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REVIEWER'S REPORT

Manuscript No.: IJAR-59889

Title: AI-MetaLearn-Sim A Reproducible Simulation Framework for Metacognitive Scaffolding and Self-Regulated Learning in Higher Education

Recommendation:
Accept as it is .....
Accept after minor revision.....
Accept after major revision ...✓.....
Do not accept (*Reasons below*) .....

Rating	Excel.	Good	Fair	Poor
Originality		✓		
Techn. Quality		✓		
Clarity		✓		
Significance		✓		

Reviewer's ID: JPR-098

Detailed Reviewer's Report

Decision: Accept after Major Revision

Major Revisions

1. **Oracle-like access to latent learner information:** The adaptive policy uses latent mastery, monitoring competence, and readiness when selecting interventions. This creates an important methodological limitation because these variables would not be directly observable in a real learning environment. The authors should explain how the proposed framework could operate using observable learner interactions and should distinguish the current simulation from a deployable adaptive learning system. (Sections 5 and 6.4, Pages 3–4)

2. **Outcome-conditioned confidence generation:** The confidence value is generated using the realized correctness of the learner's response. Consequently, the confidence estimate is not an independent prediction made before the outcome is known. The authors should clarify how this affects the validity of the confidence-related evaluation and consider an alternative

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confidence-generation mechanism that does not depend on the realized outcome. (Section 6.2, Page 3)

3. **Justification of simulation parameters:** Several important parameters, including learning rates, monitoring rates, dependence increments, confidence noise, and intervention thresholds, are predefined assumptions. The manuscript does not sufficiently establish why these particular values represent plausible learner behavior. The authors should provide theoretical or empirical justification for the selected values and explain how alternative parameter choices could influence the findings. (Sections 6 and 7.2, Pages 3–4)

4. **Potential dependence of outcomes on predefined transition rules:** The learning-state transition equations directly specify how planning, reflection, and hints influence mastery and monitoring competence. Therefore, the reported advantages may partly arise from the relationships already encoded in the simulation. The authors should discuss this issue and provide additional tests using alternative transition assumptions or model configurations to assess whether the findings remain consistent. (Sections 6.2–6.5, Pages 3–4)

5. **Interpretation of statistical significance and effect sizes:** The paired comparisons produce exceptionally large standardized effect sizes, including values of 19.76 and 41.01 for learning mastery. Although the manuscript acknowledges that these are simulation-level effects, their magnitude requires further explanation. The authors should report the distribution of paired differences, discuss the low variability underlying these estimates, and clearly distinguish Monte Carlo variability from uncertainty about real learners. (Section 10.6 and Table 10.7, Pages 13–15)

6. **Validity of the confidence-calibration evaluation:** The Brier score is used as the principal confidence-related measure. However, the manuscript itself acknowledges that the Brier score reflects both calibration and predictive discrimination. The authors should avoid treating it as a direct measure of calibration and, if prediction-level data are available, supplement the analysis with reliability diagrams, expected calibration error, or calibration slope and intercept. (Section 10.4, Pages 10–11)

7. **Scope and consistency of sensitivity analysis:** The sensitivity analysis considers six selected scenarios, each using 30 replications. This is useful but

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does not establish robustness across a broad range of parameter combinations. The authors should explain why these scenarios were selected, distinguish the 30-replication sensitivity results from the 100-replication main experiment, and discuss the implications of the different replication counts. (Section 7.2 and Section 10.7, Pages 4 and 17–18)

8. **Further investigation of the ablation results:** Disabling monitoring learning increases final mastery and unaided accuracy, despite substantially reducing monitoring competence. This is an important and unexpected finding. The authors should examine the relevant transition equations and policy-selection mechanism to determine why this occurs. They should also clarify whether the ablation isolates the monitoring-learning component or changes other policy decisions indirectly. (Section 10.8, Pages 19–20)

9. **Reproducibility and availability of implementation materials:** The manuscript reports that the supplied Python implementation reproduces the archived results exactly. However, it also states that a permanent public repository DOI has not been assigned and that complete learner-by-step event logs are unavailable. The authors should provide a stable public repository containing the source code, parameter configuration, dependency information, random seeds, and output files, together with clear instructions for reproducing the experiments. (Sections 7.3, 10.6.6 and 13, Pages 5, 16 and 29)

10. **Clarification of the AI-based contribution:** The proposed adaptive intervention appears to rely primarily on predefined, rule-based decision logic rather than a trained machine-learning or reinforcement-learning model. The authors should clarify the specific role of artificial intelligence in the proposed framework and ensure that the title, research contributions, and conclusions accurately reflect the implemented approach. (Sections 3, 5 and 6.4, Pages 2–4)

Minor revision comments

1. **Abstract:** The abstract provides useful numerical findings, but it should be more concise. The authors should clearly separate the principal contribution, main simulation results, and limitations without including too many implementation details. (Page 1)

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2. **Research questions and hypotheses:** The research questions and hypotheses are clearly presented. However, the authors should ensure that each hypothesis is explicitly connected to the corresponding evaluation metric and reported experiment. (Sections 3 and 4, Pages 2–3)

3. **Terminology consistency:** Terms such as *Adaptive AI*, *Adaptive AI-Based Metacognitive Scaffolding*, and *AI-MetaLearn-Sim* are used in different places. A consistent naming convention should be followed throughout the manuscript.

4. **Mathematical notation:** The mathematical expressions should be checked for consistent notation, subscripts, superscripts, brackets, and variable definitions. The notation for confidence and predicted probability should also remain consistent across the model description and Brier-score equation. (Sections 6 and 8, Pages 3–5 and 10)

5. **Variable definitions:** Some symbols, particularly \(r\), are used in different contexts, including readiness and replication indexing. The authors should review the notation and use distinct symbols wherever necessary. (Sections 6 and 7, Pages 3–5)

6. **Section numbering:** The organization and numbering of the results section should be checked carefully. The transition between the metacognitive monitoring analysis and the confidence-calibration analysis should be made clear. (Section 10, Pages 8–10)

7. **Tables:** Tables 10.1–10.10 should be checked for consistent heading styles, decimal precision, alignment, and explanatory notes. In particular, the authors should clearly distinguish results obtained from the main experiment from those obtained through the sensitivity and ablation experiments.

8. **Figures:** All figures should be checked for readability, consistent font sizes, clear axis labels, and appropriate legends. The figure captions should also identify the relevant simulation strategy and performance indicator.

9. **References:** The bibliography should be checked for consistent formatting, complete publication details, and accurate DOI links. The authors should verify each reference against the corresponding publisher or official publication record. (Pages 29–30)

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10. **Manuscript proofreading:** The manuscript requires a careful final language and formatting check. In particular, phrases that read like internal drafting instructions, such as the recommendation beginning "For a stronger journal manuscript" and the submission checklist in Section 13—should be removed or rewritten as appropriate. (Pages 11 and 29).