

1. Title & Research Question

Title

Adaptive AI Support Regulation for Preserving Critical Thinking in AI-Assisted Learning

Research Question

How can adaptive AI support strategies preserve critical thinking and independent problem-solving in student learning?”

2. Hypothesis

If AI learning systems provide adaptive and progressively escalating support instead of immediate direct answers, students will demonstrate stronger critical thinking and independent problem-solving because productive struggle and reflective reasoning are better preserved.

5. Insight / Proposed Framework

The evidence reviewed throughout this paper suggests that the cognitive risks of AI-assisted learning are not caused by AI itself, but by how and when AI support is delivered. Many current AI systems prioritize speed and instant answer generation, often removing productive struggle before meaningful reasoning can occur. While efficient, this approach can weaken the active cognitive processes associated with deep learning and long-term problem-solving development.

To address this issue, this paper proposes the **Adaptive AI Support Regulation Framework (AASRF)** — a learning-support model designed to regulate the timing, intensity, and escalation of AI assistance rather than providing immediate maximum support. The framework is organized into three stages.

Phase 1 — Independent Cognitive Engagement

The first stage prioritizes independent problem-solving before AI intervention occurs. Students are encouraged to attempt tasks on their own, allowing productive struggle, exploratory reasoning, and self-monitoring to develop naturally. Instead of treating difficulty as something to eliminate immediately, the framework treats moderate challenge as an important condition for learning.

Direct answers are intentionally delayed because research consistently shows that effortful engagement before assistance improves retention, conceptual understanding, and reasoning

ability more effectively than immediate solution delivery. Unlike conventional AI systems that often respond instantly at the first sign of difficulty, the AASRF preserves independent reasoning as the foundation of learning.

Phase 2 — Adaptive Monitoring and Reflective Guidance

If learners begin showing signs of unproductive struggle — such as repeated failed attempts, long pauses, stalled progress, or repeated answer requests — the system introduces limited intervention through reflective prompts, conceptual hints, and metacognitive guidance.

Rather than solving the task directly, the AI encourages learners to continue reasoning independently. For example, instead of giving a direct mathematics solution, the system may ask:

“What pattern do you notice between the previous steps?”

This form of reflective guidance helps students reactivate their own reasoning processes while still receiving support. Research suggests that targeted and indirect intervention often produces stronger cognitive engagement than immediate correction. However, the framework also recognizes that excessive prompting may create cognitive overload, so reflective guidance should remain adaptive and selectively triggered rather than constant.

Phase 3 — Progressive Support Escalation

If reflective guidance remains insufficient, the framework gradually increases support intensity through progressive hint escalation. Assistance becomes more specific only when necessary, ensuring that support remains proportional to learner need rather than immediate and unrestricted. Full explanations are treated as a final stage of intervention instead of the default starting point.

This structure addresses a major weakness in many unrestricted AI systems: they often provide maximum assistance regardless of learner condition. In contrast, the AASRF regulates support according to cognitive necessity, balancing two educational risks simultaneously — excessive struggle, which may cause frustration, and excessive assistance, which may weaken independent reasoning through cognitive offloading.

Ultimately, the AASRF represents a shift from unrestricted answer-generation systems toward cognition-preserving AI learning support systems designed to strengthen, rather than replace, critical thinking and independent problem-solving.

The operational structure of the proposed framework is illustrated below.



Figure 1. Adaptive AI Support Regulation Framework (AASRF) process flow.

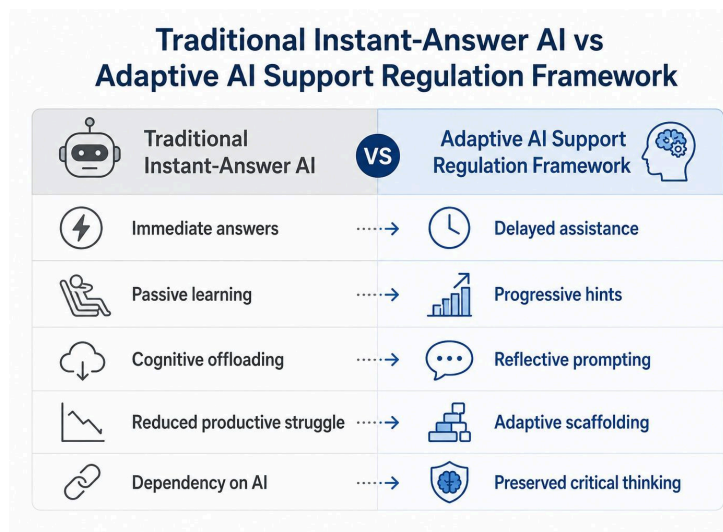


Figure 2. Conceptual comparison between traditional instant-answer AI systems and the proposed Adaptive AI Support Regulation Framework (AASRF).

6. Conclusion

This paper found that unrestricted instant-answer AI systems may weaken productive struggle and independent reasoning through cognitive offloading. In contrast, adaptive support strategies such as delayed intervention, reflective prompting, and progressive hint

escalation appear more effective in preserving critical thinking during AI-assisted learning. The proposed Adaptive AI Support Regulation Framework (AASRF) demonstrates how AI can support learning without replacing student cognition. Ultimately, the educational value of AI depends not only on answer generation, but on its ability to preserve active thinking and independent problem-solving.”

7. References

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