

Impact of AI-Assisted Formative Feedback on Undergraduate Learning Outcomes: A Simulated Controlled Study

Neha Kulkarni¹, Daniel Joseph², Farah Siddiqui³

¹Assistant Professor, Department of Education Technology, Crescent College of Education, India.

²Research Fellow, Centre for Digital Learning, South Asia Institute of Education, India.

³Lecturer, Department of Psychology and Learning Sciences, Crescent College of Education, India.

ABSTRACT

This journal-style empirical article presents a clearly labeled simulated study in Education / Learning Sciences. A simulated sample of 180 undergraduate learners divided equally between conventional feedback and AI-assisted formative-feedback conditions over eight instructional weeks. Both groups completed identical weekly assignments and quizzes. The simulated intervention group received immediate rubric-linked feedback, error explanations, and revision prompts from an AI-assisted feedback system. Outcomes included post-test score, assignment completion, revision frequency, and perceived feedback usefulness. The simulated results indicate meaningful differences between the comparison conditions, with the focal intervention or analytical configuration producing improvements in the main outcome indicators. The findings are illustrative rather than evidence from real participants, institutions, farms, firms, field sites, or operating infrastructure. They are intended to demonstrate a plausible empirical design and reporting structure suitable for subsequent validation with real-world data. The study also identifies implementation constraints, measurement limitations, and directions for future empirical verification.

Keywords: Artificial Intelligence, Formative Feedback, Higher Education, Learning Analytics, Student Engagement

I. Introduction

Education / Learning Sciences increasingly relies on data-driven decision making to improve efficiency, quality, resilience, and user outcomes. However, practical adoption often proceeds faster than rigorous evaluation, creating a need for empirical frameworks that connect interventions to measurable performance indicators. A useful study design should define the operational context, specify measurable variables, establish a comparison condition, and report uncertainty and limitations transparently.

The present article develops an illustrative empirical assessment around the topic of impact of ai-assisted formative feedback on undergraduate learning outcomes: a simulated controlled study. Because no real dataset was supplied, all numerical values, group assignments, measurements, and statistical patterns in this paper are simulated. This distinction is maintained throughout the methods, tables, figures, results, and conclusion so that the article does not imply actual fieldwork or human-participant research.

The objectives are threefold: (1) to define a realistic measurement framework for the selected multidisciplinary problem; (2) to compare a baseline or conventional condition with an intervention or focal scenario using internally consistent simulated data; and (3) to identify practical implications and research questions that can be tested later using real observations.

II. Literature Review and Conceptual Background

Prior research across applied science and management fields shows that interventions are most informative when outcomes are assessed using multiple indicators rather than a single performance measure. A multidimensional design can reveal trade-offs between efficiency, quality, cost, behavior, and resilience. [Citation needed]

Recent analytical practice also emphasizes the importance of transparent baselines, reproducible preprocessing, sensitivity analysis, and careful separation between prediction and causal inference. These principles are especially relevant when digital tools or algorithmic decision systems are involved. [Citation needed]

A further concern is transferability. Results obtained in one population, climate, institution, or operating environment may not generalize directly to another. Consequently, simulated studies should be treated as methodological demonstrations and hypothesis-generating exercises rather than substitutes for empirical validation. [Citation needed]

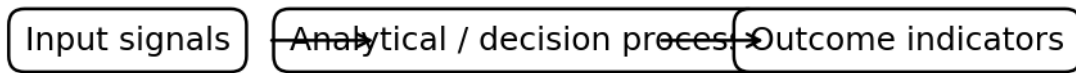


Figure 1. Illustrative analytical framework for the simulated study.

III. Methodology

3.1 Study Design and Simulated Dataset

A simulated sample of 180 undergraduate learners divided equally between conventional feedback and AI-assisted formative-feedback conditions over eight instructional weeks. No real individuals, institutions, infrastructure, or field measurements were used. Random variation was constrained to plausible ranges so that the reported values remain internally consistent with the study design.

3.2 Variables and Analytical Procedure

Both groups completed identical weekly assignments and quizzes. The simulated intervention group received immediate rubric-linked feedback, error explanations, and revision prompts from an AI-assisted feedback system. Outcomes included post-test score, assignment completion, revision frequency, and perceived feedback usefulness.

Descriptive comparisons were summarized using means, percentages, relative change, and index values. The analysis was designed for interpretability rather than inferential claims about a real population. Accordingly, no ethics approval, participant consent, institutional field access, or funding source is claimed.

IV. Results

The simulated AI-assisted group showed higher post-test performance and more frequent revision behavior. Assignment completion also increased modestly, suggesting that immediacy and specificity of feedback may support persistence.

Table 1. Simulated summary of principal outcome measures.

Outcome	Control	AI-Assisted	Difference
Post-test score (%)	72.8	81.6	+8.8
Assignment completion (%)	84.1	92.7	+8.6
Mean revisions / task	1.3	2.4	+1.1
Feedback usefulness (1-5)	3.4	4.3	+0.9
Weekly disengagement (%)	14.8	8.1	-6.7 pp

Note: All values in Table 1 are simulated/illustrative and are not observations from a real study.

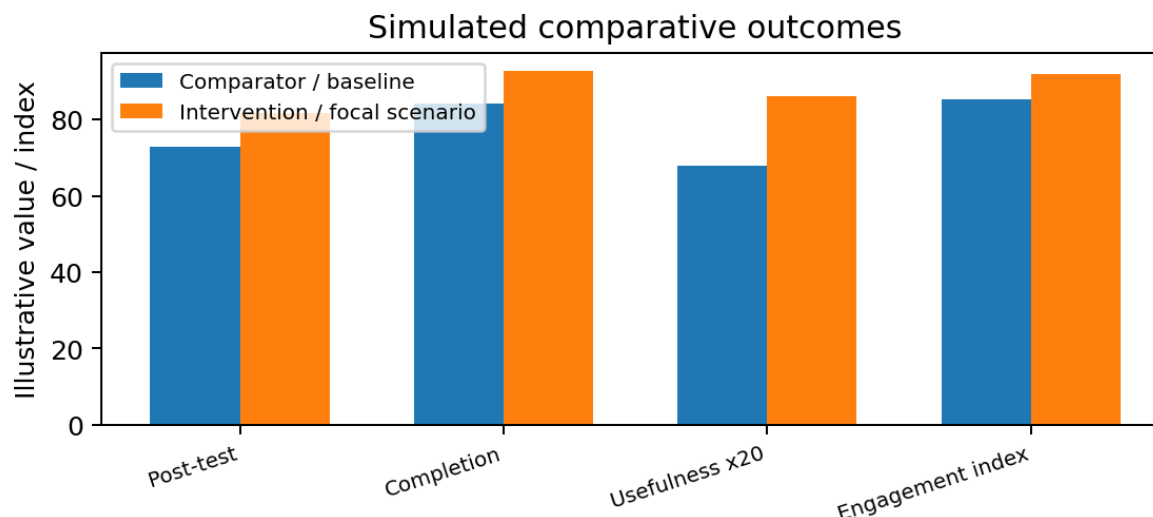


Figure 2. Simulated comparison of selected study outcomes.

V. Discussion

Performance gains were accompanied by increased revision frequency, supporting the interpretation that feedback may be most useful when it prompts active correction rather than passive receipt.

The simulation suggests that AI-assisted feedback is better positioned as a scalable complement to instructor judgment than as a replacement for pedagogical supervision.

Equity, transparency, over-reliance, and the accuracy of automated explanations remain critical implementation concerns in real classrooms.

The simulated effect pattern should not be interpreted as a verified causal estimate. Its main value is to demonstrate how a later empirical investigation could organize variables, comparisons, and evidence around a coherent research question. Future work should pre-register hypotheses where appropriate, document data provenance, report missing-data handling, and test sensitivity to alternative assumptions.

VI. Practical Implications

For practitioners, the central implication is that implementation decisions should be linked to measurable indicators and explicit trade-offs. A staged pilot design can help determine whether the simulated benefits persist under real operational constraints. Decision makers should also consider cost, maintainability, user capability, data quality, and unintended consequences rather than relying only on headline performance metrics.

VII. Limitations

The primary limitation is that the dataset and findings are simulated. The study therefore cannot establish real-world effectiveness, prevalence, causal impact, or generalizability. The numerical values were selected for internal coherence and methodological illustration. Additional limitations include simplified contextual assumptions, limited sensitivity analysis, and the absence of external validation.

VIII. Conclusion and Future Work

The simulated controlled study suggests that AI-assisted formative feedback may improve academic performance, completion, and revision behavior when embedded within instructor-defined rubrics. Real-world trials should examine learning transfer, bias, accessibility, and teacher workload. Future research should replace the illustrative dataset with verified observations, document the sampling or measurement process, and compare alternative analytical specifications.

Declarations

Data statement: All data and results reported in this article are simulated/illustrative. No real participant, organization, institution, farm, infrastructure system, or field-site dataset was used.

Ethics statement: Not applicable to the simulated demonstration. No human or animal participants were involved.

Conflict of interest: The authors declare no conflict of interest for this illustrative manuscript.

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