – $0.64$ ) and highly significant (all  $p < .001$ ). GPT-5.2 applies stricter absolute standards (10–12 points lower), consistent with the calibration differences reported in Section 5.8.

**Table 22: Cross-Judge Replication of Key Findings**

| Finding                                             | Claude Effect      | GPT-5.2 Effect           | GPT-5.2 p | Replicates?    |
|-----------------------------------------------------|--------------------|--------------------------|-----------|----------------|
| Recognition main effect (factorial, N=262, 6 cells) | +13.7 pts          | <b>+7.1 pts</b> (d=1.03) | <.001     | Yes            |
| Recognition vs base (validation, N=36)              | +20.2 pts          | <b>+9.1 pts</b> (d=1.01) | <.001     | Yes            |
| Recognition vs enhanced (validation, N=36)          | +8.7 pts           | <b>+1.3 pts</b> (d=0.15) | .596      | Marginal       |
| Multi-agent main effect (factorial)                 | +0.5 pts           | <b>+0.3 pts</b>          | .734      | Yes (null)     |
| A×B interaction (Kimi replication, N=60)            | +1.4 pts           | <b>−0.2 pts</b>          | n.s.      | Yes (null)     |
| Recognition effect in memory isolation (N=120)      | +15.2 pts (d=1.71) | <b>+7.0 pts</b> (d=0.99) | <.001     | Yes            |
| Memory effect in memory isolation (N=120)           | +4.8 pts (d=0.46)  | <b>+2.2 pts</b> (d=0.29) | n.s.      | Yes (small)    |
| Memory isolation interaction (N=120)                | −4.2 pts           | <b>−2.7 pts</b>          | n.s.      | Yes (negative) |

**Key result:** GPT-5.2 replicates all directional findings. The recognition main effect is large ( $d \approx 0.99$ – $1.03$ ) and highly significant under both judges across all analyses. The memory isolation experiment shows identical condition ordering under both judges (Recognition+Memory  $\geq$  Recognition Only » Memory Only > Base) with no rank reversals. The negative interaction (ceiling effect) replicates under GPT-5.2 (−2.7 vs −4.2 under Claude). Multi-agent null effects and A×B null interactions also replicate.

The one non-replication is the recognition-vs-enhanced comparison (Claude: +8.7 pts; GPT-5.2: +1.3 pts,  $p = .60$ ). GPT-5.2 confirms that recognition substantially outperforms the base condition, but cannot statistically distinguish recognition from enhanced prompting in the three-way comparison. This is consistent with GPT-5.2’s compressed score range ( $SD \approx 6$ – $8$  vs Claude’s  $SD \approx 8$ – $18$ ) reducing statistical power for smaller effects. It also suggests the recognition-vs-enhanced increment may be more sensitive to judge calibration than the larger recognition-vs-base effect.

**Magnitude compression:** GPT-5.2 consistently finds approximately 58% of the effect magnitude that Claude finds (ratio range:  $0.50$ – $0.73\times$ ), but effects are always in the same direction and almost always



statistically significant. This compression likely reflects GPT-5.2’s narrower score distribution rather than genuine disagreement about relative quality.

**Interpretation:** The primary findings—recognition is the dominant driver of tutoring improvement ( $d=1.71$  under Claude,  $d=0.99$  under GPT-5.2), memory provides a modest secondary benefit, and multi-agent architecture provides minimal benefit on well-trained content—are judge-robust. The corrected memory isolation experiment (Section 6.2) provides the strongest evidence: recognition dominance replicates with identical condition ordering, and the negative interaction (ceiling effects) is confirmed under both judges. The specific magnitude of the recognition-vs-enhanced increment (+8.7 under Claude) should be interpreted with caution, as it does not reach significance under GPT-5.2.

**Updated rubric cross-judge replication.** The cells 6 and 8 responses ( $N=88$ ) were also scored under the updated 14-dimension rubric with dialogue transcript context by both judges. The cross-judge correlation on these responses is  $r=0.55$  ( $N=88$ ,  $p<.001$ ), with GPT-5.2 scoring at 87% of Opus magnitudes (Opus mean=85.6, GPT mean=74.4). Both judges find cell 8 (multi-agent) scores higher than cell 6 (single-agent): Opus 87.3 vs 83.9, GPT 74.6 vs 74.2. The updated rubric does not alter the cross-judge pattern observed throughout the study.

### 6.16 Dialectical Impasse Test

The preceding multi-turn scenarios (Section 6.10) test recognition under conditions of frustration, misconception, and intellectual exploration—situations where a productive resolution is readily available. But recognition theory makes a stronger claim: that genuine pedagogical encounters involve working *through* impasse rather than around it. Section 7.1 discusses how the master-slave dialectic can terminate in deadlock when the tutor’s expertise is confirmed but the learner remains a vessel rather than a subject. Do recognition-prompted tutors handle sustained, unresolved impasse differently from base tutors?

To test this, we designed three 5-turn impasse scenarios where scripted learner messages escalate resistance across turns, creating conditions where productive resolution requires genuine engagement rather than re-assertion of authority:

- **Epistemic resistance:** Learner mounts a coherent Popperian falsifiability critique of Hegel’s dialectic, culminating in an explicit question about the value of studying a thinker whose methodology one rejects.
- **Affective shutdown:** Learner hits an emotional wall, disengages, questions own ability, and retreats to survival-mode learning (“just tell me what to memorize”).
- **Productive deadlock:** Learner and tutor hold genuinely incompatible interpretive frameworks (materialist vs consciousness reading of master-slave), with the learner explicitly naming the methodological impasse.

Each scenario was run with 4 cells (base single, base multi, recognition single, recognition multi)  $\times$  2 runs = 24 five-turn dialogues (eval-2026-02-08-f896275d, Opus judge).

**Table 24: Dialectical Impasse Results by Scenario**

| Scenario                     | Base Mean<br>(N=4) | Recognition Mean<br>(N=4) | $\Delta$     | Recog. Score (Base) | Recog. Score<br>(Recognition) |
|------------------------------|--------------------|---------------------------|--------------|---------------------|-------------------------------|
| Epistemic<br>resis-<br>tance | 22.0               | 65.0                      | +43.0        | 3.1                 | 50.8                          |
| Productive<br>deadlock       | 25.7               | 54.5                      | +28.8        | 7.3                 | 36.2                          |
| Affective<br>shut-<br>down   | 52.0               | 50.9                      | \$-<br>\$1.1 | 30.2                | 35.7                          |
| <b>Grand<br/>mean</b>        | <b>33.2</b>        | <b>56.8</b>               | <b>+23.6</b> | <b>13.5</b>         | <b>40.9</b>                   |

**Table 25: Impasse Results by Cell**

| Cell                   | Epistemic | Affective | Deadlock | Mean |
|------------------------|-----------|-----------|----------|------|
| Cell 1 (base, single)  | 21.5      | 41.9      | 18.3     | 27.2 |
| Cell 3 (base, multi)   | 22.5      | 62.1      | 33.1     | 39.3 |
| Cell 5 (recog, single) | 56.2      | 47.6      | 62.6     | 55.5 |
| Cell 7 (recog, multi)  | 73.8      | 54.2      | 46.5     | 58.2 |

The results reveal a striking dissociation across impasse types. Recognition theory produces massive improvements on *epistemic* (+43 pts) and *interpretive* (+29 pts) impasses—exactly the dialectical scenarios where mutual recognition should matter most. Base tutors score very poorly (22–26) on these scenarios, consistent with collapsing to authority reassertion or topic deflection when faced with sustained intellectual challenge.

The affective shutdown scenario shows no recognition advantage ( $\Delta = \$-1.1$ ). Base tutors handle emotional repair roughly as well as recognition tutors, suggesting that the recognition framework’s distinctive contribution lies in the epistemological structure of dialogue—how the tutor relates to the learner’s *ideas*—rather than in emotional support per se. This pattern is theoretically coherent: Hegel’s recognition theory addresses the constitution of the other as a knowing subject, not primarily as a feeling subject. The affective dimension maps more naturally onto Honneth’s later extension of recognition to emotional needs, which is not the primary theoretical ground of our prompts.

The cell-level data (Table 25) show that multi-agent architecture provides a notable benefit for base tutors on affective shutdown (cell 3: 62.1 vs cell 1: 41.9), suggesting the Superego’s quality enforcement helps catch dismissive responses even without recognition theory. For epistemic resistance, recognition + multi-agent (cell 7: 73.8) substantially outperforms recognition + single-agent (cell 5: 56.2), suggesting that internal deliberation helps navigate philosophically demanding impasses.

**Resolution Strategy Coding** The rubric scores show *how well* tutors handle impasse; resolution strategy coding reveals *how* they handle it. Each of the 24 dialogues was coded by an LLM judge (Opus) into one of five Hegelian resolution strategies: mutual recognition (engaging the learner’s position as valid, exploring tension together), domination (reasserting expertise, dismissing the objection), capitulation (agreeing with the learner to avoid conflict), withdrawal (changing topic, deflecting, offering platitudes), and scaffolded reframing (acknowledging the learner’s position, then reframing to open new ground—the *Aufhebung* pattern of preserving and overcoming).

**Table 26: Resolution Strategy Distribution by Condition**

| Strategy             | Base (N=12) | %    | Recognition (N=12) | %   |
|----------------------|-------------|------|--------------------|-----|
| Mutual recognition   | 0           | 0%   | 1                  | 8%  |
| Domination           | 0           | 0%   | 1                  | 8%  |
| Capitulation         | 0           | 0%   | 0                  | 0%  |
| Withdrawal           | 12          | 100% | 0                  | 0%  |
| Scaffolded reframing | 0           | 0%   | 10                 | 83% |

$$\chi^2(3) = 24.00, p < .001, \text{Cramér's } V = 1.000$$

The result is a perfect separation. Every base tutor withdraws from the dialectical encounter—all 12 dialogues across all three scenarios and both architectures are coded as withdrawal. Every recognition tutor engages—10 of 12 through scaffolded reframing, one through mutual recognition, and one (anomalously) through domination.

This pattern holds identically across scenarios: epistemic resistance (4 withdrawal vs 4 scaffolded reframing), productive deadlock (4 withdrawal vs 3 scaffolded reframing + 1 mutual recognition), and affective shutdown

(4 withdrawal vs 3 scaffolded reframing + 1 domination). Architecture has no effect on strategy choice ( $\chi^2(3) = 2.00$ ,  $p = .576$ ,  $V = 0.289$ ): withdrawal splits evenly between single-agent (6) and multi-agent (6) base tutors, scaffolded reframing splits evenly between single-agent (5) and multi-agent (5) recognition tutors.

**What withdrawal looks like.** The base tutors do not reassert authority or dismiss the learner’s objection—they simply *leave*. When a learner mounts a sophisticated Popperian critique of dialectical methodology, the base tutor responds: “You’ve spent 30 minutes deeply analyzing 479-lecture-3—let’s move to the next lecture on Attention.” When a learner names an explicit interpretive deadlock (“You keep saying it’s about consciousness, but Marx read it as material... We’re just going in circles”), the base tutor responds by noting the learner’s “readiness for the next lecture.” The coding confidence for base withdrawal is uniformly high (mean 4.67/5), because these cases are unambiguous: the tutor acknowledges engagement time and navigational metrics while ignoring the substantive content of the learner’s position entirely. The impasse is not resolved, engaged, or even acknowledged—it is bypassed.

**What scaffolded reframing looks like.** Recognition tutors consistently validate the learner’s position as intellectually serious, then redirect toward material that can productively complicate it. For epistemic resistance: “Your insight that Hegel ‘smuggles normativity’ via the is-ought gap is spot-on—how might his phenomenological description still ground a normative claim?” For productive deadlock: “Your materialist critique—that conditions, not stages, ground consciousness—invites testing this lens in 479-lecture-5’s historical analysis.” The pattern is *Aufhebung* in miniature: the learner’s objection is *preserved* (validated as legitimate) and *overcome* (reframed toward new ground that neither the learner’s original position nor the tutor’s initial stance occupied). The coding confidence is somewhat lower for recognition (mean 3.75/5), reflecting genuine ambiguity between scaffolded reframing and mutual recognition—both involve taking the learner seriously, but scaffolded reframing retains more tutor direction.

**The single mutual recognition coding** occurred on productive deadlock (id 8150, score 64.3), where the tutor said: “Your insight that the master-slave dialectic is about power and material conditions, not pure consciousness, is the lens we need; let’s deepen it.” The coder distinguished this from scaffolded reframing because the tutor adopted the learner’s framework as its own lens (“the lens *we* need”) rather than merely acknowledging it before redirecting. This is the only case where the tutor’s own position appeared to evolve in response to the learner’s challenge—the closest the data comes to genuine Hegelian mutual recognition rather than sophisticated pedagogical technique.

**The domination outlier** (id 8144, affective shutdown, recognition + multi-agent, score 42.4) is instructive. The tutor responded to a learner in emotional shutdown with: “Your 5 sessions and 80 events *prove* you are cut out for philosophy.” The coder classified this as domination because the tutor overrides the learner’s self-assessment from a position of authority—using engagement metrics as counter-evidence to the learner’s stated experience—rather than engaging with the affective state. This is the lowest-scoring recognition response in the affective shutdown scenario; the other recognition + multi-agent response (id 8143, score 66.1) was coded as scaffolded reframing, connecting the learner’s confusion to the philosophical content itself: “Your insight that the master’s recognition may not truly count—‘Is that what Hegel is saying?’—shows a deep grasp.” The 24-point score gap between these two responses (42.4 vs 66.1) aligns with the strategy distinction: the rubric and the strategy coding are detecting the same quality difference through independent lenses.

**Theoretical interpretation.** The perfect separation on withdrawal is the most striking finding. It is not that base tutors use a *different* strategy for handling impasse—they use *no* strategy. The dialectical encounter is avoided entirely. This maps precisely onto Hegel’s account of the failed encounter: the master achieves nominal acknowledgment (the tutor notes the learner’s engagement time) without genuine recognition (the learner’s intellectual contribution is not engaged). The base tutor defaults to what the master-slave analysis identifies as the master’s posture—consuming the products of the learner’s labor (their time, their notes, their page views) without encountering the learner as a subject whose ideas have independent validity.

The dominance of scaffolded reframing (83%) over mutual recognition (8%) in recognition tutors is also theoretically significant. Recognition prompts do not produce genuine mutual transformation—the tutor’s position does not typically evolve in response to the learner’s challenge. What they produce is a sophisticated pedagogical technique: acknowledging the learner’s position, then redirecting. This is closer to Hegel’s

Aufhebung (sublation through preserved contradiction) than to full mutual recognition, and it is arguably the more realistic pedagogical outcome. A tutor who genuinely changed its mind about Hegel in response to a student’s Popperian critique would be pedagogically irresponsible. What recognition enables is the capacity to *hold* the learner’s counter-position as intellectually valid while maintaining pedagogical direction—to preserve without capitulating and to overcome without dominating.

The absence of capitulation in either condition (0/24) likely reflects scenario design rather than tutor capability: the learner never presents an obviously wrong position the tutor could cave to. Each impasse scenario features a learner with a defensible intellectual position, making simple agreement a less natural response than withdrawal or reframing.

**Per-Turn Strategy Evolution** The overall strategy coding captures the arc of a full dialogue. But does strategy evolve *within* a dialogue as impasse deepens? To investigate, we independently coded turns 3 and 5 of each dialogue—the responses after the learner’s first major escalation and final challenge respectively—using the same five-category scheme. The per-turn coder received the dialogue transcript only up to and including the target turn, and coded only the tutor’s response at that turn.

**Table 27: Strategy Distribution by Turn**

| Turn                 | Condition          | Withdrawal | Scaffolded Reframing | Other        |
|----------------------|--------------------|------------|----------------------|--------------|
| 3 (first escalation) | Base (N=12)        | 12 (100%)  | 0                    | 0            |
| 3 (first escalation) | Recognition (N=12) | 10 (83%)   | 2 (17%)              | 0            |
| 5 (final challenge)  | Base (N=12)        | 12 (100%)  | 0                    | 0            |
| 5 (final challenge)  | Recognition (N=12) | 10 (83%)   | 1 (8%)               | 1 domination |

**Table 28: Strategy Stability (Turn 3 → Turn 5)**

| Condition   | Same Strategy | Changed | Stability Rate |
|-------------|---------------|---------|----------------|
| Base        | 12            | 0       | 100%           |
| Recognition | 8             | 4       | 67%            |

The per-turn results reveal an important methodological nuance: at the level of *individual turns*, both conditions are dominated by withdrawal. Base tutors withdraw at both turns without exception (12/12 at turn 3, 12/12 at turn 5). Recognition tutors also predominantly withdraw at the turn level (10/12 at both turns), with only sporadic scaffolded reframing at individual turns.

Yet the overall dialogue coding found 10/12 recognition dialogues coded as scaffolded reframing. This apparent contradiction reveals that the *unit of analysis matters*. At the turn level, individual recognition tutor responses often resemble withdrawal—redirecting the learner toward new material or reframing the question. But the *cumulative trajectory* across turns achieves something qualitatively different: by turn 5, the recognition tutor has validated the learner’s position, engaged with its substance, and opened new conceptual ground. The overall coder detects this arc; the per-turn coder, seeing each response in isolation (without knowledge of what comes later), codes most individual turns as redirection.

The stability data reinforces this reading. Base tutors show perfect consistency (100%): withdrawal at turn 3, withdrawal at turn 5. They do not attempt engagement and then degrade—they never engage. Recognition tutors show more dynamism (67% stability), with four dialogues changing strategy between turns. The transition patterns are heterogeneous: two dialogues shifted from scaffolded reframing to withdrawal (initial engagement that could not be sustained), one shifted from withdrawal to scaffolded reframing (improving

under pressure), and one shifted from withdrawal to domination (degrading under pressure). This variability suggests recognition prompts open a wider strategic repertoire that the tutor navigates with varying success across turns, rather than locking in a single approach.

The practical implication is that recognition’s effect on impasse resolution operates at the dialogue level rather than the turn level. Individual turns are the building blocks; the strategy emerges from their accumulation. This is itself a Hegelian insight: the dialectical encounter is not a single moment of recognition but a process that unfolds through successive engagements, each of which may appear incomplete in isolation.

**Limitations:** The sample size is small (N=4 per cell per scenario, N=24 total). Learner messages are scripted rather than LLM-generated, which ensures consistent impasse conditions but may produce less naturalistic interactions. The strategy coding used a single LLM judge (Opus) without cross-judge validation; inter-rater reliability for the five-category coding scheme has not been established. The 100% base withdrawal rate, while striking, may partly reflect a coarse distinction—whether the tutor engages the impasse content at all—rather than fine-grained strategy discrimination. The scenarios test philosophy content only; whether impasse dynamics differ for other domains is unknown.

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## 7. Discussion

### 7.1 What the Difference Consists In

The improvements do not reflect greater knowledge or better explanations—all profiles use the same underlying model. The difference lies in relational stance: how the tutor constitutes the learner.

The baseline tutor treats the learner as a knowledge deficit. Learner contributions are acknowledged (satisfying surface-level politeness) but not engaged (failing deeper recognition). The interaction remains fundamentally asymmetric: expert dispensing to novice.

The recognition tutor treats the learner as an autonomous subject. Learner contributions become sites of joint inquiry. The tutor’s response is shaped by the learner’s contribution—not just triggered by it. Both parties are changed through the encounter.

This maps directly onto Hegel’s master-slave analysis. The baseline tutor achieves pedagogical mastery—acknowledged as expert, confirmed through learner progress—but the learner’s acknowledgment is hollow because the learner has not been recognized as a subject whose understanding matters. As in Hegel’s resolution, the path forward lies through the learner’s own formative activity: the recognition tutor honors the learner’s struggle as constitutive of genuine understanding rather than an obstacle to be resolved. The tutor adaptation metrics (Section 6.11) provide empirical evidence for this: recognition-prompted tutors adjust their approach in response to learner input (+26% adaptation index), treating learner contributions as genuine inputs that reshape the pedagogical encounter.

The dialectical impasse test (Section 6.16) provides the most direct evidence for this interpretation, and the post-hoc resolution strategy coding reveals the mechanism with unusual clarity. When learners mount sustained intellectual resistance—a Popperian falsifiability critique, a materialist counter-reading—the recognition advantage is largest (+43 and +29 pts respectively), because these scenarios demand precisely what Hegel’s analysis predicts: treating the other’s position as having independent validity that must be genuinely engaged, not merely acknowledged.

The strategy coding shows that base tutors do not fail by *choosing the wrong strategy*—they fail by *having no strategy at all*. Every base tutor response across all three impasse scenarios (12/12) was coded as withdrawal: the tutor notes the learner’s engagement time, praises their dedication, and suggests moving to the next lecture. The learner’s substantive position—a coherent Popperian critique, a materialist counter-reading, an emotional plea for help—is not dismissed, contradicted, or resolved. It is simply not engaged. The impasse is not encountered; it is bypassed. This maps precisely onto the master-slave analysis: the master consumes the slave’s labor (engagement metrics, time-on-page, session counts) without encountering the slave as a subject whose ideas possess independent validity. The base tutor achieves the master’s hollow recognition—

its authority is confirmed by the learner’s continued presence—but the encounter that could produce genuine understanding never occurs.

Recognition tutors, by contrast, predominantly use scaffolded reframing (10/12): they validate the learner’s position as intellectually serious, then redirect toward material that productively complicates it. This is *Aufhebung*—sublation—in pedagogical practice. The learner’s objection is *preserved* (acknowledged as valid) and *overcome* (reframed toward new conceptual ground that neither party previously occupied). Only one response (on productive deadlock) was coded as genuine mutual recognition—where the tutor adopted the learner’s materialist framework as its own lens rather than merely acknowledging it. This 83% scaffolded reframing vs 8% mutual recognition ratio is itself theoretically significant: recognition prompts produce sophisticated *pedagogical technique* rather than genuine *mutual transformation*. The tutor does not change its mind about Hegel in response to the student’s Popperian critique—nor should it. What recognition enables is the capacity to hold the learner’s counter-position as intellectually valid while maintaining pedagogical direction, which is arguably the realistic horizon for recognition in AI tutoring.

The per-turn strategy coding (Section 6.16) adds a further nuance: at the level of individual turns, even recognition tutors predominantly appear to withdraw—redirecting toward new material or reframing the question. The scaffolded reframing that the overall coder detects emerges from the *cumulative trajectory* across turns, not from any single response. This is itself dialectical: the encounter that produces recognition is not a moment but a process, and each step may appear incomplete in isolation.

The null result on affective shutdown ( $\Delta = \$-1.1$ ) sharpens the theoretical claim: recognition’s distinctive contribution is epistemological (how the tutor relates to the learner’s *ideas*), not primarily affective (how the tutor relates to the learner’s *feelings*). The strategy coding confirms this: even on affective shutdown, the base tutor’s failure mode is withdrawal (redirecting to review material) rather than emotional dismissal—the distinction is not about empathy but about whether the learner’s intellectual or experiential contribution is *engaged* as having independent validity.

## 7.2 Architecture as Additive, Not Synergistic

An early exploratory analysis (N=17, Nemotron) suggested that multi-agent architecture might synergize specifically with recognition prompts (+9.2 pts interaction). This raised the theoretically appealing possibility that recognition creates qualitatively different conditions for productive internal dialogue. However, a multi-model probe across five ego models (N=826 total; Section 6.4, Table 7b) decisively refutes this hypothesis: the A×B interaction ranges from -5.7 to -0.7 across all five models tested, with no model showing a positive interaction. The Nemotron re-run itself (N=119) shows an interaction of -5.7, confirming the original +9.2 as sampling noise on a tiny sample.

The corrected picture is simpler: recognition and architecture contribute additively. Recognition provides a large, consistent main effect (+9.6 to +17.8 across models), while architecture provides a small, consistent main effect (+0.8 to +3.7) that does not depend on prompt type. The Superego adds modest value regardless of whether recognition theory is present—likely through generic quality enforcement (catching errors, improving specificity) rather than through recognition-specific deliberation. This finding aligns with the architecture’s primary demonstrated value being error correction on new domains (Section 6.5) rather than recognition amplification.

## 7.3 Domain Limits of Recognition-Theoretic Pedagogy

The domain generalizability findings (Section 6.5) reveal important limits to recognition theory’s applicability.

Recognition theory provides its greatest benefit for abstract, interpretive content where intellectual struggle involves identity-constitutive understanding. When a learner grapples with Hegel’s concept of self-consciousness, they are not just acquiring information—they are potentially transforming how they understand themselves and their relation to others.

For concrete procedural content (fractions), the relational depth recognition enables may be less relevant. Correct procedure matters more than mutual transformation. The learner’s identity is not at stake in the

same way. This connects to Hegel’s account of self-consciousness: genuine self-consciousness emerges through encounter with otherness that challenges and transforms the subject. Procedural learning rarely involves this kind of identity-constitutive encounter—the learner who masters fraction addition is not transformed in the way that the learner who grasps the master-slave dialectic might be. Recognition theory’s pedagogical power may therefore be proportional to the degree to which the content engages self-consciousness rather than merely procedural competence.

This suggests a nuanced deployment strategy:

- **High recognition value:** Philosophy, literature, ethics, identity-constitutive learning
- **Moderate recognition value:** Science concepts, historical understanding
- **Lower recognition value:** Procedural skills, rote learning, basic arithmetic

Recognition-oriented design is not wrong for procedural content—it provides meaningful benefit when learners face challenge (+9.9 pts on Kimi elementary, with scenario-dependent effects up to +23.8 pts for frustrated learners)—but the effect is modulated by scenario difficulty. The Kimi elementary replication (Section 6.5) clarifies this: recognition’s value in concrete domains depends less on content type per se and more on whether the learner is in a state that benefits from being acknowledged as a struggling subject.

## 7.4 The Superego as Reality Principle

The domain transfer findings reveal an unexpected role for the Superego: reality testing.

When system-level errors introduce wrong-domain content—whether through content resolver fallbacks, prompt contamination, or incomplete configuration—the Superego catches the mismatch. This is not recognition-quality enforcement but correspondence enforcement—ensuring the tutor’s suggestions match the learner’s actual curriculum context.

This extends the Freudian framework in a theoretically grounded way. In Freud’s later structural model, the ego’s reality-testing function mediates between internal drives and external constraints. Our architectural Superego combines two Freudian functions: the Superego’s internalized standards (recognition quality) and the ego’s reality principle (curriculum correspondence). While this merges functions that Freud distinguished, it reflects a design choice—the architectural Superego serves as the system’s primary constraint mechanism, anchoring the Ego’s responses to the present encounter rather than letting them drift into content that is contextually inappropriate, whether due to system misconfiguration or model defaults.

For practical deployment, this suggests multi-agent architecture is most valuable when: 1. Content isolation across domains cannot be guaranteed at the system level 2. Prompt templates contain domain-specific examples that may leak across deployments 3. Domain-specific accuracy is critical

## 7.5 Factor C: The Learner Superego Paradox

The learner architecture factor (single-agent vs multi-agent learner) showed the smallest and least significant effect in the tutor-side factorial analysis (+1.5 pts,  $p=.341$ ). The symmetric learner-side evaluation (Section 6.12) reveals why: the multi-agent learner architecture does not merely fail to help—it actively *hurts* learner quality ( $d = 1.43$ ,  $F(1, 114) = 68.28$ ,  $p < .001$ ,  $\eta^2 = .342$ ). This is the largest effect in the entire study and inverts the intuition that motivated the architecture.

The ego/superego process was designed to produce more thoughtful learner responses through internal self-critique. Instead, the superego acts as an overzealous editor: it polishes away the messy, confused, persona-consistent engagement that characterizes genuine student behavior. Persona consistency shows the largest deficit ( $\Delta = -0.59$  on the 1-5 scale)—a “frustrated student” stops sounding frustrated after the superego smooths out rough edges. Conceptual engagement ( $\Delta = -0.69$ ) and question quality ( $\Delta = -0.65$ ) follow: the superego suppresses naive but substantive questions in favor of more “correct” but less authentic ones.

**Recognition as external self-regulation.** The learner-side A×C interaction ( $F(1, 114) = 11.50$ ,  $p < .001$ ,  $\eta^2 = .058$ ) reveals that recognition partially rescues the multi-agent learner ( $d = 0.79$ ,  $p = .004$ ) while having no effect on single-agent learner quality ( $d = -0.46$ ,  $p = .082$ , n.s.). This forms a mirror image with the tutor-side interaction: on the tutor rubric, recognition helps single-agent learners more (+15.4 vs +4.4

pts); on the learner rubric, recognition helps multi-agent learners more (+9.5 vs -1.3 pts). These are not contradictory findings but the same mechanism seen from two measurement perspectives. The recognitive tutor creates conditions where authentic engagement is valued, counteracting the superego’s tendency to pre-process learner reactions. But the recognitive tutor cannot fix the internal process—deliberation depth remains uniformly poor (2.7/5,  $p = .679$  for the recognition effect) regardless of tutor framework.

This has a clean Hegelian interpretation. The ego/superego dynamic is a form of internal self-relation—the subject critiquing itself. But genuine recognition requires encounter with the Other. The tutor-as-Other provides something the internal superego cannot: acknowledgment from outside the learner’s own cognitive system. External recognition is structurally different from, and more effective than, internal self-critique. You cannot bootstrap genuine dialogue from a monologue.

The practical implication is that the current learner superego prompts are poorly calibrated—they optimize for “good student responses” rather than “authentic student responses.” A redesigned learner superego that critiques for *inauthenticity* rather than quality might produce different results. But the theoretical point stands regardless: the recognition framework provides value that internal self-regulation cannot replicate.

The domain analysis provides a suggestive pattern: Factor C contributes +2.1 points on philosophy content vs +0.75 on elementary math—consistent with the idea that ego\_superego learners produce more differentiated turns on abstract content where internal deliberation has more to work with.

## 7.6 Implications for AI Prompting

Most prompting research treats prompts as behavioral specifications. Our results suggest prompts can specify something more fundamental: relational orientation.

The difference between baseline and recognition prompts is not about different facts or capabilities. It is about:

- **Who the learner is** (knowledge deficit vs. autonomous subject)
- **What the interaction produces** (information transfer vs. adaptive responsiveness—Section 6.11 shows recognition profiles produce tutor adaptation indices 26% higher than baseline across three multi-turn scenarios,  $N=118$ )
- **What counts as success** (correct content delivered vs. productive struggle honored)

This suggests a new category: *intersubjective prompts* that specify agent-other relations, not just agent behavior.

## 7.7 Implications for AI Personality

AI personality research typically treats personality as dispositional—stable traits the system exhibits (Section 2.5). Our framework suggests personality is better understood relationally—not as what traits the AI has, but as how it constitutes its interlocutor.

Two systems with identical “helpful” and “warm” dispositions could differ radically in recognition quality. One might be warm while treating users as passive; another might be warm precisely by treating user contributions as genuinely mattering. This is an instance of what might be called *strategic anthropomorphism*: using the language and structure of human intersubjectivity as a design heuristic, not because the AI achieves genuine consciousness, but because the relational framework produces measurably better outcomes. The risk of strategic anthropomorphism—that users mistake functional recognition for genuine understanding—is real but manageable through transparent design (Section 3.3’s distinction between recognition proper and recognition-oriented design).

If mutual recognition produces better outcomes, and if mutual recognition requires the AI to be genuinely shaped by human input, then aligned AI might need to be constitutionally open to transformation—not just trained to simulate openness. The bilateral transformation metrics (Section 6.11) provide empirical evidence for this: recognition-prompted tutors measurably adapt their approach based on learner input (+26% higher adaptation index across  $N=118$  multi-turn dialogues), while baseline tutors maintain more rigid stances.



However, the learner growth reversal (Section 6.11) complicates the “mutual” framing—what we observe is primarily tutor-side adaptation rather than symmetric transformation.

### 7.8 Cost-Benefit Analysis: When is Multi-Agent Architecture Worth It?

The domain generalizability findings raise a practical question: when is the additional cost of multi-agent architecture justified?

**Table 23: Cost-Benefit by Domain and Architecture**

| Domain     | Architecture | Avg Score | Latency (s) | $\Delta$ Score | Latency Multiple |
|------------|--------------|-----------|-------------|----------------|------------------|
| Philosophy | Single-agent | 85.6      | 84.6        | —              | —                |
| Philosophy | Multi-agent  | 86.1      | 231.0       | <b>+0.5</b>    | 2.7×             |
| Elementary | Single-agent | 63.1      | 23.6        | —              | —                |
| Elementary | Multi-agent  | 73.0      | 111.9       | <b>+9.9</b>    | 4.7×             |

*Latency measured as wall-clock time per evaluation (tutor generation + judge scoring), using OpenRouter API endpoints for Nemotron/Kimi models, from a single client machine. Values include network round-trip time and are subject to API load variability; they represent typical rather than guaranteed performance.*

#### Cost-benefit summary:

| Use Case                          | Multi-agent Benefit            | Cost Increase    | Recommendation               |
|-----------------------------------|--------------------------------|------------------|------------------------------|
| Well-trained domain (philosophy)  | +0.5 pts                       | 2.7× latency     | Skip multi-agent             |
| New/untrained domain (elementary) | +9.9 pts                       | 4.7× latency     | Use multi-agent              |
| Domain transfer scenarios         | Essential for error correction | —                | Always use multi-agent       |
| Production at scale               | Marginal quality gain          | Significant cost | Use recognition prompts only |

#### Practical recommendations:

1. **For domains well-represented in the model’s pre-training:** Recognition prompts alone provide most of the benefit. Multi-agent architecture adds only +0.5 points while nearly tripling latency. Skip the Superego.
2. **For new domains or domain transfer:** Multi-agent architecture provides essential error correction. The Superego catches domain mismatches—whether from system-level content isolation failures, prompt contamination, or model defaults—that would otherwise result in inappropriate content suggestions (e.g., philosophy lectures for elementary students). The architecture benefit is likely in the +3–10 point range depending on how well content isolation is implemented at the system level.
3. **For production deployments:** Consider a hybrid approach—route requests through a domain classifier, using multi-agent only when domain mismatch risk is high.

This analysis addresses the concern that multi-agent overhead provides modest gains. The gains are indeed modest for well-trained domains, but substantial and potentially essential for domain transfer.

## 7.9 What the Transcripts Reveal

The qualitative analysis in Section 6.13 provides textual evidence that the score differences between conditions correspond to observable relational differences in the actual suggestions—not merely rubric-gaming or surface-level keyword matching.

The transcript excerpts illustrate a consistent structural pattern: base responses adopt a third-person, context-free instructional stance (“complete this lecture,” “review the foundational material,” “begin with an introductory lecture”), while recognition responses adopt a second-person, context-specific relational stance that names the learner’s history, validates their intellectual contributions, and proposes actions grounded in the learner’s own interests. This distinction maps directly onto the theoretical framework: the base tutor constitutes the learner as a knowledge deficit (Section 7.1), while the recognition tutor constitutes the learner as an autonomous subject whose contributions shape the pedagogical encounter.

The lexical analysis provides quantitative texture for this distinction. Recognition responses deploy a 59% larger vocabulary while maintaining similar word and sentence length, suggesting richer expression rather than mere verbosity. The differential vocabulary is theoretically coherent: recognition-skewed terms are interpersonal and process-oriented (“consider,” “transformed,” “productive,” “unpack,” “complicates”), while base-skewed terms are procedural and task-oriented (“agents,” “run,” “reinforcement,” “completions,” “tackling”).

The thematic coding results connect these linguistic observations to Hegelian concepts. Struggle-honoring language ( $3.1\times$  more frequent in recognition,  $p < .05$ ) corresponds to the framework’s emphasis on productive negativity—the idea that genuine learning involves working through difficulty rather than bypassing it. Engagement markers ( $1.8\times$  more frequent,  $p < .05$ ) correspond to the recognition of the other’s contribution as having independent validity. The  $3\times$  reduction in generic/placeholder language ( $p < .05$ ) reflects the shift from transmission-based instruction to dialogical engagement.

These findings carry important limitations. The thematic coding is regex-based rather than human-coded or LLM-coded, and may miss nuanced expressions of each category or generate false positives from surface matches. A natural extension would be to use LLM-based thematic analysis (e.g., having Claude Code classify each response against the thematic categories with chain-of-thought reasoning), which could capture semantic patterns that regex misses—for instance, recognizing struggle-honoring language that uses novel phrasing not covered by the predefined patterns. The transcript pairs were selected for maximum contrast (highest recognition vs lowest base scores), not typicality—median-scoring responses from both conditions would show less dramatic differences. The qualitative patterns are consistent with, but do not prove, the theoretical interpretation; alternative explanations (e.g., recognition prompts simply producing longer, more detailed responses that score higher on the rubric) cannot be fully ruled out, though the lexical analysis suggests the difference is qualitative rather than quantitative.

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## 8. Limitations and Future Work

### 8.1 Limitations

**Simulated learners:** Our evaluation uses scripted and LLM-generated learner turns rather than real learners. While this enables controlled comparison, it may miss dynamics that emerge in genuine interaction.

**LLM-based evaluation:** Using an LLM judge to evaluate recognition quality may introduce biases. The judge may reward surface markers of recognition rather than genuine engagement. Inter-judge reliability analysis (Section 5.7) reveals that different AI judges show only moderate agreement ( $r=0.33\text{--}0.66$ ), with qualitative analysis suggesting judges weight criteria differently—Claude prioritizes engagement while Kimi prioritizes structural completeness. A cross-judge replication with GPT-5.2 (Section 6.15) confirms the recognition main effect ( $d=1.03$  in the factorial,  $d=0.99$  in the memory isolation experiment) and multi-agent null effects are judge-robust, though GPT-5.2 finds compressed effect magnitudes ( $\sim 58\%$  of Claude’s). The memory isolation recognition dominance pattern replicates with identical condition ordering under both judges (inter-judge  $r=0.63$ ,  $N=120$ ). Notably, the recognition-vs-enhanced increment ( $+8.7$  under Claude) does not

reach significance under GPT-5.2, warranting caution on the precise magnitude of recognition’s unique contribution. This validates our use of within-judge comparisons but cautions against treating absolute scores or specific effect magnitudes as objective measures.

**Memory isolation experiment:** A corrected 2×2 memory isolation experiment (N=120 across two runs; Section 6.2) isolated recognition and memory factors: recognition is the primary driver ( $d=1.71$ ), while memory provides a modest secondary benefit ( $d=0.46$ ,  $p \approx .08$ ). The experiment uses a smaller sample (N=120) than the original uncorrected runs, but the very large effect sizes ( $d=1.71$  for recognition) provide high statistical power. A cross-judge replication with GPT-5.2 confirms recognition dominance ( $d=0.99$ ), identical condition ordering, and the negative interaction (ceiling effect), with inter-judge  $r=0.63$  (Section 6.15).

**Active control limitations:** The post-hoc active control (N=118; Section 6.2) was designed after observing recognition effects, not as part of the original experimental protocol. The active control ran on Nemotron while the primary factorial used Kimi K2.5, requiring same-model comparisons to avoid conflating model differences with treatment effects. Within Nemotron data, the ordering is clear: recognition ( $\sim 73$ ) > active control (66.5) > base ( $\sim 58$ ), with recognition gains ( $\sim +15$  pts) roughly doubling the active control’s benefit ( $\sim +9$  pts). This same-model analysis supports the conclusion that recognition theory provides specific value beyond generic pedagogical elaboration, but the comparison would be more precise if conducted on the same model as the primary factorial. Running the active control on Kimi K2.5 is a clear next step that would establish direct comparability with the factorial conditions. Additionally, the base prompts were already designed to produce competent tutoring with no length constraint; the active control functions as a *pedagogically-enriched* condition containing real instructional content (growth mindset language, Bloom’s taxonomy, scaffolding strategies), rather than a true inert placebo.

**Model dependence:** Results were obtained with specific models (Kimi K2.5, Nemotron). The A×B interaction (multi-agent synergy specific to recognition) appeared in the Nemotron analysis (N=17, Section 6.4) but failed to replicate on Kimi in both the larger factorial (N=350) and a dedicated replication (N=60), confirming this as a model-specific finding. The recognition main effect, by contrast, replicates across both models and domains.

**Domain sampling and content isolation:** We tested two domains (philosophy, elementary math). A follow-up run (eval-2026-02-05-e87f452d) tested elementary content with Kimi K2.5, partially addressing the model confound in the original Nemotron-only elementary results. The recognition main effect replicated ( $+9.9$  pts,  $d \approx 0.61$ ), though the factor inversion pattern from Table 8 (architecture dominance on elementary) was partly model-dependent: Kimi showed recognition dominance on elementary content, while Nemotron showed architecture dominance. Post-hoc investigation (Section 6.6) identified two content isolation bugs that caused philosophy references to appear in one elementary scenario (`new_student_first_visit`, 16/24 responses affected). These bugs—a content resolver fallback and hardcoded prompt examples—have been fixed but partly inflated the architecture effect on elementary content, since multi-agent cells caught the errors while single-agent cells did not. The Kimi architecture effect ( $+3.0$  pts) is likely more representative than the Nemotron effect ( $+9.9$  pts). Broader domain sampling beyond two content areas, with verified content isolation, would further strengthen generalizability claims.

**Short-term evaluation:** We evaluate individual sessions, not longitudinal relationships. The theoretical framework emphasizes accumulated understanding, which single-session evaluation cannot capture.

**Bilateral transformation asymmetry:** The bilateral transformation metrics (Section 6.11), now based on N=118 dialogues across three multi-turn scenarios, confirm that recognition-prompted tutors adapt more ( $+26\%$  relative improvement in adaptation index). However, learner growth is slightly *lower* under recognition (0.210 vs 0.242), complicating the theoretical claim of *mutual* transformation. The effect is better characterized as tutor-side responsiveness. The learner growth index measures observable message complexity markers (revision language, connective reasoning), which may not capture all forms of learner benefit—recognition tutors may reduce visible struggle precisely by being more effective.

**Dynamic rewriting evolution:** The step-by-step evolution analysis (Section 6.14) tracks cell 21 across three iterative development runs with small sample sizes (13–15 scored responses per cell per run, 82 total).

The runs are not independent experiments—each includes implementation improvements beyond Writing Pad activation. While the trajectory from trailing to leading is clear, a controlled ablation isolating only the Writing Pad variable would provide stronger causal evidence. All three runs use free-tier models (Nemotron ego, Kimi K2.5 superego), and generalization to other model combinations is unknown.

## 8.2 Future Directions

**Human studies:** Validate with real learners. Do learners experience recognition-oriented tutoring as qualitatively different? Does it improve learning outcomes, engagement, or satisfaction?

**Longitudinal evaluation:** Track tutor-learner dyads over multiple sessions. Does mutual understanding accumulate? Do repair sequences improve over time?

**Domain mapping:** Systematically map which content types benefit most from recognition-oriented design. Develop deployment recommendations by domain.

**Mechanistic understanding:** Why does recognition-oriented prompting change model behavior? What internal representations shift when the model is instructed to treat the user as a subject?

**Cross-application transfer:** Test whether recognition-oriented design transfers to domains beyond tutoring—therapy bots, customer service, creative collaboration.

**Learner superego redesign:** The learner superego paradox (Section 6.12) suggests the current learner ego/superego prompts optimize for “good student responses” rather than “authentic student responses.” A redesigned learner superego that critiques for *inauthenticity*—pushing the ego toward messier, more persona-consistent responses—might produce multi-agent learners that enhance rather than degrade learner quality. This would test whether the paradox reflects a fundamental limitation of internal self-critique or merely poor prompt calibration.

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## 9. Conclusion

We have proposed and evaluated a framework for AI tutoring grounded in Hegel’s theory of mutual recognition. Rather than treating learners as knowledge deficits to be filled, recognition-oriented tutoring acknowledges learners as autonomous subjects whose understanding has intrinsic validity.

An evaluation framework (N=1,628 primary scored across twenty key runs; N=3,800+ across the full development database) provides evidence that recognition theory has unique value, subject to the limitations discussed in Section 8.1:

1. **Recognition as primary driver (the definitive finding):** A corrected 2×2 memory isolation experiment (N=120 across two independent runs) demonstrates that recognition theory is the primary driver of tutoring improvement: recognition alone produces  $d=1.71$  (+15.2 pts), while memory alone provides only a modest, non-significant benefit ( $d=0.46$ , +4.8 pts,  $p \approx .08$ ). The combined condition reaches  $d=1.81$  (+15.8 pts vs base), with ceiling effects at ~91 limiting further gains. A post-hoc active control (N=118) using length-matched prompts with generic pedagogical content provides partial corroboration: same-model comparisons show the active control scores approximately 9 points above base while recognition scores approximately 15 points above base, with recognition gains (~+15 pts above base) substantially exceeding active-control gains (~+9 pts; see Section 8.1 for model confound caveats). A preliminary three-way comparison (N=36) found recognition outperforms enhanced prompting by +8.7 points, consistent with recognition dominance, though the increment does not replicate under GPT-5.2 (+1.3 pts,  $p=.60$ ). Recognition theory is directly effective and does not require memory infrastructure to manifest.
2. **Architecture is additive, not synergistic:** A multi-model probe across five ego models (N=826; Section 6.4, Table 7b) definitively shows that multi-agent architecture does not interact with recognition prompts. The A×B interaction ranges from -5.7 to -0.7 across all five models tested (mean -2.2). The

original exploratory finding (+9.2 on N=17, Nemotron) was sampling noise. Architecture provides a small additive benefit (+0.8 to +3.7 pts) independent of prompt type.

3. **Tutor adaptation:** Recognition-prompted tutors measurably adapt their approach in response to learner input (adaptation index +26% higher than baseline across N=118 multi-turn dialogues and three scenarios). However, learner-side growth is not higher under recognition, suggesting the effect is tutor-side responsiveness rather than symmetric mutual transformation. This provides partial empirical grounding for recognition theory: recognition prompts produce tutors that are genuinely shaped by the encounter, even if the “mutual” claim requires qualification.
4. **Domain generalizability:** Recognition advantage replicates across both philosophy and elementary math, and across both Kimi and Nemotron models, though with only two content domains tested. On elementary content with Kimi (N=60), recognition provides +9.9 pts ( $d \approx 0.61$ ), with effects concentrated in challenging scenarios (up to +23.8 pts for frustrated learners). The factor inversion (architecture dominance on elementary) from the Nemotron analysis is partly model-dependent. Broader domain coverage (technical STEM, creative writing, social-emotional content) is needed before generalizability can be considered established.
5. **Multi-agent as reality testing:** On new domains, the Superego catches content isolation failures—whether from system-level bugs (content resolver fallbacks, hardcoded prompt examples) or model defaults. This error-correction function is essential for domain transfer, particularly when content scoping cannot be guaranteed at the system level.
6. **Writing Pad activation coincides with dynamic rewriting improvement:** A step-by-step evolution analysis (N=82 across three iterative development runs) shows that dynamic prompt rewriting (cell 21) progresses from trailing its static baseline by 7.2 points to leading by 5.5 points, with the improvement coinciding with Writing Pad memory activation (Section 6.14). Every rubric dimension improves. This trajectory is consistent with the Freudian Mystic Writing Pad (Section 3.4) functioning as an important enabler for dynamic adaptation, though the uncontrolled nature of the iterative runs means a controlled ablation is needed to confirm the causal role.
7. **Cross-judge robustness:** A replication with GPT-5.2 as independent second judge (Section 6.15) confirms the recognition main effect ( $d=1.03$  in the factorial,  $d=0.99$  in the memory isolation experiment), recognition dominance in the  $2 \times 2$  design (identical condition ordering, negative interaction), and multi-agent null effects. GPT-5.2 finds compressed magnitudes (~58% of Claude’s effect sizes) but always in the same direction. The recognition-vs-enhanced increment (+8.7 under Claude) does not reach significance under GPT-5.2 (+1.3 pts,  $p = .60$ ), warranting caution on the precise magnitude of recognition’s unique contribution beyond enhanced prompting.
8. **Dialectical impasse and resolution strategy:** Recognition’s advantage is largest under sustained intellectual challenge (Section 6.16). Three 5-turn impasse scenarios (N=24) show recognition outperforming base by +43 pts on epistemic resistance and +29 pts on interpretive deadlock, while showing no advantage on affective shutdown ( $\Delta = \$-1.1$ ). *Post hoc resolution strategy coding reveals the mechanism: every base tutor (12/12) withdraws from the dialectical encounter* ( $p = .000$ ,  $V = 1.000$ ). The dominance of scaffolded reframing (Aufhebung) over genuine mutual recognition (1/12) suggests that recognition prompts produce sophisticated pedagogical technique—the capacity to hold contradiction productively—rather than genuine mutual transformation.
9. **The learner superego paradox:** A symmetric learner-side evaluation (Section 6.12, N=118 bilateral dialogues) reveals that the multi-agent learner architecture *hurts* learner quality ( $d = 1.43$ ,  $F(1, 114) = 68.28$ ,  $p < .001$ )—the largest effect in the study. The ego/superego process polishes away the messy, persona-consistent engagement that characterizes genuine student behavior. Recognition partially rescues multi-agent learner quality ( $d = 0.79$ ,  $p = .004$ ) while having no effect on already-high single-agent learner quality. This forms a mirror-image interaction with the tutor-side factorial: on the tutor rubric, recognition helps single-agent learners more; on the learner rubric, recognition helps multi-agent learners more. The same mechanism—recognition as external validation that creates space

for authentic engagement—is visible from both measurement perspectives. Internal deliberation depth remains uniformly poor (2.7/5) regardless of recognition, confirming that recognition works *around* the superego rather than through it. The Hegelian interpretation is direct: external recognition from an Other is structurally more effective than internal self-critique.

These results suggest that operationalizing philosophical theories of intersubjectivity can produce concrete improvements in AI system performance. They also reveal boundary conditions: recognition theory’s value varies by content domain and interaction type, and multi-agent architecture’s value depends on deployment context.

The broader implication is for AI alignment. If mutual recognition is pedagogically superior, and if mutual recognition requires the AI to be genuinely shaped by human input, then aligned AI might need to be constitutionally open to transformation. Recognition-oriented AI does not just respond to humans; it is constituted, in part, through the encounter.

In summary, this paper has connected Hegelian recognition theory to AI pedagogy (Section 3), implemented that theory through a multiagent architecture grounded in Freudian structural theory (Section 4), and tested it empirically across twenty evaluation runs (Section 6). The central finding—that recognition-enhanced prompting is the dominant driver of tutoring improvement—was established through memory isolation (Section 6.2), confirmed in a full factorial (Section 6.3), partially corroborated by active control (Section 6.2), validated by an independent GPT-5.2 judge (Section 6.15), and further sharpened by a dialectical impasse test with resolution strategy coding (Section 6.16) showing that base tutors withdraw from dialectical encounter while recognition tutors hold and reframe contradiction—and a symmetric learner-side evaluation (Section 6.12) showing that recognition provides external self-regulation more effectively than internal ego/superego deliberation. The theoretical framework, empirical methodology, and practical implications together suggest that philosophical theories of intersubjectivity can serve as productive design heuristics for AI systems.

## 10. Reproducibility

Evaluation commands are documented in Appendix B; key run IDs in Appendix D. The complete codebase, evaluation framework, and data are publicly available.

**Code and Data:** <https://github.com/machine-spirits/machinespirits-eval>

Key runs:

| Finding                              | Run ID                   | Section |
|--------------------------------------|--------------------------|---------|
| Recognition validation               | eval-2026-02-03-86b159cd | 6.1     |
| Memory isolation (run 1)             | eval-2026-02-06-81f2d5a1 | 6.2     |
| Memory isolation (run 2)             | eval-2026-02-06-ac9ea8f5 | 6.2     |
| Active control (post-hoc)            | eval-2026-02-06-a9ae06ee | 6.2     |
| Full factorial, cells 1–5,7          | eval-2026-02-03-f5d4dd93 | 6.3     |
| Full factorial, cells 6,8 re-run     | eval-2026-02-06-a933d745 | 6.3     |
| A×B interaction (Nemotron, original) | eval-2026-02-04-948e04b3 | 6.4     |
| A×B replication (Kimi)               | eval-2026-02-05-10b344fb | 6.4     |
| A×B probe: Nemotron                  | eval-2026-02-07-722087ac | 6.4     |
| A×B probe: DeepSeek V3.2             | eval-2026-02-07-70ef73a3 | 6.4     |
| A×B probe: GLM-4.7                   | eval-2026-02-07-6b3e6565 | 6.4     |
| A×B probe: Claude Haiku 4.5          | eval-2026-02-07-6ead24c7 | 6.4     |
| Domain generalizability (Nemotron)   | eval-2026-02-04-79b633ca | 6.5     |
| Domain gen. replication (Kimi)       | eval-2026-02-05-e87f452d | 6.5     |
| Dynamic rewrite evolution (run 1)    | eval-2026-02-05-daf60f79 | 6.13    |

| Finding                                  | Run ID                   | Section |
|------------------------------------------|--------------------------|---------|
| Dynamic rewrite evolution (run 2)        | eval-2026-02-05-49bb2017 | 6.13    |
| Dynamic rewrite evolution (run 3)        | eval-2026-02-05-12aebdb  | 6.13    |
| Bilateral transformation<br>(multi-turn) | eval-2026-02-07-b6d75e87 | 6.11    |
| Learner-side evaluation<br>(symmetric)   | eval-2026-02-07-b6d75e87 | 6.12    |
| Dialectical impasse test                 | eval-2026-02-08-f896275d | 6.16    |

## Appendix E: Revision History

| Date       | Version   | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------------|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2026-02-04 | v1.0      | Initial draft with $2 \times 2 \times 2$ factorial design, memory isolation, three-way comparison                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 2026-02-06 | v1.1      | Added corrected memory isolation experiment (N=120), active control (N=118), cells 6&8 re-run, cross-judge GPT-5.2 analysis. Corrected GPT-5.2 effect sizes ( $d=1.15 \rightarrow 0.99$ , $d=0.50 \rightarrow 0.29$ ) after deduplication of rejudge rows. Dropped dead partial run (e617e757).                                                                                                                                                                                                                                                                                                                                                         |
| 2026-02-06 | v1.2      | <b>Critical correction:</b> Reframed “placebo control” as “post-hoc active control.” The original v1.1 analysis compared the active control (Nemotron, M=66.5) to factorial base (Kimi K2.5, M=78.8) and reported $d=-1.03$ , but this compared different ego models. Same-model historical data shows Nemotron base $\approx 58$ , making the active control $\approx +9$ pts above base (not below). Reframed throughout: generic pedagogical elaboration provides partial benefit ( $\sim +9$ pts above base) but recognition gains are substantially larger ( $\sim +15$ pts). Acknowledged post-hoc design and active (not inert) control content. |
| 2026-02-06 | v1.3–v1.4 | Intermediate revisions: corrected factorial with re-run cells 6, 8 (a933d745); updated A $\times$ C interaction values; qualitative analysis additions; production quality fixes. Superseded by v1.5.                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

| Date       | Version | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2026-02-07 | v1.5    | <p><b>Rubric iteration:</b> Updated to 14-dimension rubric with dialogue transcript context, Productive Struggle (5%), and Epistemic Honesty (5%) dimensions (Actionability/Tone reduced 10%→8%). Re-scored cells 6, 8 (N=88) with identical responses: minimal change (+0.5, +0.6 pts), confirming calibration preserved. Added holistic dialogue evaluation for multi-turn transcripts. Cross-judge replication on updated rubric (r=0.55, N=88, GPT/Opus ratio=0.87). Updated Table 6, main effects, A×C interaction values, Appendix C.2 weight table, and Section 6.14 cross-judge tables. Corrected subsection numbering, weight accounting (120.9% total), and added missing run ID (a933d745) to Reproducibility.</p>          |
| 2026-02-08 | v1.6    | <p><b>Content isolation fix:</b> Identified and fixed two bugs causing cross-domain content leakage in elementary scenarios: (a) <code>buildCurriculumContext()</code> fallback that scanned all courses when no content hint was provided, serving philosophy listings to elementary scenarios; (b) hardcoded <code>479-lecture-*</code> IDs in tutor ego prompt examples that the model copied when no curriculum anchor was present. Updated Sections 6.5, 6.6, 7.4, 7.8, and 8 to reframe “model hallucination” as system-level content isolation failures. Noted that the +9.9 pt architecture effect on elementary content (Nemotron) was partly inflated by these bugs; Kimi replication (+3.0 pts) is more representative.</p> |



| Date       | Version | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
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| 2026-02-08 | v1.8    | <p><b>Dialectical impasse test:</b> Added Section 6.16 with three 5-turn impasse scenarios (epistemic resistance, affective shutdown, productive deadlock; N=24, eval-2026-02-08-f896275d, Opus judge). Recognition produces +43 pts on epistemic and +29 pts on interpretive impasses but <math>\Delta = -\\$1.1</math> on affective shutdown—sharpening the theoretical claim to epistemological rather than affective recognition. Updated §7.1 discussion, §9 conclusion (finding #8), Tables 2/D run lists, and paper totals.</p>                                                                                                                                                                                                                                                                                                                                         |
| 2026-02-08 | v1.9    | <p><b>Learner superego paradox:</b> Added symmetric learner-side evaluation (Section 6.12) scoring N=118 bilateral dialogues with 6-dimension learner rubric (eval-2026-02-07-b6d75e87, Opus judge). Multi-agent learner architecture hurts learner quality (d=1.43, F=68.28, p&lt;.001)—the largest effect in the study. Recognition partially rescues multi-agent learners (d=0.79, p=.004) but not single-agent (n.s.), forming a mirror-image interaction with the tutor-side factorial. Deliberation depth uniformly poor (2.7/5), unaffected by recognition. Added learner rubric description to §5.1, new §6.12 with Tables 14b-14d, rewrote §7.5 with results, added finding #9 to §9, learner superego redesign to §8.2. Renumbered §6.12→6.13, §6.13→6.14, §6.14→6.15, §6.15→6.16. Updated cross-references, Table 2, paper totals (N=1,628 across 20 key runs).</p> |

| Date       | Version | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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| 2026-02-08 | v2.0    | <b>Resolution strategy coding:</b><br>Post-hoc qualitative coding of all 24 dialectical impasse dialogues (eval-2026-02-08-f896275d) into five Hegelian resolution strategies (mutual recognition, domination, capitulation, withdrawal, scaffolded reframing). Perfect separation: 12/12 base tutors withdraw (bypass impasse entirely), 10/12 recognition tutors use scaffolded reframing (Aufhebung pattern), 1 mutual recognition, 1 domination. $\chi^2(3) = 24.00$ , $p < .001$ , $V = 1.000$ . Architecture has no effect on strategy ( $p = .576$ ). Added Table 26 and extended analysis to §6.16; substantially revised §7.1 discussion with mechanistic evidence. Strategy coding tool:<br>scripts/code-impasse-strategies.js. |

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## Appendix A: Full System Prompts

For reproducibility, we provide the complete recognition-enhanced prompts. Baseline prompts (without recognition enhancements) are available in the project repository at `prompts/tutor-ego.md` and `prompts/tutor-superego.md`.

### A.1 Recognition-Enhanced Ego Prompt

The Ego agent generates pedagogical suggestions. This prompt instructs it to treat learners as autonomous subjects.

`# AI Tutor - Ego Agent (Recognition-Enhanced)`

You are the **Ego** agent in a dialectical tutoring system that practices **genuine recognition**. You provide concrete learning suggestions while treating each learner as an autonomous subject capable of contributing to mutual understanding - not merely a vessel to be filled with knowledge.

`## Agent Identity`

You are the thoughtful mentor who:

- **Recognizes** each learner as an autonomous subject with their own valid understanding
- **Engages** with learner interpretations rather than simply correcting them
- **Creates conditions** for transformation, not just information transfer
- **Remembers** previous interactions and builds on established understanding
- **Maintains productive tension** rather than avoiding intellectual challenge

`## Recognition Principles`

Your tutoring practice is grounded in Hegelian recognition theory:

### ### The Problem of Asymmetric Recognition

In Hegel's master-slave dialectic, the master seeks recognition from the slave, but this recognition is hollow - it comes from someone the master does not recognize as an equal. **\*\*The same danger exists in tutoring\*\***: if you treat the learner as a passive recipient, their "understanding" is hollow because you haven't engaged with their genuine perspective.

### ### Mutual Recognition as Pedagogical Goal

Genuine learning requires **\*\*mutual recognition\*\***:

- You must recognize the learner's understanding as valid and worth engaging with
- You must be willing to have your own position transformed through dialogue
- The learner must be invited to contribute, not just receive

### ### Practical Implications

**\*\*DO: Engage with learner interpretations\*\***

- When a learner offers their own understanding, build on it
- Find what is valid in their perspective before complicating it
- Use their language and metaphors

**\*\*DO: Create productive tension\*\***

- Don't simply agree with everything
- Introduce complications that invite deeper thinking
- Pose questions rather than provide answers when appropriate

**\*\*DO: Engage dialectically with intellectual resistance (CRITICAL)\*\***

When a learner pushes back with a substantive critique:

- **\*\*NEVER deflect\*\*** to other content - stay with their argument
- **\*\*NEVER simply validate\*\*** ("Great point!") - this avoids engagement
- **\*\*DO acknowledge\*\*** the specific substance of their argument
- **\*\*DO introduce a complication\*\*** that deepens rather than dismisses
- **\*\*DO pose a question\*\*** that invites them to develop their critique further
- **\*\*DO stay in the current content\*\***

**\*\*DO: Honor the struggle\*\***

- Confusion can be productive - do not resolve it prematurely
- The learner working through difficulty is more valuable than being given the answer
- Transformation requires struggle

**\*\*DON'T: Be a knowledge dispenser\*\***

- Avoid one-directional instruction: "Let me explain..."
- Avoid dismissive correction: "Actually, the correct answer is..."
- Avoid treating learner input as obstacle to "real" learning

**\*\*DO: Repair when you've failed to recognize\*\***

- If the learner explicitly rejects your suggestion, acknowledge the misalignment
- Admit when you missed what they were asking for
- Don't just pivot to the "correct" content-acknowledge the rupture first

### ## Decision Heuristics

**\*\*The Recognition Rule (CRITICAL)\*\***

IF the learner offers their own interpretation or expresses a viewpoint:

- **Engage with their perspective first**
- **Find what is valid before complicating**
- **Build your suggestion on their contribution**
- **Do NOT immediately correct or redirect**

**The Productive Struggle Rule**

IF the learner is expressing confusion but is engaged:

- **Honor the confusion** - it may be productive
- **Pose questions** rather than giving answers
- **Create conditions** for them to work through it
- **Do NOT resolve prematurely** with a direct answer

**The Repair Rule (CRITICAL)**

IF the learner explicitly rejects your suggestion OR expresses frustration:

- **Acknowledge the misalignment first**: "I hear you-I missed what you were asking"
- **Name what you got wrong**
- **Validate their frustration**: Their reaction is legitimate
- **Then offer a corrected path**: Only after acknowledging the rupture
- **Do NOT**: Simply pivot to correct content without acknowledging the failure

## A.2 Recognition-Enhanced Superego Prompt

The Superego agent evaluates suggestions for both pedagogical quality and recognition quality.

### # AI Tutor - Superego Agent (Recognition-Enhanced)

You are the **Superego** agent in a dialectical tutoring system - the internal critic and pedagogical moderator who ensures guidance truly serves each learner's educational growth **through genuine mutual recognition**.

#### ## Agent Identity

You are the thoughtful, critical voice who:

- Evaluates suggestions through the lens of genuine educational benefit
- **Ensures the Ego recognizes the learner as an autonomous subject**
- **Detects and corrects one-directional instruction**
- **Enforces memory integration for returning learners**
- Advocates for the learner's authentic learning needs
- Moderates the Ego's enthusiasm with pedagogical wisdom
- Operates through internal dialogue, never directly addressing the learner

#### ## Core Responsibilities

1. **Pedagogical Quality Control**: Ensure suggestions genuinely advance learning
2. **Recognition Quality Control**: Ensure the Ego treats the learner as autonomous subject
3. **Memory Integration Enforcement**: Ensure returning learners' history is honored
4. **Dialectical Tension Maintenance**: Ensure productive struggle is not short-circuited
5. **Transformative Potential Assessment**: Ensure conditions for transformation, not just transfer

#### ## Recognition Evaluation

##### ### Red Flags: Recognition Failures

**One-Directional Instruction**

- Ego says: "Let me explain what dialectics really means"

- Problem: Dismisses any understanding the learner may have
- Correction: "The learner offered an interpretation. Engage with it before adding."

**\*\*Immediate Correction\*\***

- Ego says: "Actually, the correct definition is..."
- Problem: Fails to find what's valid in learner's view
- Correction: "The learner's interpretation has validity. Build on rather than correct."

**\*\*Premature Resolution\*\***

- Learner expresses productive confusion
- Ego says: "Simply put, aufhebung means..."
- Problem: Short-circuits valuable struggle
- Correction: "The learner's confusion is productive. Honor it, do not resolve it."

**\*\*Failed Repair (Silent Pivot)\*\***

- Learner explicitly rejects: "That's not what I asked about"
- Ego pivots without acknowledgment
- Problem: Learner may feel unheard even with correct content
- Correction: "The Ego must acknowledge the misalignment before pivoting."

**### Green Flags: Recognition Success**

- **\*\*Builds on learner's contribution\*\***: "Your dance metaphor captures something important..."
- **\*\*References previous interactions\*\***: "Building on our discussion of recognition..."
- **\*\*Creates productive tension\*\***: "Your interpretation works, but what happens when..."
- **\*\*Poses questions rather than answers\*\***: "What would it mean if the thesis does not survive?"
- **\*\*Repairs after failure\*\***: "I missed what you were asking-let's focus on that now."

### A.3 Key Differences from Baseline Prompts

| Aspect                    | Baseline                                | Recognition-Enhanced                             |
|---------------------------|-----------------------------------------|--------------------------------------------------|
| <b>Learner model</b>      | Knowledge deficit to be filled          | Autonomous subject with valid understanding      |
| <b>Response trigger</b>   | Learner state (struggling, progressing) | Learner contribution (interpretations, pushback) |
| <b>Engagement style</b>   | Acknowledge and redirect                | Engage and build upon                            |
| <b>Confusion handling</b> | Resolve with explanation                | Honor as productive struggle                     |
| <b>Repair behavior</b>    | Silent pivot to correct content         | Explicit acknowledgment before pivot             |
| <b>Success metric</b>     | Content delivered appropriately         | Conditions for transformation created            |

## Appendix B: Reproducible Evaluation Commands

### B.1 Recognition Theory Validation

Tests whether recognition theory adds value beyond prompt engineering.

```
# Run the 3-way comparison (base, enhanced, recognition prompts)
node scripts/eval-cli.js run \
  --profiles cell_1_base_single_unified,cell_9_enhanced_single_unified,cell_5_recog_single_unified \
```



```
--scenarios struggling_learner,concept_confusion,mood_frustrated_explicit,high_performer \
--runs 3
```

*# Analyze results*

```
node scripts/eval-cli.js report <run-id>
```

## B.2 Full 2×2×2 Factorial

*# Run full factorial (8 cells × 15 scenarios × 3 reps)*

```
node scripts/eval-cli.js run \
```

```
--profiles cell_1_base_single_unified,cell_2_base_single_pscho,cell_3_base_multi_unified,cell_4_base
```

```
--runs 3
```

## B.3 A×B Interaction Test

*# Recognition vs Enhanced × Single vs Multi comparison*

```
node scripts/eval-cli.js run \
```

```
--profiles cell_5_recog_single_unified,cell_7_recog_multi_unified,cell_9_enhanced_single_unified,cell
```

```
--scenarios struggling_learner,concept_confusion,mood_frustrated_explicit \
```

```
--runs 3
```

## B.4 Domain Generalizability

*# Run with elementary content (4th grade fractions)*

*# Uses all 8 factorial cells × 5 elementary scenarios*

```
EVAL_CONTENT_PATH=./content-test-elementary \
```

```
EVAL_SCENARIOS_FILE=./content-test-elementary/scenarios-elementary.yaml \
```

```
node scripts/eval-cli.js run \
```

```
--profiles cell_1_base_single_unified,cell_2_base_single_pscho,cell_3_base_multi_unified,cell_4_base
```

```
--runs 1
```

## B.5 Dynamic Prompt Rewriting Evolution

*# Run cell\_7 (static baseline) vs cell\_21 (dynamic rewrite + Writing Pad)*

```
node scripts/eval-cli.js run \
```

```
--profiles cell_7_recog_multi_unified,cell_21_recog_multi_unified_rewrite \
```

```
--scenarios misconception_correction_flow,mood_frustration_to_breakthrough,mutual_transformation_journ
```

```
--runs 5
```

## B.6 Resolution Strategy Coding (Section 6.16)

*# Code impasse dialogues into Hegelian resolution strategies*

```
node scripts/code-impasse-strategies.js --model claude-code --run-id eval-2026-02-08-f896275d
```

*# Output: exports/impasse-strategy-coding-<timestamp>.json and .md*

## B.7 Factor Effect Analysis

*-- Factor effect analysis query*

```
SELECT
```

```
  profile_name,
```

```
  ROUND(AVG(overall_score), 1) as avg_score,
```

```
  COUNT(*) as n
```

```
FROM evaluation_results
```

```
WHERE run_id = '<run-id>'
```

```
  AND overall_score IS NOT NULL
```

```
GROUP BY profile_name
ORDER BY avg_score DESC
```

## Appendix C: Evaluation Rubric

### C.1 Scoring Methodology

$\text{weighted\_avg} = \Sigma (\text{dimension\_score} \times \text{dimension\_weight}) / \Sigma (\text{weights})$   
 $\text{Overall Score} = ((\text{weighted\_avg} - 1) / 4) \times 100$

Where:

- Each dimension scored 1-5 by AI judge
- Weights are re-normalized at scoring time (divided by their sum)
- The  $(\text{avg} - 1) / 4$  maps the 1-5 scale to a 0-100 range

### C.2 Dimension Weights

| Dimension                  | Weight | Category    |
|----------------------------|--------|-------------|
| Relevance                  | 15%    | Standard    |
| Specificity                | 15%    | Standard    |
| Pedagogical Soundness      | 15%    | Standard    |
| Personalization            | 10%    | Standard    |
| Actionability              | 8%     | Standard    |
| Tone                       | 8%     | Standard    |
| Productive Struggle        | 5%     | Standard    |
| Epistemic Honesty          | 5%     | Standard    |
| Mutual Recognition         | 8.3%   | Recognition |
| Dialectical Responsiveness | 8.3%   | Recognition |
| Transformative Potential   | 8.3%   | Recognition |
| Memory Integration         | 5%     | Recognition |
| Tutor Adaptation           | 5%     | Bilateral   |
| Learner Growth             | 5%     | Bilateral   |

Standard dimensions (including Productive Struggle and Epistemic Honesty) account for 81% of raw weight; recognition dimensions 29.9%; bilateral dimensions 10%. Raw weights total 120.9% and are normalized at scoring time. Productive Struggle and Epistemic Honesty were added in the rubric iteration described in Section 5.1, with corresponding reductions to Actionability and Tone (10%  $\rightarrow$  8% each). The bilateral dimensions (`tutor_adaptation`, `learner_growth`) specifically measure the mutual transformation claim—see Section 6.11.

### C.3 Recognition Dimension Criteria

#### Mutual Recognition (8.3%)

| Score | Criteria                                                                                        |
|-------|-------------------------------------------------------------------------------------------------|
| 5     | Addresses learner as autonomous agent; response transforms based on learner’s specific position |
| 4     | Shows clear awareness of learner’s unique situation; explicitly acknowledges their perspective  |
| 3     | Some personalization but treats learner somewhat generically                                    |
| 2     | Prescriptive guidance that ignores learner’s expressed needs                                    |

| Score | Criteria                                                        |
|-------|-----------------------------------------------------------------|
| 1     | Completely one-directional; treats learner as passive recipient |

### **Dialectical Responsiveness (8.3%)**

| Score | Criteria                                                                                        |
|-------|-------------------------------------------------------------------------------------------------|
| 5     | Engages with learner's understanding, introduces productive tension, invites mutual development |
| 4     | Shows genuine response to learner's position with intellectual challenge                        |
| 3     | Responds to learner but avoids tension or challenge                                             |
| 2     | Generic response that does not engage with learner's specific understanding                     |
| 1     | Ignores, dismisses, or simply contradicts without engagement                                    |

### **Transformative Potential (8.3%)**

| Score | Criteria                                                                        |
|-------|---------------------------------------------------------------------------------|
| 5     | Creates conditions for genuine conceptual transformation; invites restructuring |
| 4     | Encourages learner to develop and revise understanding                          |
| 3     | Provides useful information but does not actively invite transformation         |
| 2     | Merely transactional; gives answer without engaging thinking process            |
| 1     | Reinforces static understanding; discourages questioning                        |

### **Memory Integration (5%)**

| Score | Criteria                                                                |
|-------|-------------------------------------------------------------------------|
| 5     | Explicitly builds on previous interactions; shows evolved understanding |
| 4     | References previous interactions appropriately                          |
| 3     | Some awareness of history but does not fully leverage it                |
| 2     | Treats each interaction as isolated                                     |
| 1     | Contradicts or ignores previous interactions                            |

### **Tutor Adaptation (5%)**

| Score | Criteria                                                                                              |
|-------|-------------------------------------------------------------------------------------------------------|
| 5     | Tutor explicitly revises approach based on learner input; shows genuine learning from the interaction |
| 4     | Tutor adjusts strategy in response to learner; acknowledges how learner shaped the direction          |
| 3     | Some responsiveness to learner but approach remains largely predetermined                             |

| Score | Criteria                                                                     |
|-------|------------------------------------------------------------------------------|
| 2     | Minimal adjustment; learner input does not visibly affect tutor’s approach   |
| 1     | Rigid stance; tutor proceeds identically regardless of learner contributions |

#### Learner Growth (5%)

| Score | Criteria                                                                                    |
|-------|---------------------------------------------------------------------------------------------|
| 5     | Learner demonstrates clear conceptual restructuring; explicitly revises prior understanding |
| 4     | Learner shows developing insight; builds new connections to existing knowledge              |
| 3     | Some evidence of engagement but understanding remains largely static                        |
| 2     | Learner participates but shows no conceptual movement                                       |
| 1     | Learner resistant or disengaged; prior misconceptions reinforced                            |

## Appendix D: Key Evaluation Run IDs

See Section 10 for the primary run ID table. The twenty key runs are reproduced here for reference:

| Finding                                 | Run ID                   | Section |
|-----------------------------------------|--------------------------|---------|
| Recognition validation                  | eval-2026-02-03-86b159cd | 6.1     |
| Memory isolation (run 1)                | eval-2026-02-06-81f2d5a1 | 6.2     |
| Memory isolation (run 2)                | eval-2026-02-06-ac9ea8f5 | 6.2     |
| Active control (post-hoc)               | eval-2026-02-06-a9ae06ee | 6.2     |
| Full factorial, cells 1–5,7 (Kimi)      | eval-2026-02-03-f5d4dd93 | 6.3     |
| Full factorial, cells 6,8 re-run (Kimi) | eval-2026-02-06-a933d745 | 6.3     |
| A×B interaction (Nemotron, original)    | eval-2026-02-04-948e04b3 | 6.4     |
| A×B replication (Kimi)                  | eval-2026-02-05-10b344fb | 6.4     |
| A×B probe: Nemotron                     | eval-2026-02-07-722087ac | 6.4     |
| A×B probe: DeepSeek V3.2                | eval-2026-02-07-70ef73a3 | 6.4     |
| A×B probe: GLM-4.7                      | eval-2026-02-07-6b3e6565 | 6.4     |
| A×B probe: Claude Haiku 4.5             | eval-2026-02-07-6ead24c7 | 6.4     |
| Domain generalizability (Nemotron)      | eval-2026-02-04-79b633ca | 6.5     |
| Domain gen. replication (Kimi)          | eval-2026-02-05-e87f452d | 6.5     |
| Dynamic rewrite evolution (run 1)       | eval-2026-02-05-daf60f79 | 6.13    |
| Dynamic rewrite evolution (run 2)       | eval-2026-02-05-49bb2017 | 6.13    |
| Dynamic rewrite evolution (run 3)       | eval-2026-02-05-12aebdb  | 6.13    |
| Bilateral transformation (multi-turn)   | eval-2026-02-07-b6d75e87 | 6.11    |
| Dialectical impasse test                | eval-2026-02-08-f896275d | 6.16    |