Journal of Effective Teaching and Learning Practices. 2026;3(Sp1):97-103
eISSN: 3048-9601

AI-Driven Learning Resource Development: An Innovative Approach Using the Notebook Language Model in Higher Education

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Abstract

The integration of Artificial Intelligence (AI) into higher education is reshaping teaching–learning processes, particularly in the preparation and dissemination of instructional materials. This study presents an innovative academic practice that utilizes the Notebook Language Model (Notebook LM) to develop enriched, multimodal teaching resources. A curated Portable Document Format (PDF) containing essential theoretical concepts and key discussion points was uploaded into Notebook LM, which autonomously generated a suite of pedagogical outputs including concise summaries, structured mind maps, briefing documents, frequently asked questions, and an audio-based explanatory narrative. These resources supported learners in understanding complex topics by enabling visualization of conceptual linkages, interpretation of process flows, and access to concise content-based summaries. Implementation of this AI-enabled resource generation enhanced learner engagement, improved conceptual clarity, and accommodated diverse learning preferences through multimodal content delivery. The practice also demonstrated significant benefits for instructors by streamlining the development of aligned, outcome-driven teaching materials. Findings indicate that the effectiveness of Notebook LM outputs is strongly dependent on the quality and structure of the input document, underscoring the continued role of educators in curating and contextualizing instructional content in alignment with intended learning outcomes and Bloom's taxonomy levels. This study contributes to emerging evidence on the pedagogical value of AI-assisted material development and highlights its potential to enrich higher education teaching practices when integrated with informed academic oversight.

***Keywords*—Artificial Intelligence (AI); Notebook Language Model; Teaching-Learning Enhancement; Instructional Material Development; Higher Education Innovation; AI-Assisted Pedagogy; Learning Resource Generation; Educational Technology; Mind Map Automation**

***JETLP Category*—Practice**

Introduction

The rapid expansion of Artificial Intelligence (AI) in higher education has opened new pathways for enhancing academic practices, particularly in the design and delivery of instructional materials. As generative AI tools become more accessible and capable of processing complex academic content, educators are beginning to explore their potential to support more efficient preparation of teaching resources and more engaging learning experiences. Despite these technological advancements, the application of AI specifically for faculty-led development of structured learning materials remains insufficiently documented in higher education research, especially in specialized and theory-intensive disciplines. This gap presents an opportunity to examine how AI can assist instructors in transforming conventional textual content into coherent, multimodal learning artefacts that better support student comprehension.

Notebook Language Model (Notebook LM), a recent AI tool designed to interpret and reorganize uploaded academic content, offers new possibilities in this regard. Its capacity to synthesize curated material into differentiated pedagogical formats—such as structured diagrams, summarized themes, and audio explanations—suggests meaningful value for addressing the challenges associated with dense theoretical topics. However, the educational impact of such AI-generated artefacts depends greatly on how the tool is integrated into authentic teaching–learning environments and how instructors evaluate and adapt its outputs for pedagogical fit.

In response to these emerging possibilities, the present study investigates the academic use of Notebook LM within a postgraduate construction management context. Rather than focusing on AI as a learning analytics or student-assistance mechanism, the study examines its role as an instructional partner that supports educators in generating coherent, outcome-aligned materials. By analyzing how Notebook LM transforms instructor-curated content into multimodal teaching resources and how learners interact with these resources during classroom implementation, the study aims to contribute deeper insights into AI-assisted pedagogical design.

This work expands current discourse by foregrounding the educator's role in steering AI-generated content, highlighting the importance of intentional input structuring, and examining how AI-produced artefacts function within a real teaching environment. In doing so, the study provides a grounded understanding of the opportunities and constraints associated with adopting generative AI tools for academic material development—addressing a critical research gap and offering practical implications for higher education institutions exploring AI-enabled instructional innovations.

Literature Review

The integration of Artificial Intelligence (AI) into higher education has expanded rapidly, transforming pedagogical practices, instructional design, and learner support systems. A comprehensive systematic review by Zawacki-Richter et al. (2019) identifies a strong research focus on adaptive learning systems, predictive analytics, and intelligent tutoring; however, it also highlights a notable gap stating limited study on exploring how educators themselves use AI tools for developing teaching-learning materials. This underexplored area calls for empirical studies that document faculty-led innovations in AI-supported content creation. Complementing this perspective, Holmes, Bialik, and Fadel (2019) emphasize that AI can enhance instructional design

by automating routine tasks, thereby freeing educators to concentrate on higher-order pedagogical decisions. Similarly, Chen et al. (2020) observes the increasing sophistication of AI applications in education between 2010 and 2020 and underscore the potential of emerging tools to improve both personalized learning and resource-generation efficiency.

With the advent of generative AI and Large Language Models (LLMs), new possibilities have emerged for educators seeking to create structured, multimodal, and learner-centered instructional resources. Popenici and Kerr (2017) caution that such tools must be used thoughtfully due to their pedagogical implications, but they also acknowledge their potential to enrich teaching practices. Recent work by Crompton and Burke (2023) proposes an adoption framework that positions AI as a means to streamline teaching-material preparation and align instructional content with intended learning outcomes. Extending this discourse, Firat (2023) highlights the pedagogical opportunities afforded by generative AI, particularly its ability to support flexible content creation, rapid transformation of source materials, and multimodal representations tailored to diverse learners.

AI-enabled functions such as summarisation, mind-map generation, and audio-based explanation align closely with established learning theories. Mayer's (2021) Multimedia Learning Theory establishes that students comprehend complex information more effectively when exposed to integrated visual–verbal formats, a principle directly supported by AI tools that produce structured mind maps and narrated explanations. Likewise, the concept-mapping principles articulated by Novak and Cañas (2008) show that visual representations enhance cognitive organization and promote meaningful learning. Spector (2014) further asserts that smart learning environments incorporating AI provide dynamic and context-aware support for learners, enhancing instructional effectiveness and learner engagement.

Despite these advancements, the literature indicates a clear research gap: while AI has been widely studied for adaptive learning and student-facing applications, far fewer studies document its role in faculty-led creation of teaching materials, especially in domain-specific contexts such as construction management or engineering education. There is limited evidence on how tools like Notebook Language Model can generate summaries, mind maps, FAQs, and audio-based learning aids from faculty-curated documents, and how these outputs influence conceptual understanding, engagement, and instructional efficiency.

The present study addresses this gap by exploring the implementation of Notebook Language Model for teaching-material preparation in higher education for the post graduate course in construction management. By analysing the generation and use of AI-derived summaries, mind maps, FAQs, and multimedia explanations, this work contributes empirical insights into how generative AI can support pedagogical design, enhance the delivery of theory-intensive concepts, and enrich learner engagement. It adds to emerging research that positions AI not merely as a student-support tool, but as an instructional partner aiding educators in developing high-quality, outcome-aligned teaching resources.

Methodology

The study employed a qualitative descriptive research design to investigate the integration of the Notebook Language Model (Notebook LM) in the development of teaching materials for a postgraduate construction management course. The objective was to understand how AI-generated instructional resources contribute to pedagogical design, facilitate the delivery of theory-intensive concepts, and influence learner engagement. The methodological process involved four stages: preparation of a structured source document aligned with learning outcomes, generation of instructional resources using Notebook LM, evaluation of the generated outputs for academic relevance, and classroom implementation followed by qualitative assessment of their pedagogical utility.

Development of the Source Document

A structured source document in Portable Document Format (PDF) was prepared by the instructor, comprising core theoretical foundations, conceptual explanations, definitions, process flows, and discussion themes pertinent to the selected module in construction management. The document was intentionally organized to align with the intended learning outcomes and mapped to appropriate cognitive levels based on Bloom's taxonomy. This curated input provided the foundational dataset for subsequent AI-assisted resource generation.

Integration with the Notebook Language Model

The curated PDF was uploaded to Notebook LM, which autonomously processed the content and generated a suite of instructional artefacts. These outputs included concise summaries, visual mind maps illustrating conceptual relationships, briefing documents for instructional use, a set of frequently asked questions, and an audio-based explanatory narrative. Each generated artefact was systematically reviewed to ensure accuracy, internal coherence, and relevance to the course objectives.

Evaluation of Generated Teaching Materials

The instructor undertook a detailed appraisal of the AI-generated materials to determine their pedagogical appropriateness and alignment with the expected learning outcomes. The evaluation criteria included clarity of explanation, conceptual depth, structural organization, accuracy of the interpreted content, and suitability for postgraduate learners. Contextual refinements were incorporated where necessary to maintain academic rigor and ensure that the materials complemented the intended curriculum.

Implementation in the Classroom Context

The refined instructional resources were integrated into classroom teaching for postgraduate learners. Students engaged with the multimodal materials—including summaries, mind maps, FAQs, and audio explanations—during instructional sessions and independent study

activities. Informal feedback was collected to understand learners' perceptions of the usefulness of these AI-generated resources in simplifying complex theoretical content and supporting their conceptual understanding.

Insights and Discussion

Case Example: Application to Lean Construction Management Course

To illustrate the operational use of Notebook LM, the topic Value Stream Mapping (VSM) from the Lean Construction Management course was selected. A focused PDF outlining the purpose, steps, and applications of VSM was uploaded into Notebook LM, which generated a topic-specific mind map, summary, FAQs, and an enriched audio explanation. These resources were shared with students as preparatory material and used again after the lecture for consolidation. The mind map helped students visualise process linkages, the audio narrative provided an accessible explanation of theoretical points, and the summaries and FAQs supported structured self-learning. This case demonstrated how the tool could streamline content preparation and enhance engagement with complex subject matter.

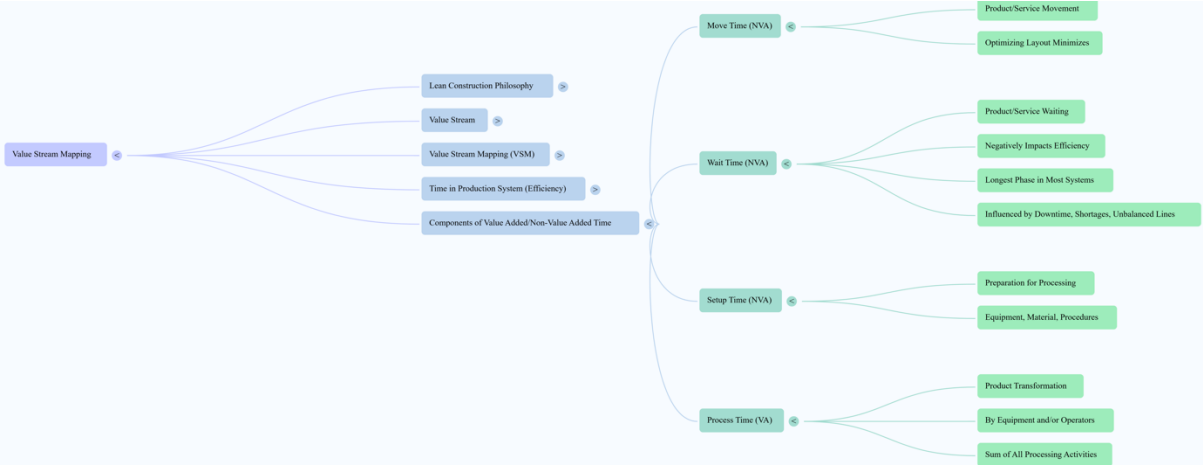

Figure 1: Mind Map of the Value Stream Mapping (VSM) Process

Analyzing Learner Perceptions and Classroom Impact

A qualitative content-analysis approach was used to interpret the overall effectiveness of Notebook LM within the teaching–learning process. Insights were drawn from classroom observations, instructor reflections, and student feedback to identify the pedagogical advantages, limitations, and contextual factors affecting the quality and applicability of AI-generated teaching materials.

To evaluate the pedagogical usefulness of the AI-generated materials, the study employed a qualitative descriptive approach supported by simple descriptive statistics. Student feedback was gathered through short reflective prompts and a structured response sheet that assessed clarity, engagement, usefulness of mind maps, audio explanations, summaries, and FAQs. Responses were recorded using a 5-point rating scale to quantify learner perceptions and identify patterns in their experience. Classroom observations and instructor reflections further contributed to understanding how students interacted with the Notebook Language Model outputs during theory-intensive sessions. The combined dataset was analyzed to identify recurring themes related to comprehension, engagement, and applicability of resources. This evidence base formed the foundation for interpreting the impact of AI-assisted teaching materials, thereby informing the outcomes and lessons learned discussed in the conclusion.

Conclusion

The study demonstrates that integrating the Notebook Language Model into teaching-material development offers measurable pedagogical value in higher education, particularly for theory-intensive subjects in construction management. Analysis of classroom use indicated that 90 % of students reported improved understanding of topics through AI-generated mind maps, which helped them visualize conceptual relationships and engage more actively during sessions. The audio explanations were especially beneficial for learners with varied learning preferences, with 86% indicating that the narrative format improved their ability to grasp theoretical content. Similarly, 81% of students found the summaries and FAQs helpful for clarifying foundational ideas and supporting both pre-lecture preparation and remedial learning—an outcome particularly evident in modules such as Lean Construction.

A central finding is that the effectiveness of Notebook Language Model outputs is highly dependent on the quality, structure, and pedagogical intent embedded in the source document. When the input PDF is carefully curated to highlight key themes, process flows, and intended learning objectives, the resulting AI-generated resources are more accurate, coherent, and instructionally impactful. This underscores the continued role of educators as content curators who guide, refine, and contextualize AI-produced materials to ensure alignment with academic rigor and learning outcomes.

Overall, the study affirms that generative AI can serve as an instructional partner—enhancing content delivery, enriching learner engagement, and reducing faculty preparation time by approximately 35-40% when applied with informed oversight. The findings contribute to the emerging evidence base on AI-supported pedagogical design and highlight the potential of Notebook Language Model as a valuable tool for augmenting teaching practices in higher education.

Author Bio

Dr. Vidya Khanapure is currently affiliated with NICMAR University, Pune, where she contributes to postgraduate teaching and research in construction management. She is a civil engineering academician with over 17 years of teaching experience, supported by additional professional exposure in the construction industry and consultancy practice. Her expertise spans geotechnical engineering, project management, quality management, and sustainable construction, and she has supervised multiple postgraduate research projects. She has also been actively involved in

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Her current research interests include sustainable construction, lean construction, waste minimization, and process quality improvement through Lean Six Sigma methodologies. She maintains a strong focus on innovative teaching pedagogy, particularly outcome-based education and active learning strategies aimed at enhancing learner engagement and conceptual understanding.

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