

A Visual Tool to Support Multimodal Instructional Planning

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Abstract. *LEML Studio.Br is a visual tool designed to support multimodal instructional planning across face to face, synchronous, asynchronous, and hybrid settings. We evaluated the tool with 16 university Software Engineering instructors using a mixed methods online questionnaire that combined Likert scale items and open responses. Participants reported high usability and strong alignment with prior process modeling experience yet revealed a persistent gap between technical fluency with the notation and pedagogical appropriation of its elements. We conclude that visual modeling facilitates the externalization and inspection of instructional flows and helps identify planning gaps, but its pedagogical impact depends on embedded conceptual scaffolds and targeted teacher development*

Keywords— Educational technology, Multimodal instruction, Instructional design, Visual modeling, Learning Environment Modeling Language; Teacher professional development.

Resumo. *O LEML Studio.Br é uma ferramenta visual projetada para apoiar o planejamento instrucional multimodal em ambientes presenciais, síncronos, assíncronos e híbridos. Avaliamos a ferramenta com 16 professores universitários de Engenharia de Software por meio de um questionário on-line de métodos mistos que combinava itens da escala de Likert e respostas abertas. Os participantes relataram alta usabilidade e forte alinhamento com experiências anteriores de modelagem de processos, mas revelaram uma lacuna persistente entre a fluência técnica com a notação e a apropriação pedagógica de seus elementos. Concluímos que a modelagem visual facilita a externalização e a inspeção dos fluxos instrucionais e ajuda a identificar lacunas no planejamento, mas seu impacto pedagógico depende de estruturas conceituais integradas e do desenvolvimento profissional direcionado dos professores.*

Palavras-chave— Tecnologia educacional, Ensino multimodal, Design instrucional, Modelagem visual, Linguagem de Modelagem de Ambientes de Aprendizagem; Desenvolvimento profissional de professores.

1. Introduction

The rapid expansion of hybrid and digital learning environments in the post-pandemic era has made multimodality a central concern for higher education, increasing both the opportunities for interaction and the complexity of instructional planning [Mentzer et al. 2025, Leijon and Lundgren, 2019].

Multimodal instructional design—the intentional integration of face-to-face, synchronous, asynchronous, and simulated learning spaces—requires explicit articulation among learning objectives, activities, mediation strategies, and assessment mechanisms to preserve coherence, accessibility, and continuity across contexts [Laforcade, 2005, Jiang, 2011]. Yet many institutions continue to rely on linear documents and fragmented templates that obscure structural relationships and hinder systematic planning [Kikbanova and Zhienbayeva, 2024].

Formal educational modeling languages offer a promising alternative by making pedagogical logic explicit and verifiable. The Learning Environment Modeling Language (LEML) provides a visual notation capable of representing activities, resources, interactions, and evidence of learning, and its process-oriented syntax aligns naturally with modeling practices familiar to instructors in technical fields [Kourouma et al., 2022]. However, the adoption of such languages depends on tools that render the notation accessible to teachers without specialized training in instructional design. As the manuscript notes, “The interface feels familiar, similar to tools I already use for workflow modeling.” and “I understand what the icons represent technically, but I am not always sure what they mean pedagogically.”

This paper introduces LEML Studio.Br, a visual tool designed to support multimodal instructional planning by translating pedagogical decisions into structured, shareable models. We report an exploratory mixed-methods evaluation with 16 university Software Engineering instructors that examine perceptions of interface clarity, conceptual understanding of the language, and perceived pedagogical applicability.

Our primary contribution is twofold: [1] a practical artifact that operationalizes LEML for multimodal course design, and [2] empirical evidence of a recurring tension between technical usability and pedagogical appropriation, which motivates the integration of embedded conceptual scaffolds and targeted teacher development in future tool iterations.

2. Fundamentals

This chapter presents the conceptual foundations that inform the development of LEML Studio.Br. It integrates four complementary perspectives: multimodal instructional design, educational modeling languages, usability and pedagogical appropriation, and visual modeling as a mediator of instructional planning.

To align the theoretical discussion with the practical contribution of this study, the chapter concludes with a dedicated subsection describing the LEML Studio.Br tool, its architecture, and its intended pedagogical affordances.

2.1 Multimodality and Instructional Design

The post-pandemic expansion of hybrid and digital learning has made multimodality a central concern for higher education, increasing both pedagogical opportunities and

design complexity [Shim, 2023]. Multimodal instructional design requires the intentional coordination of face-to-face, synchronous, asynchronous, and simulated learning spaces so that objectives, activities, mediations, and assessments remain coherent and accessible across contexts [Jiang, 2011].

When planning remains confined to linear documents or fragmented templates, instructors struggle to represent structural relationships, anticipate student cognitive load, and preserve continuity across modalities [Kikbanova and Zhienbayeva, 2024]. Consequently, tools that make relationships explicit and verifiable are essential for sustaining pedagogical coherence in multimodal courses.

2.2 Educational Modeling Languages

Formal modeling languages translate instructional logic into structured, shareable representations. The Learning Environment Modeling Language [LEML] offers a visual notation capable of representing activities, resources, interactions, and evidence of learning within instructional flows [Yingyi, Razak and Halili, 2024].

LEML draws inspiration from process-modeling traditions in software engineering (e.g., UML, BPMN), which makes it particularly accessible to instructors with technical backgrounds (6). The adoption of such languages promises three practical benefits: (1) explicit representation of pedagogical logic, enabling clearer alignment among objectives, activities, and assessment; (2) standardization of design practices, supporting reuse and collaboration; and (3) improved communication between instructors and instructional designers. However, the effectiveness of these benefits depends on tool affordances that lower the barrier to entry for educators without formal training in modeling or instructional design.

2.3 Usability and Pedagogical Appropriation

Adoption of educational modeling tools involves two distinct but related constructs: usability and pedagogical appropriation. Usability concerns interface clarity, navigation, and interaction efficiency; pedagogical appropriation concerns the user's ability to interpret modeling elements in instructional terms and to translate pedagogical intentions into formal representations.

Prior work shows that high usability does not guarantee pedagogical uptake when users lack conceptual scaffolding: they may manipulate graphical elements correctly without understanding their instructional function [Rojas-Magdaleno and López-Morteo, 2025]. Thus, evaluations of modeling tools must assess both the technical ease of use and the extent to which the tool supports meaningful pedagogical reasoning.

2.4 Visual Modeling as a Mediator of Instructional Design

Visual modeling functions as a cognitive artifact that externalizes instructional structure and supports reflective design. By rendering flows, dependencies, and evidence explicit, diagrams help instructors identify gaps between objectives and activities, anticipate transitions across modalities, and plan assessment and mediation strategies more systematically.

In multimodal contexts—where students navigate between physical and digital spaces—such externalization can reduce fragmentation and support continuity. Yet, for visual modeling to mediate pedagogical reasoning effectively, tools must combine clear

syntax with embedded conceptual support (examples, templates, prompts) that guide users in mapping pedagogical intentions to modeling constructs. Without these supports, visual clarity may facilitate initial engagement but fail to produce deeper changes in instructional practice.

2.5 Description of the Developed Tool

To operationalize LEML for multimodal instructional planning, we developed LEML Studio.Br, a visual modeling software environment that enables instructors to construct, inspect, and refine multimodal instructional flows.

The tool translates pedagogical decisions into structured visual representations, enabling instructors to articulate relationships among learning activities, resources, interactions, and evidence of learning across face-to-face, synchronous online, asynchronous online, and hybrid modalities. This subsection describes the tool's purpose, interface architecture, and core functionalities, situating it within the theoretical perspectives discussed above.

The development of LEML Studio.Br responds to a well-documented challenge in multimodal instructional design: traditional linear planning formats (e.g., textual syllabi, checklists) obscure the structural dependencies that shape learning experiences. Visual modeling languages such as LEML offer a means to externalize instructional logic, but their adoption depends on accessible tooling that supports both syntactic manipulation and pedagogical interpretation. LEML Studio.Br was therefore conceived as a lightweight, software environment that lowers the entry barrier for instructors while preserving the expressive power of the underlying notation.

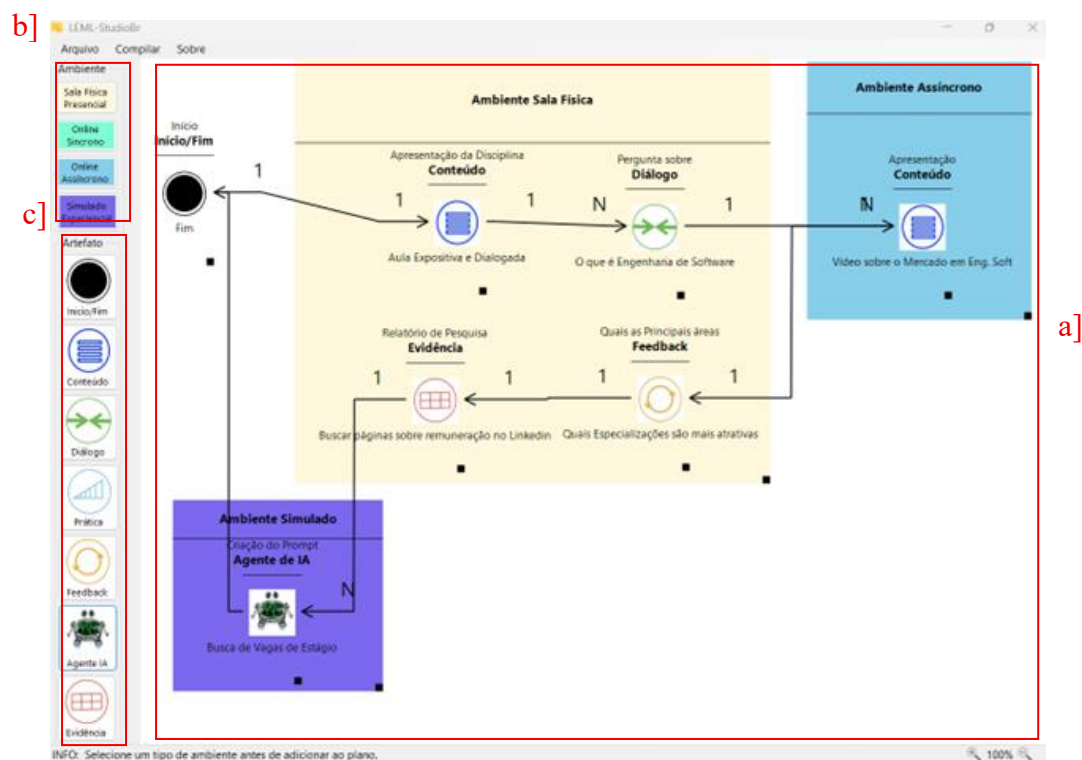


Figure 1. LEML Studio.Br Screen

The tool is organized into three integrated components, see in Figure 1:

- a) **Modeling Canvas.** A central drag-and-drop workspace where instructors construct instructional flows by arranging and connecting LEML elements. The canvas supports free spatial organization, enabling users to represent linear, branching, or iterative sequences.
- b) **Element Palette.** A sidebar containing the core LEML constructs—*Learning Activities*, *Resources*, *Interactions*, and *Evidence*. Each construct is represented by a distinct iconography and color scheme to facilitate rapid recognition and reduce cognitive load during model construction.
- c) **Properties Panel.** A contextual panel that appears upon element selection, allowing users to specify pedagogically relevant attributes such as modality, duration, learning objectives, required materials, or assessment artifacts. This panel bridges visual syntax with semantic detail, supporting more precise instructional representation.

This architecture mirrors established workflow-modeling environments, which contributes to the sense of familiarity reported by instructors with backgrounds in software engineering and process modeling.

LEML Studio.Br implements a set of core functionalities aligned with the requirements of multimodal instructional planning:

- **Element creation and manipulation**, including duplication, deletion, and repositioning.
- **Directional linking** to represent instructional flow, dependencies, and transitions between modalities.
- **Modality tagging**, enabling explicit identification of face-to-face, synchronous online, asynchronous online, and hybrid activities.
- **Visual validation cues**, which highlight disconnected elements or missing evidence of learning, prompting refinement of the instructional model.
- **Model export and sharing**, supporting collaborative design and documentation.

These capabilities allow instructors to iteratively refine instructional structures and to visualize the coherence of multimodal sequences.

A typical modeling session begins with the placement of a Learning Activity on the canvas, followed by the assignment of a modality and the addition of associated Resources and Interactions.

The instructor then links Evidence elements to the activity to represent assessment or verification of learning. As the model expands, transitions between modalities become visually explicit, enabling instructors to identify gaps, redundancies, or misalignments. Participants in the evaluation reported that this visual externalization prompted forms of pedagogical reflection not commonly achieved through traditional planning documents.

3. Methodology

This study adopted an exploratory mixed-methods design to evaluate LEML Studio.Br with respect to both interface usability and pedagogical interpretation. The approach combined descriptive quantitative measures with thematic qualitative analysis to capture patterns of acceptance, conceptual understanding, and perceived pedagogical value.

3.1 Research design and rationale

We selected a convergent mixed-methods design appropriate for an early evaluation of an emergent educational tool: quantitative items provide a structured view of perceived clarity and usability, while open responses reveal interpretive tensions and design needs. The exploratory framing is justified by the tool's developmental stage and the need to surface initial patterns, limitations, and directions for iteration.

3.2 Participants

Sixteen university instructors from Software Engineering and related fields in Brazilian higher-education institutions participated by convenience sampling. Participants varied in teaching experience (from early-career to senior faculty) and reported substantial familiarity with formal modeling languages such as UML and BPMN. We treat this technical profile as an analytic lens: prior modeling experience likely facilitates interface comprehension but may limit generalizability to non-technical disciplines.

3.3 Procedure

Participants received access to LEML Studio.Br and were instructed to explore the tool freely prior to completing the questionnaire.

The exploratory session was asynchronous and self-paced; average completion time for the questionnaire ranged from 10 to 15 minutes. This procedure prioritized ecological validity by allowing spontaneous interaction, but the short interaction window is acknowledged as a limitation for assessing deeper pedagogical appropriation.

3.4 Instrument

Data were collected using a structured questionnaire developed specifically for this study to evaluate participants' perceptions of the usability, conceptual clarity, and pedagogical applicability of LEML Studio.Br.

The instrument was organized into five thematic sections, each aligned with the analytical dimensions of the research: (a) professional profile and teaching context; (b) comprehension and usability of the tool; (c) perceived applicability of the tool for instructional planning; (d) perceived impacts on teaching practice; and (e) limitations and suggestions for improvement.

The questionnaire combined closed-ended items and open-ended prompts. The closed-ended items employed a five-point Likert scale (1 = strongly disagree; 5 = strongly agree) to capture structured perceptions regarding interface clarity, visual organization, coherence of modeling elements, and pedagogical utility. Table 1 presents the complete set of Likert items used in the evaluation.

The open-ended questions were designed to elicit qualitative insights into participants' interpretive processes, perceived challenges, and recommendations for future enhancements. Although the instrument was not subjected to formal psychometric validation, it underwent expert review for clarity and alignment with the study's objectives, ensuring suitability for exploratory research in educational technology.

Table 1. Likert-Scale Items Assessing Usability and Pedagogical Applicability of App

Code	Item
P01	The LEML Studio.Br interface is intuitive and easy to understand.
P02	The organization of visual elements and commands facilitates navigation within the tool.
P03	The tool's visual resources and notations are coherent with my prior experience in process modeling.
P04	The conceptual elements of the LEML model are easy to comprehend.
P05	The tool helps structure multimodal learning activities in a clear and organized manner.
P06	LEML Studio.Br adequately represents different instructional modalities and resources (face-to-face, virtual, simulated).
P07	The tool's visual notation makes the pedagogical architecture of the course explicit.
P08	Using the tool enhances coherence and integration among learning objectives, instructional strategies, and assessments.
P09	The tool supports alignment between educational objectives, learning tasks, and instructional modalities.
P10	The tool facilitates pedagogical transitions between synchronous and asynchronous learning moments.
P11	The purpose of the "rooms" (Physical, Online Synchronous, Online Asynchronous, Simulated) is clear to me.
P12	It is easy to distinguish and use the "artifacts" (Content, Dialogue, Practice, Feedback, Evidence, AI Agent) to represent pedagogical actions.
P13	The use of directional arrows and cardinalities to represent instructional flow is intuitive.

3.5 Data analysis

We report descriptive statistics for each Likert item (frequencies, medians, interquartile ranges) and summarize dimension scores (e.g., usability, conceptual clarity, pedagogical applicability). Given the small sample, inferential statistics were not used; instead, descriptive patterns guided integration with qualitative findings.

Open responses were analyzed using reflexive thematic analysis: iterative reading, open coding, and category development. Codes were grouped into themes that reflected (a) perceptions of interface affordances, (b) difficulties mapping pedagogical intentions to notation, and (c) suggestions for scaffolding and training. Integration of datasets followed an interpretive triangulation strategy: quantitative tendencies were used to orient qualitative coding, and qualitative excerpts were used to explain and nuance numeric patterns.

3.6 Ethical considerations

The study received institutional ethics approval (CAAE: 78969222.7.0000.5547], and the participation was voluntary and anonymous; They informed consent was obtained digitally. Key limitations include convenience sampling, the predominance of technically oriented participants (UML/BPMN familiarity), reliance on self-report rather than observational measures, and the brief interaction period (10–15 minutes) that constrains

claims about long-term appropriation or changes in instructional practice. These limitations are explicitly considered when interpreting findings and formulating recommendations for future, longitudinal studies that include observational and performance-based measures.

4. Results

This section integrates descriptive quantitative tendencies with thematic qualitative evidence to characterize participants' interactions with LEML Studio.Br. Findings are organized around three focal dimensions: usability and visual clarity, conceptual understanding of LEML elements, and perceived pedagogical value and limitations.

4.1 Usability and visual clarity

Participants reported consistently high ratings for interface clarity, visual organization, and navigation. Across items addressing layout, icon consistency, and manipulation of elements, the modal responses clustered at the positive end of the five-point scale (majority "agree" or "strongly agree"), and medians for core usability items fell at or above the scale midpoint. Qualitative comments corroborated these tendencies: several respondents described the interface as familiar and immediately manipulable, reducing the initial learning burden.

4.2 Conceptual understanding and pedagogical appropriation

Despite high usability scores, items probing conceptual clarity and the pedagogical semantics of modeling elements showed greater dispersion and higher rates of neutral or undecided responses. Participants frequently distinguished between technical comprehension of icons and pedagogical interpretation of those icons' instructional functions. Several open responses expressed uncertainty about mapping instructional intentions (e.g., choice of modality, assessment artifacts) onto the language's constructs.

Thematic analysis produced two recurrent subthemes: (a) syntax fluency—users could create and connect elements with minimal instruction; and (b) semantic uncertainty—users hesitated when asked to justify pedagogical choices encoded in the model. This divergence evidences a gap between operational usability and deeper pedagogical appropriation.

4.3 Perceived pedagogical value and identified needs

Participants recognized concrete pedagogical benefits of externalizing instructional flows. Commonly reported gains included improved visibility of transitions between modalities, easier identification of gaps or redundancies in activity sequences, and enhanced capacity to discuss course architecture with colleagues. Several respondents noted that the model prompted reflection that they had not achieved with linear planning documents.

At the same time, participants recommended specific supports to realize the tool's pedagogical potential: embedded examples and templates, contextual prompts explaining when to select a particular modalities or artifacts, and short, scenario-based tutorials. These suggestions map directly onto the conceptual gap identified above and point to actionable design priorities for subsequent iterations.

The integration of quantitative and qualitative evidence revealed differentiated patterns across the three evaluative dimensions. Usability emerged as a strong point, particularly for participants already familiar with UML or BPMN, whose prior exposure to similar interfaces appeared to reduce initial operational friction.

In contrast, perceptions of conceptual clarity were more heterogeneous; the descriptive statistics indicated greater dispersion and a tendency toward neutral responses, especially for items addressing pedagogical semantics, suggesting that these constructs were less immediately accessible.

Finally, participants generally regarded the tool's pedagogical applicability as valuable for supporting reflective practice and identifying learning gaps, although they emphasized that its effective use remains dependent on additional scaffolding and sustained teacher professional development.

5. Discussion

5.1 Interpretation of findings

The evaluation reveals a consistent pattern: high technical usability of LEML Studio.Br among Software Engineering instructors coexists with partial pedagogical appropriation. Participants reported that the interface was familiar and easy to manipulate, which reduced initial learning costs and supported rapid model construction.

At the same time, many users expressed uncertainty about the pedagogical meaning of specific notation elements and hesitated when mapping instructional intentions to modality choices.

This divergence indicates that interface fluency alone does not guarantee that users will translate models into robust instructional decisions. The pattern aligns with prior work showing that engineering-inspired notations can lower interactional barriers while leaving semantic interpretation unresolved [Kourouma et al., 2022, Rojas-Magdaleno and López-Morteo, 2025].

5.2 Theoretical implications

Two theoretical implications follow. First, the results empirically reinforce the distinction between usability and pedagogical appropriation as separate constructs that must be measured and supported independently.

Tools that optimize for one do not automatically achieve the other. Second, visual modeling functions as a cognitive mediator: it externalizes instructional structure and prompts reflection, but its mediating power depends on the availability of conceptual scaffolds that connect syntax to pedagogical reasoning. These implications extend literature on educational modeling languages by emphasizing the necessity of integrated semantic support for meaningful adoption [Selander, 2021, Yingyi, Razak and Halili, 2024].

5.3 Practical implications for tool design and teacher support

The findings indicate three central priorities for the design of pedagogical tools and the support offered to teachers. First, interfaces should incorporate conceptual scaffolds that reduce semantic ambiguity, including contextualized examples, prompts that guide

modality selection, and concise explanations of the pedagogical rationale behind each element.

Second, providing templates and scenario libraries can streamline instructional decision-making by offering reusable structures for common multimodal sequences, while also serving as concrete exemplars for novice educators.

Third, professional development should be targeted and practice-oriented, emphasizing the connection between modeling constructs and instructional objectives; such focused training is likely to foster appropriation more effectively than interface-based tutorials alone. Taking together, these design and support strategies can help transform initial usability gains into sustained and meaningful pedagogical practice.

5.3 Limitations and boundary conditions

Interpretation of the results must account for several limitations. The sample (N=16) was a convenience cohort of technically oriented instructors with prior UML/BPMN experience; this profile likely inflated usability ratings and limits generalizability to non-technical disciplines.

The asynchronous, self-paced exploration and the short interaction window (10–15 minutes) constrain inferences about long-term appropriation and changes in planning behavior. Finally, reliance on self-report measures precludes claims about actual instructional outcomes; observational and performance-based measures are required to establish behavioral change.

5.4 Directions for future research

Future studies should pursue three complementary lines. First, longitudinal field studies that observe instructors using LEML Studio.Br during real course design cycles will clarify whether embedded scaffolds and training produce durable appropriation.

Second, comparative studies with instructors from non-technical disciplines will test the tool's transferability and reveal disciplines specific scaffold needs.

Third, integrating and experimentally evaluating AI-assisted pedagogical agents or adaptive templates could determine whether automated guidance accelerates the mapping from syntax to pedagogy without undermining teacher agency. These directions will help move from promising usability to demonstrate a pedagogical impact.

6. Conclusion

LEML Studio.Br exhibits high usability among instructors familiar with process-modeling notations and effectively externalizes instructional flows, enabling the identification of gaps and inconsistencies in multimodal course plans. At the same time, our evaluation reveals a persistent pedagogical-conceptual gap: technical fluency with the notation does not automatically translate into confident pedagogical decision-making within multimodal frameworks.

As noted in the manuscript: “LEML Studio.Br shows high usability, particularly among instructors with strong technical backgrounds in formal modeling languages such as UML and BPMN”, or “While instructors readily understood the tool's visual syntax, many expressed uncertainties when attempting to represent instructional decisions within multimodal structures”.

These findings imply two linked conclusions. First, visual clarity is necessary but not sufficient: an intuitive interface reduces initial friction but does not ensure that models will be used to make sound instructional choices. Second, bridging syntax and semantics is essential: the tool must supply conceptual scaffolds that translate graphical constructs into pedagogical rationales if it is to influence planning practice meaningfully.

We therefore recommend three priorities for future development and evaluation. (1) Embed conceptual scaffolds within the interface—contextual examples, modality-selection prompts, and concise rationales for element use. (2) Provide reusable templates and scenario libraries that exemplify common multimodal sequences and reduce cognitive load during design. (3) Offer targeted professional development that links modeling constructs to concrete instructional aims and assessment strategies.

Finally, we emphasize boundary conditions for interpretation. The study’s small, technically oriented convenience sample, brief interaction window, and reliance on self-report limit claims about long-term appropriation and student outcomes. Future work should pursue longitudinal, practice-based evaluations that combine observational measures, standardized usability instruments, and diverse disciplinary samples to determine whether embedded scaffolds and training produce durable pedagogical appropriation and measurable improvements in multimodal course design.

Ethical Note on the Use of Artificial Intelligence

The authors report that AI-assisted tools were employed solely for language editing and copyediting (grammar, phrasing, and stylistic polishing). All substantive scholarly work—conceptualization, study design, data collection, analysis, interpretation, and conclusions—was conducted by the authors and remains their sole responsibility.

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