Abhishek Shrivastava, 2026, 14:2
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology
An Open Access Journal

Development of an Adaptive E-Learning System using LLM Modules

Abhishek Shrivastava [1], Philip Christopher [2], Nikhil Singh [3]
Department of Computer Science SRM Institute of Science & Technology
Chennai, India

Abstract- The rapid development of artificial intelligence (AI) provides new opportunities for improving e-learning environments. AI-powered Moodle modules can transform traditional learning management systems into adaptive, personalized platforms that deliver digital content tailored to the needs of learners. These modules focus on automated test generation, intelligent learning, predictive analytics, and learning content creation, which can reduce educator workload and improve student engagement. Our pilot experiments show that integrating AI into Moodle can increase efficiency, learning outcomes, and overall satisfaction for both learners and educators.

Keywords—artificial intelligence, e-learning, Moodle, personalized education, adaptive content.

I. INTRODUCTION

The infusion of artificial intelligence (AI) into educational paradigms is reshaping the delivery and reception of knowledge in profound ways. AI-driven systems excel at personalizing educational content by dynamically adapting materials in real-time to match the unique needs, pace, and preferences of individual students, thereby amplifying engagement and optimizing learning outcomes [1]. This personalization extends beyond mere content adjustment; it encompasses the automation of pedagogical tasks, allowing learners to concentrate on deeper analytical activities, such as case studies and problem-solving, rather than grappling with logistical or technical hurdles in content delivery.

For educators, AI serves as a liberating force by providing immediate, actionable feedback and curating adaptive content streams based on learner profiles, which in turn liberates instructors to prioritize high-impact interactions like mentoring and creative guidance. Empirical evidence from various studies highlights the motivational uplift and higher course completion rates associated with AI interactions, particularly in higher education settings through intelligent tutoring systems and recommendation engines [1]. Yet, this technological advancement is not without its complexities. Ethical dilemmas, including data privacy concerns, algorithmic biases, and the occasional inaccuracies in AI outputs, necessitate vigilant human oversight to ensure equitable and reliable educational experiences. Furthermore, the imperative for inclusive education—making higher learning accessible to individuals with disabilities —calls for the seamless embedding of AI tools into digital infrastructures, leveraging techniques like comprehension testing and advanced natural language processing (NLP) to foster personalized and optimized student engagements.

At the heart of this transformation lies the Moodle Learning Management System (LMS), a globally dominant open-source platform renowned for its versatility and extensibility. Moodle commands substantial market penetration, holding a 73% share among institutions in Latin America and 56% in Oceania (including Australia and New Zealand) [2]. Its strengths in structuring courses, facilitating student-teacher communication, and managing assessments are well-documented, yet its dependence on manual instructor inputs for content curation and learner support presents ripe opportunities for AI augmentation. Moodle's inherently modular architecture lends itself ideally to the incorporation of AI enhancements, enabling the development of plugins that enrich the pedagogical process.

Direct AI integration within Moodle—via plugins for generating tailored content or assessments—harnesses machine learning (ML) algorithms and

behavioral analytics to craft individualized learning trajectories attuned to students' learning styles and requirements [3]. Comparative analyses of AI-infused content systems, such as MoodleSense, Canvas LMS, Docebo, TalentLMS, and Blackboard Learn, alongside manual approaches augmented by tools like ChatGPT, reveal marked advancements in instructor productivity, material quality, and curricular alignment. These AI capabilities in Moodle pave the way for advanced concepts like adaptive learning, skill-based knowledge evaluation through intelligent assessments, and instantaneous feedback loops. A key advantage is the substantial reduction in educators' preparatory workload, allowing more time for substantive teaching.

Nevertheless, guaranteeing the pedagogical integrity of AI-produced materials poses hurdles, demanding adherence to academic standards, data protection protocols, and ethical AI governance. Emerging scholarship posits that these efforts are forging the next era of e-learning platforms, synergizing AI personalization with robust pedagogical frameworks, though refinements are essential.

II. LITERATURE REVIEW

One hallmark of AI's educational value is its capacity for swift content synthesis, which extends to refining assessment protocols within Moodle. Educators can leverage AI to automate evaluations and dispense formative insights, with sophisticated NLP models enabling precise scoring of essays, assignments, and projects. Beyond grading, AI utilities detect plagiarism, discern paraphrasing, and fabricate resources like quizzes or lecture synopses, expediting the expansion of instructionalassets while ensuring alignment with pedagogical goals and multimedia integration.

Moodle's AI augmentation further bolsters predictive analytics, accessibility enhancements, and inclusivity for learners with special needs. Predictive algorithms track engagement metrics to flag at-risk students prone to attrition, while collaborative features—such as AI-orchestrated group formations, virtual/augmented reality infusions, and experiential simulations—fortify student-instructor synergies. For faculty, AI yields productivity gains through intuitive dashboards and automated curriculum recommendations. As the preeminent LMS globally, Moodle's plugin ecosystem is a fertile ground for AI innovation, with this review spotlighting tools that advance content authoring, assessment, and integrity safeguards.

Exemplary plugins include:

- AIC Content Generator (attoaic): This module seamlessly embeds generative AI (e.g., OpenAI's ChatGPT) into Moodle's Atto text editor, empowering instructors to produce course elements like summaries or activity guidelines without platform egress. With tunable draft lengths and role-specific permissions, it excels in swift prototyping, aligning with research on AI assistants that curtail repetitive authoring while mandating supervisory review [4].

- Generative AI Question Bank (qbank_genai) and AI Text to Question Generator (local_aiquestions): These harness OpenAI models to transmute course documents or prompts into multiple-choice or short-answer items, populating Moodle's question repository for curation [5]. They mitigate the labor-intensive nature of question stockpiling; studies affirm that instructor-vetted AI queries rival human-crafted ones in reliability and educational merit.

- TurinQ: An external AI question generator aligned with Bloom's Taxonomy, it processes lecture notes or transcripts to yield questions spanning recall to critical analysis, exportable as Moodle-compatible XML. This taxonomic fidelity upholds assessment best practices, equilibrating cognitive demands.

- Detecting AI and Copyleaks Integration: These plugins furnish granular linguistic scrutiny of submissions, flagging AI authorship, paraphrasing, or plagiarism. Amid generative AI's proliferation, such detectors are vital for upholding assessment credibility, with evolving

accuracies addressing false positives from stylistic cues.

- TinyMCE Editor's Built-in AI (tiny_ai): Tailored for Moodle's TinyMCE interface, it integrates via the AI Manager plugin to offer text simplification, personalization, accessibility tweaks, and multimedia generation (e.g., summaries, translations, audio, images) directly in forums or pages. It streamlines authoring for inclusivity and creativity.

- Local AI Manager (local_ai_manager): Serving as a hub for multilingual model orchestration (ChatGPT, Ollama, Gemini), it enables user/role-based segmentation, credit allocation, usage analytics, and self-hosted integrations, facilitating scalable, institution-tailored AI governance [6].

The proliferation of these plugins positions Moodle as an evolving, intelligent scaffold for teaching and learning. Yet, integration pitfalls persist: AI outputs may harbor factual inaccuracies, misaligned queries, or vague formulations that undermine efficacy absent instructor intervention [7]. Ethical/legal frictions—data privacy, algorithmic inequities, over-dependence—compound with integrity threats from generative tools, amplified by API costs and setup complexities in under-resourced settings [7, 8]. Ultimately, AI's promise in Moodle—to amplify efficiency, engagement, and scalability—demands a balanced, hybrid paradigm where AI augments, rather than supplants, human pedagogical acumen.

III. SYSTEM ARCHITECTURE DIAGRAM

Traditional e-learning environments often suffer from a "one-size-fits-all" approach, providing static content that fails to account for varying student proficiency levels or offer tangible interaction. This paper presents a novel, hybrid adaptive learning system that leverages the cognitive capabilities of Generative Artificial Intelligence (AI) and Retrieval-Augmented Generation (RAG) to provide personalized, grounded educational experiences. The proposed framework utilizes an OpenAI-orchestrated backend via FastAPI to dynamically synthesize lessons and assessment modules categorized into Beginner, Intermediate, and Professional tiers.

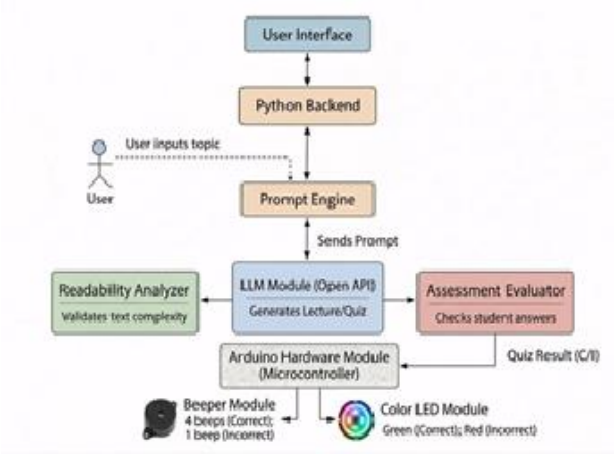

Fig. 1. System Architecture of an Adaptive E-Learning System using LLM Modules

IV. METHOD

A. Research Design

This investigation adopts an experimental paradigm to probe AI-powered plugin assimilation in Moodle for content fabrication. The methodology unfolds across four iterative phases: (1) Environment Setup, (2) AI Content Generation, (3) AI Content Evaluation, and (4) Reporting Content Issues. This phased structure ensures a methodical progression from technical provisioning to qualitative scrutiny, yielding robust insights into AI's practical viability.

B. Experimental Environment

Central to the study is a dedicated Moodle LMS instance, augmented with curated AI plugins for content synthesis (e.g., AIC Content Generator, tiny_ai), question formulation (e.g., qbank_genai, local_aiquestions), and evaluative adjuncts like grammar validators and readability auditors. A bespoke experimental Moodle deployment was erected to isolate testing from live courses, preserving ecological validity while mitigating disruptions.

C. Research Procedure

The evaluative framework dissects AI content integration into Moodle via a quartet of sequential

stages, as delineated in Section A (see Fig. 1 for process visualization).

- Stage 1: Environment Setup initiates with Moodle configuration, encompassing plugin installation, sample course instantiation, and API linkages (e.g., to external services). This phase emulates authentic instructional contexts to generalize findings.

- Stage 2: AI Content Generation deploys AI modules to fabricate foundational materials per a standardized schema, targeting lecture narratives and assessment instruments. Text generators craft topical lectures from source inputs, while question tools auto-populate Moodle banks—mirroring AI's core role in easing instructor content labor. Prompt engineering is pivotal here, ensuring topical relevance.

- Stage 3: AI Content Evaluation rigorously assays output quality for pedagogical fitness, employing dual metrics: AI-driven grammar audits for syntactic fidelity and readability scans for comprehension accessibility. These validate alignment with scholarly benchmarks and learner suitability.

- Stage 4: Reporting Content Issues aggregates findings into actionable dossiers, cataloging discrepancies, errorThis orchestrated approach harmonizes technical execution with pedagogical validation, affirming AI's supportive mantle in efficacious instruction

V. RESULTS AND DISCUSSION

Subsequent AI Content Generation tested three lectures (L1: Introduction to HTML; L2: Basic HTML Tags; L3: Introduction to CSS) and cognate question banks (QB1–QB3, five items each), yielding ~349 words per lecture via prompts like "Generate a lecture on Web technologies topic [X] with examples."

Automated evaluation in Stage 3 harnessed WebFX and Grammarly across 14 indices (Table I). Lectures evinced greater intricacy (e.g., L1: Flesch Reading Ease 52.3, Grade Level 10.8) versus banks' brevity (QB1: Ease 85.4, Grade 3.5). Grammarly scores excelled (91–97), with lectures boasting richer lexicons (31–58% unique words) and elongated sentences (7.9–20.3 words), befitting specialized audiences like upper-secondary or university cohorts. L2 shone in readability, buoyed by bulleted exemplars.

Stage 4's reportage illuminated variances: AI yields digestible yet superficial content, excelling in scaffolds but faltering in profundity. Prompt specificity modulates outputs—e.g., L2's structure elevated metrics—yet theoretical lacunae persist, underscoring human curation's necessity.

Key Insights Addressing the Research Question:

- Integration Feasibility: AI providers and editors render Moodle augmentation intuitive for course orchestration.
- Generative Efficiency: Modules expedite lectures, banks, and tasks; bespoke prompts calibrate depth/simplicity per goals.
- Quality Metrics: Topic complexity and exemplars sway readability; AI suits augmentation, not autonomy.

I. Ai Content Evaluation Results

Metric		**AI Content**		**AI Question Bank**		
L1	***L2***	***L3***	***QB1***	***QB2***	***QB3***	
1. Flesch Kincaid Reading Ease	52,3	75,9	67,2	85,4	77,4	87,1
2. Flesch Kincaid Grade Level	10,8	4,5	7,8	3,5	5,5	4,9
3. Gunning Fog Score	13,7	6,7	9,3	5	8,6	8,5
4. SMOG Index	10,2	5,7	8,1	3,8	6,6	5,8
5. Coleman Liau Index	14,1	8	7,9	5,9	5,9	1,3
6. Automated Readability Index	12,3	1,2	5,5	0,3	2	-1

7. Grammarly Text score	91	97	93	95	96	96
8. Grammarly Readability score	50	71	57	87	82	94
9. Grammarly Unique words	58%	31%	31%	36%	42%	46%
10. Grammarly Rare words	34%	34%	33%	20%	30%	21%
11. Words	330	330	379	168	159	169
12. Word length	5,1	2,8	2,6	3,3	3,8	4
13. Sentences	17	56	37	28	36	36
14. Sentence length	20,3	7,9	10,2	6	4,4	4,7

VI. CONCLUSION

The assimilation of AI modules into Moodle heralds a paradigm shift in content dissemination, particularly for nascent lecture drafts, ancillary study aids, and evaluative constructs. While AI augments efficiency and scaffolds coherent materials, educators' stewardship remains paramount to infuse pedagogical depth, factual precision, and curricular congruence. Analyses reveal Readability fluctuations by theme underscore clarification needs for diverse audiences, reaffirming instructors' expertise in exemplar curation. In domains like programming or web tech, AI's prowess in code snippet generation could heighten comprehension and immersion, prioritizing conceptual essence over tedium. Output caliber hinges on prompt granularity and topical nuance, advocating instructor-led refinement. In sum, AI enriches Moodle ecosystems as a potent adjunct, expediting preparation while upholding human-centric excellence in learning efficacy.

REFERENCES

1. C.-C. Lin, A. Y. Q. Huang, and O. H. T. Lu, "Artificial intelligence in intelligent tutoring systems toward sustainable education: a systematic review," Smart Learning Environments, vol. 10, no. 1, Aug. 2023
2. P. Hill, "Observations on the higher education LMS market," On EdTech Newsletter, Mar. 14, 2024. [Online]. Available: https://onedtech.philhillaa.com/p/observations-on-higher-ed-lms- market. [Accessed: Aug. 24, 2025].
3. O. Ovtšarenko, "Innovative techniques for e-learning log data processing: Trends and methods," Journal of Innovation & Knowledge, vol. 10, no. 5, p. 100765, Jul. 2025, doi: 10.1016/j.jik.2025.100765.
4. Developer CK, "AIC content generator," Moodle.org, Mar. 14, 2024. [Online]. Available: https://moodle.org/plugins/atto_aic. [Accessed: Aug. 25, 2025].
5. Wilenius, "Generative AI Question Bank," Moodle.org, 2024. [Online]. Available: https://moodle.org/plugins/qbank_genai. [Accessed: Aug. 25, 2025].
6. P. Mayer, P. Memmel, and ByCS Lernplattform, "AI Manager," Moodle.org, 2025. [Online]. Available: https://moodle.org/plugins/local_ai_manager. [Accessed: Aug. 25, 2025].
7. M. Firat, "10 Key Challenges in Integrating Generative AI into Educational Systems," 36th Asian Association of Open Universities Annual Conference (AAOU 2023), pp. 45-49, 2023.
8. J. A. Delello, W. Sung, K. Mokhtari, J. Hebert, A. Bronson, and T. De Giuseppe, "AI in the Classroom: Insights from Educators on Usage, Challenges, and Mental Health," Education Sciences, vol. 15, no. 2, p. 113, Jan. 2025,
9. C. Sirisuriya, L. Ranathunga, S. Karunanayaka, and A. Abdullah, "An analysis to identify the most suitable readability formula for Sri Lankan Context: Case Study Computer Science students," .the .International Conference on Global Education and E- learning, Mar.
10. R. Gopal, M. Maniam, N. A. Madzlan, S. S. B. Shukor, and K. Neelamegam, "Readability formulas: An analysis into reading index of prose forms," Deleted Journal, vol. 8, no. 3, pp. 972–985, Sep. 2021,