

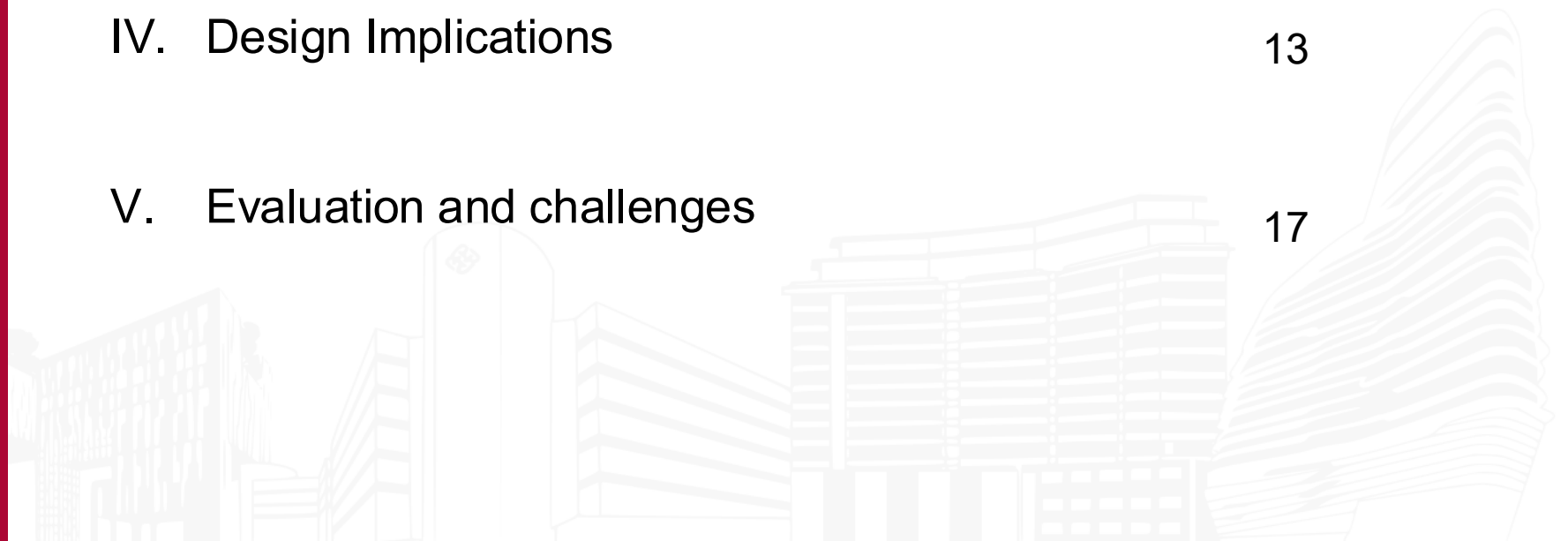
Revisiting pedagogical agents in the era of LLMs: from social agency to social interdependence

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Roadmap

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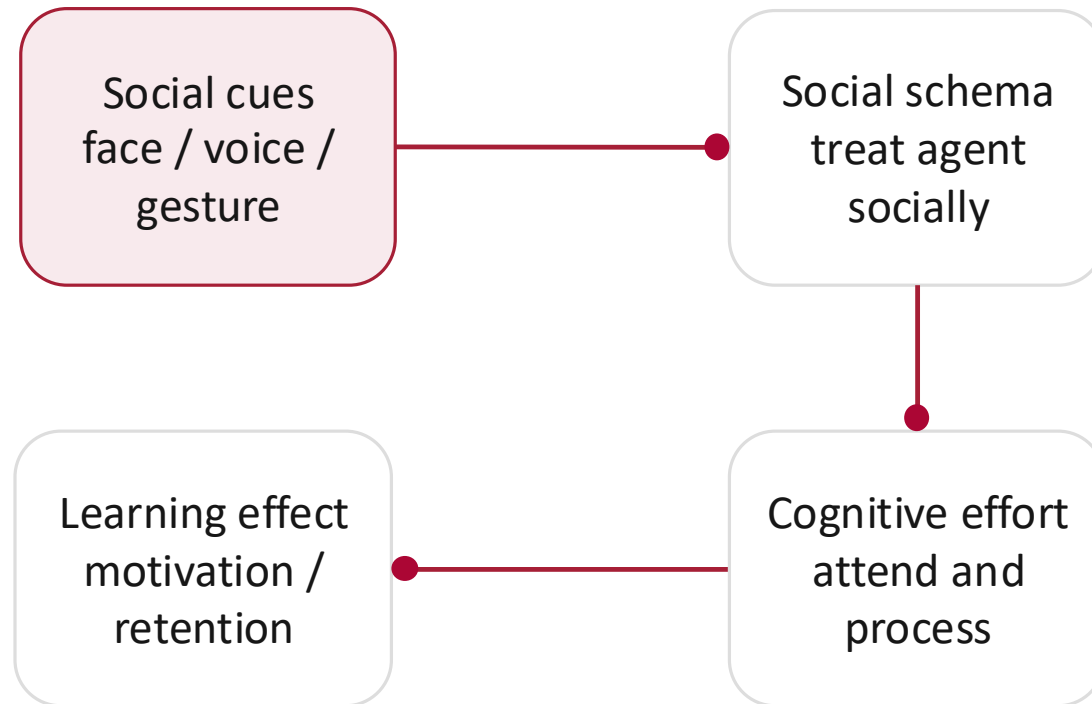


I. What is Social Agency Theory (SAT)?

**SAT: social cues
trigger social
learning responses.**

Human-like features such as face, voice, gesture and politeness activate social schemas.

The expected effect is more cognitive effort, engagement and learning.



I. Why SAT becomes insufficient: cues are not collaboration



THE DESIGN QUESTION CHANGED

From social cues to shared responsibility

SAT explained engagement through faces, voice, gesture and politeness.

But fluent LLMs change the task: the learner must question, evaluate and influence the next step.

Design for reciprocal influence: AI contributes breadth; the learner contributes judgement.



II. What changed with LLM-driven pedagogical agents?

THE TECHNOLOGICAL PREMISE
CHANGED

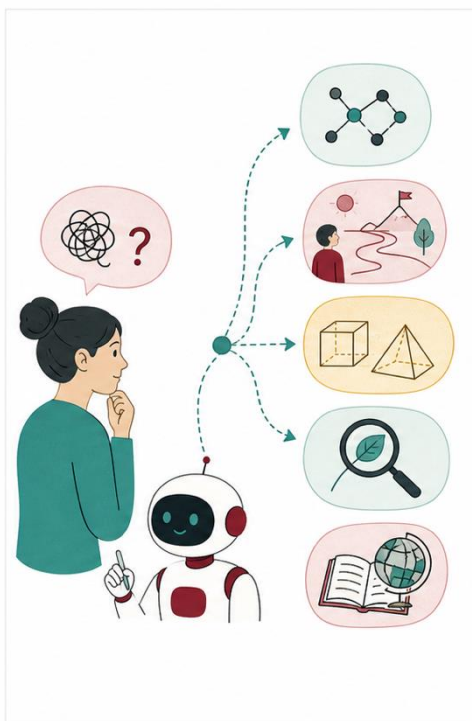
Scripted PA era

- Predefined decision trees
- Limited off-script response
- Session-bound support
- Learner mainly receives

II. What changed with LLM-driven pedagogical agents?

LLM-driven PA era

THE TECHNOLOGICAL PREMISE
CHANGED

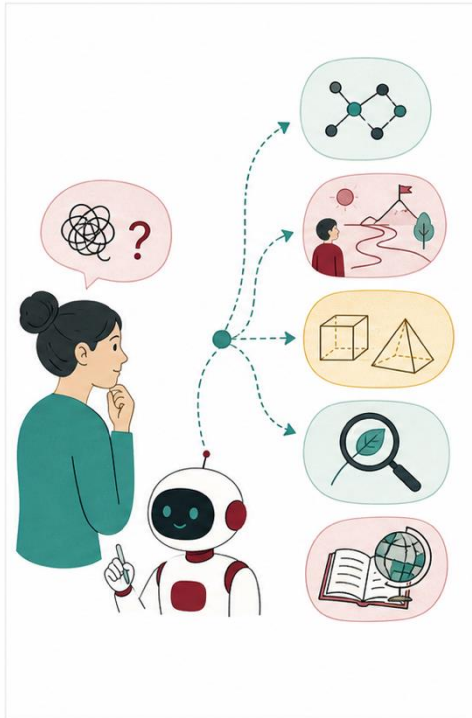


Semantic generation

Interpret nuance, generate
alternatives and reframe
explanations

II. What changed with LLM-driven pedagogical agents?

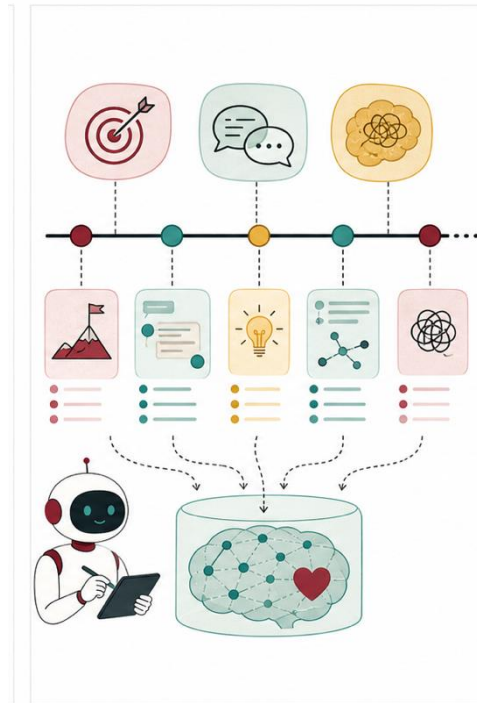
THE TECHNOLOGICAL PREMISE
CHANGED



Semantic generation

Interpret nuance, generate alternatives and reframe explanations

LLM-driven PA era



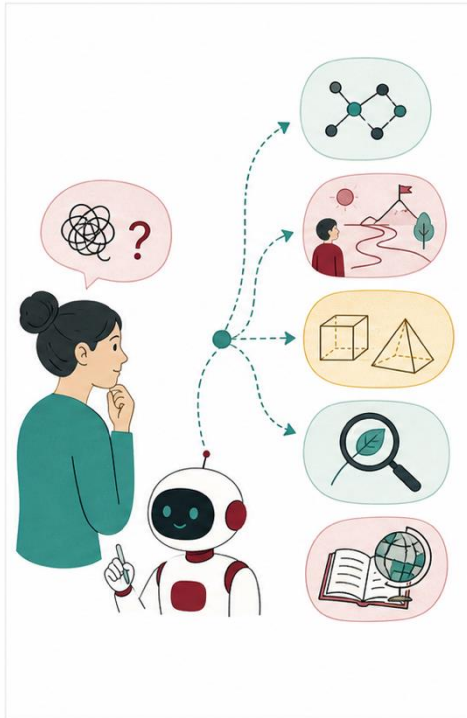
Contextual memory

Retain goals, misconceptions and learning trajectories across sessions

II. What changed with LLM-driven pedagogical agents?

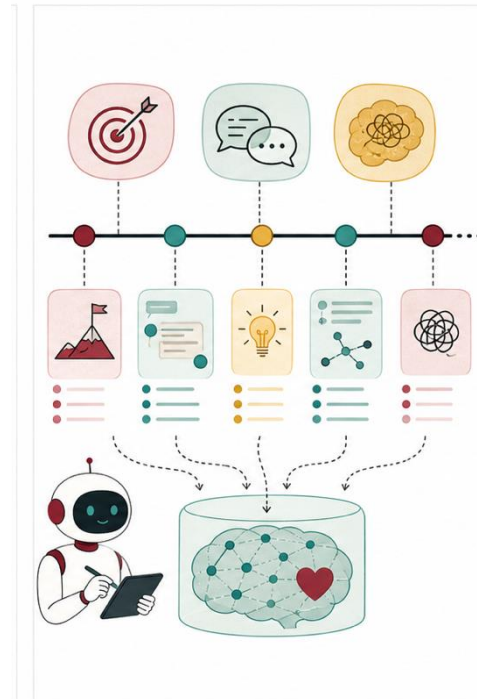
THE TECHNOLOGICAL PREMISE
CHANGED

LLM-driven PA era



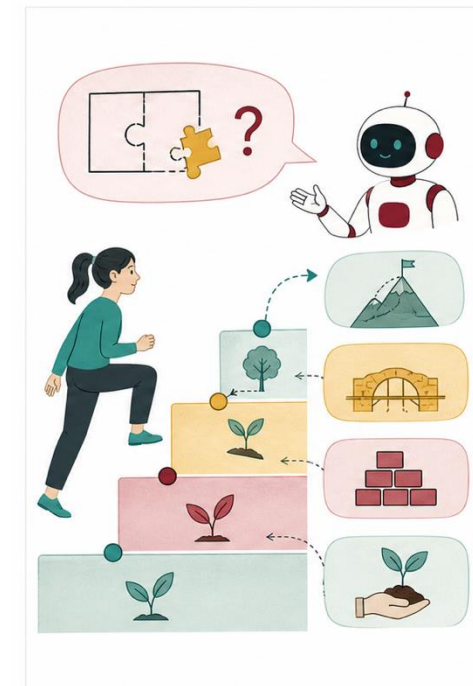
Semantic generation

Interpret nuance, generate alternatives and reframe explanations



Contextual memory

Retain goals, misconceptions and learning trajectories across sessions



Adaptive scaffolding

Use contingent feedback and Socratic prompts as needs evolve



II. What changed with LLM-driven pedagogical agents?

THE TECHNOLOGICAL PREMISE
CHANGED

LLM-driven PA era

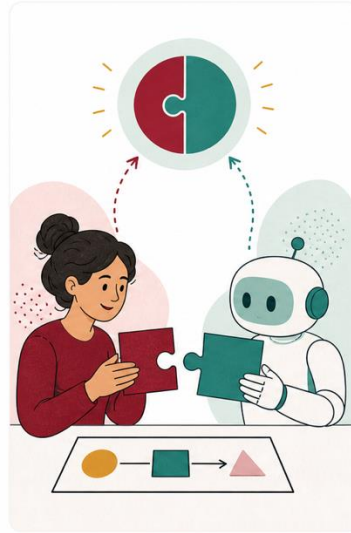
New risk: fluent answer delivery can look collaborative while still producing passive offloading.

So the design question moves from “*Does it feel social?*” to “*How is reasoning organised across the partnership?*”

III. What is Social Interdependence Theory (SIT)?

SIT: learning outcomes depend on how collaboration is structured.

For human–LLM learning, SIT is used as a design heuristic.



Positive interdependence

Agent: breadth and feedback
Learner: context, judgement and verification



Promotive interaction

Challenge assumptions,
request justification and
compare alternatives



Individual accountability

Learner explains, checks,
revises and can continue
independently

This prepares the SAT → SIT pivot and the three design implications that follow.



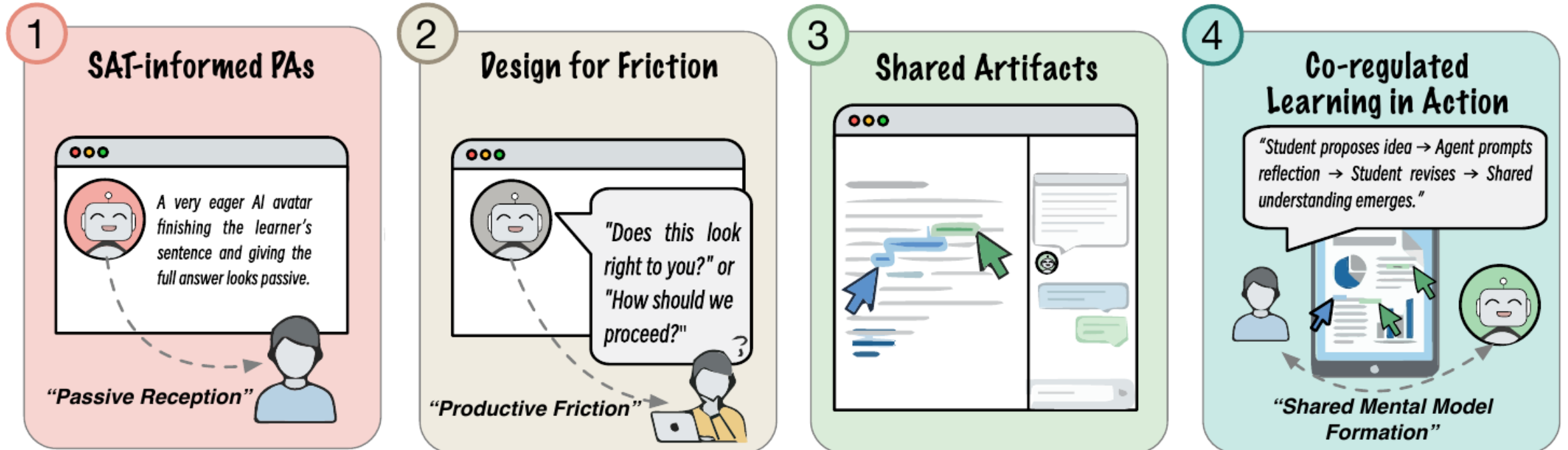
III. The theoretical pivot: from SAT to SIT

Table 1. Theoretic Shift: From SAT to SIT

Dimension	SAT	SIT
Agent Role	Expert / Tutor: Provide authoritative knowledge and guidance.	Learning Partner: Act as a collaborator in a shared task.
Learner Role	Receiver: Passively react to agent-initiated cues.	Co-constructor: Proactively engage and verify the interaction.
Mechanism	Schema Activation: Reduce cognitive load via human-like social cues.	Collaborative: Drive deep processing through negotiation of meaning.

SIT changes all three: the agent's role, the learner's role, and the mechanism of learning.

IV. Design Implications



Each pattern shifts control back to the learner. The shared work makes reciprocal influence visible.

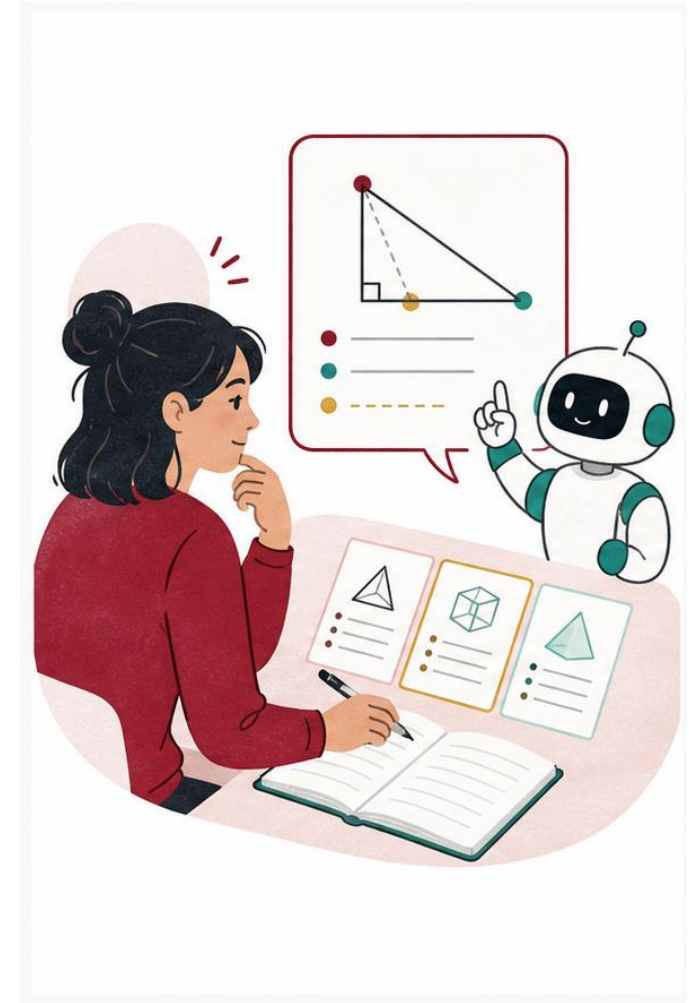
IV. Productive friction keeps learners active

DESIGN MOVE 1

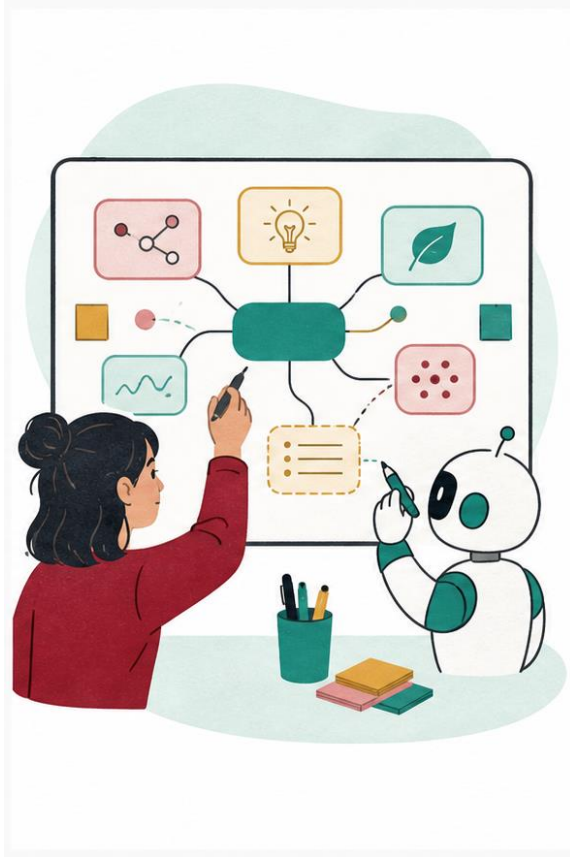
Make progress contingent on learner reasoning.

- Ask for evidence or justification
- Compare alternative approaches
- Offer partial moves - not final answers
- Require the learner to inspect and revise

Design boundary: trigger reasoning, not frustration.



IV. Shared artefacts make collaboration visible



DESIGN MOVE 2

Put shared work—not chat—at the centre.

- Co-edit a map, proof, code, design or draft
- Make goals, roles and progress negotiable
- Attribute revisions to learner and agent
- Distinguish co-construction from outsourcing

The artefact reveals who changed what - and why.

IV. Co-regulation preserves learner responsibility

DESIGN MOVE 3

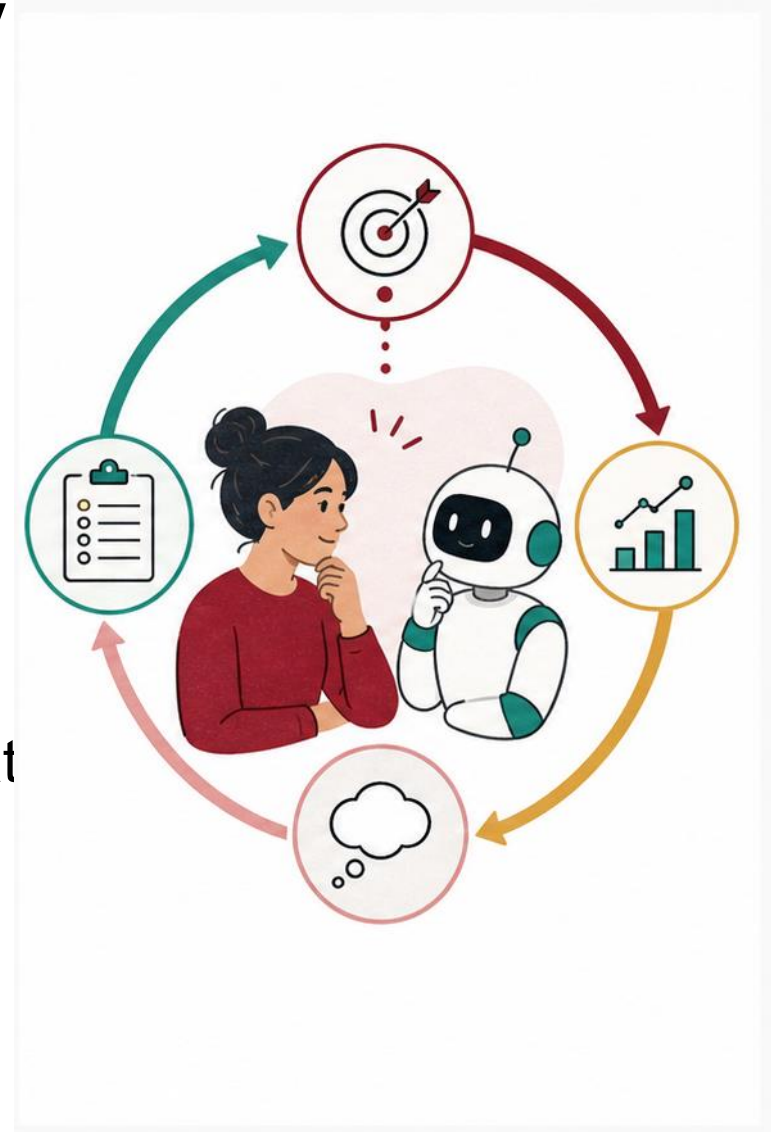
Co-regulate the learning process.

Plan agree on the shared goal, roles and evidence

Monitor track progress, uncertainty and checking

Reflect review revisions and test independent continuat

Encode it in prompts, workflow constraints, turn structure and revision protocols.



V. Evaluate the joint activity, not just the agent



MEASURE THE PARTNERSHIP

Look for process evidence.

- Substantive learner reasoning
- Contingent uptake and negotiation turns
- Revision, transfer and independent continuation
- Formation of shared mental models

Methods: discourse analysis, interaction coding, process tracing and logs

A polished answer can hide a weak learning process.

V. Challenges

IMPLEMENT WITH GUARDRAILS

Protect agency, trust and verification.

- Verification burden - signal uncertainty; prompt comparison and checking.
- Memory and profiling - make consent, retention and deletion transparent.
- Illusion of collaboration - test whether learner input changes the trajectory.



Success is a structured partnership that leaves the learner more capable.

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