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# The development of MathBot and its evaluation in integral courses

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Abstract

This study presents Mathbot, a multimodal calculus tutoring system built entirely on a resource-constrained edge node — a departmental server with a single 24 GB GPU — that keeps all interaction data on campus. This study implemented the system in the 'Definite and Indefinite Integrals' unit of a university calculus course to explore its technical effectiveness and instructional benefits.

This study employed a mixed methods research (MMR) design to conduct a pedagogical experiment. For the quantitative component, a quasi-experimental design was adopted to compare learning performance between the control and experimental groups during the instructional units on definite and indefinite integrals. For the qualitative component, reflexive thematic analysis (RTA) was used to conduct in-depth interviews with 10 students from the experimental group. Quantitative results revealed that, after controlling for pretest scores, students in the experimental group who used Mathbot for integral learning exhibited significantly higher learning engagement than those in the control group ($F = 5.208$, $p = .029$). Qualitative findings further indicated that Mathbot provided substantial support in integral instruction—students generally found the step-by-step explanations for complex integration processes highly instructive, helping them understand the underlying logic and procedural steps rather than merely receiving final answers.

Keywords: Large language model, MathBot, Mixed methods research, Multimodal learning,