



Prompt design and the reconfigured teacher: Enabling insight and creativity in GenAI-mediated classrooms

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Abstract

This article examines the transformative impact of Artificial Intelligence (AI) on the teacher's role in contemporary learning environments, focusing on a shift from knowledge transmission to the orchestration of cognitive ecosystems through pedagogical prompt design. The study adopts an exploratory mixed-methods design conducted in three ninth-grade classrooms at a public secondary school in Colombia, where an educational escape room generated using generative AI and a structured pedagogical prompt was implemented to stimulate emergent learning processes. Quantitative analysis focused on the frequency of “insight moments,” defined as audibly articulated ideas that restructured the collective cognitive field, and the complexity of students’ final creative responses. The intervention identified 32 insight moments and revealed two divergent pathways of cognitive emergence: one characterized by frequent individual insights and another by slower collaborative synthesis leading to high-complexity outcomes. These findings indicate that high frequencies of insight do not consistently predict deeper conceptual integration at the group level. Qualitative observations suggest that the teacher’s role evolved into a “Higgs-like” configurator, an invisible architect who shapes the learning field through prompt design rather than direct instruction. The study concludes that pedagogical prompting constitutes a sophisticated form of instructional planning that enables spontaneous idea generation and transdisciplinary cognition in AI-mediated classrooms.

Keywords: AI in education, Educational escape rooms, Generative artificial intelligence, Insight learning, Prompt design, Teacher role, Technology-Mediated pedagogy, Classroom technology, Quantum-inspired pedagogy.

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Contribution of this paper to the literature

This study contributes to educational technology by redefining the teacher's role as a "field configurator" through pedagogical prompt design. It introduces a novel "quantum-educational" framework to analyze emergent cognition, demonstrating how structured AI-mediated environments catalyze spontaneous "insight moments" and transdisciplinary synthesis, offering a sophisticated model for 21st-century instructional planning.

1. Introduction

Contemporary education faces the pressing challenge of preparing learners for a volatile, uncertain, and highly interconnected world. This requires a transition from traditional models of knowledge transmission toward pedagogies that promote adaptive and generative thinking (Morin, 2001; Schwab, 2016). The accelerated integration of Artificial Intelligence (AI) into educational contexts has opened new avenues for transforming learning environments; however, it simultaneously demands a critical re-examination of the teacher's role and pedagogical practices (Holmes, Bialik, & Fadel, 2019; Salas-Pilco, 2020).

While AI's capabilities to automate tasks and personalize learning pathways have been widely acknowledged, its deeper pedagogical potential to transform classroom dynamics and catalyze emergent learning processes remains underexplored. Traditionally, teachers have functioned as central figures in the transmission of knowledge, structuring content and guiding students' assimilation. However, in AI-mediated learning environments, this role is undergoing a fundamental shift.

This article examines how pedagogical prompting particularly through the design of an AI-generated educational escape room can reposition the teacher from a content transmitter to a configurator of environments conducive to spontaneous cognitive emergence. The study employs a mixed-methods approach within three ninth-grade classrooms at a public school in Colombia, measuring both the frequency of "insight moments" (defined as sudden, profound understandings) and the complexity of students' final creative responses.

The primary objective of this research is to evaluate how pedagogical prompt design facilitates a transition in the teacher's role toward environmental orchestration in GenAI-mediated classrooms, moving beyond simple automation towards a symbiosis between human and artificial intelligence (Luckin, 2018; Molenaar, 2022). By framing the classroom as a distributed network where knowledge is socially and technologically mediated (Kop & Hill, 2008; Siemens, 2005), this study seeks to answer the following research questions:

- How does the implementation of an AI-generated educational escape room as a form of postdigital pedagogy (Fawns, 2022) influence the frequency of 'insight moments' among students?
- To what extent does the teacher's reconfiguration as an 'invisible architect' through prompting affect the complexity of students' creative synthesis?
- What is the relationship between spontaneous idea emission and the depth of conceptual integration within these complex educational systems (Davis & Sumara, 2006)?"

2. Theoretical Framework

This study is grounded in a theoretical framework that interconnects three core concepts: (1) the classroom as a distributed and collaborative learning system; (2) pedagogical prompting as a strategy for configuring AI-mediated environments; and (3) the spontaneous emission of ideas as a hallmark of emergent cognition. These conceptual pillars offer a transdisciplinary lens through which to analyze how learning unfolds in systems designed not to transmit information linearly but to catalyze insight through complex, interactive configurations.

2.1. The Classroom as a Distributed and Collaborative Learning System

The classroom is conceptualized not merely as a physical or administrative unit, but as a dynamic, adaptive, and distributed learning system. Drawing from systems theory and complexity science (Nicolescu, 2005; Senge, 1990), learning is conceptualized as an emergent process arising from the interaction of multiple elements: students, teachers, technologies, curricular content, and contextual factors. In such environments, knowledge is not transferred from teacher to student; rather, it is co-constructed through the feedback loops and interdependencies among agents within the system.

This systemic perspective aligns with the principles of connectivism, in which learning is defined as a process of connecting specialized nodes or information sources within a network (Siemens, 2005). In this context, the teacher does not simply manage a group; rather, he or she orchestrates a hybrid system where human and artificial intelligences interact to expand the collective zone of proximal development (Molenaar, 2022).

Collaboration becomes a key feature of this model. Learning occurs as students engage in shared inquiry, confront alternative viewpoints, and negotiate meaning collectively (Markauskaite & Goodyear, 2017). These interactions facilitate deeper understanding and enable the system to evolve in response to both internal dynamics and external stimuli. By embracing this view, educators can shift their focus from content delivery to ecosystem design, fostering environments where knowledge production is distributed, adaptive, and inherently collaborative.

2.2. Pedagogical Prompting in AI-Mediated Environments

In AI-enhanced classrooms, pedagogical prompting emerges as a central strategy for instructional design. This refers to the intentional crafting of input (prompts) provided to generative AI systems such as large language models to produce educational scenarios, activities, or content tailored to specific pedagogical goals (Holmes et al., 2019).

Prompting moves the teacher's role beyond delivery toward that of an environmental architect. This involves investigative prompting, where the form and style of the input directly dictate the quality of the cognitive disturbance produced in the classroom (Zamfirescu-Pereira, Wong, Hartmann, & Yang, 2023). Thus, prompt design becomes a sophisticated form of post-digital pedagogy (Fawns, 2022) where the teacher pre-configures the constraints of the digital tool to ensure that the AI acts as a catalyst for critical thinking rather than a mere

answer-generator (Baidoo-Anu & Ansah, 2023).

For instance, AI can dynamically generate quizzes, create problem-solving environments, simulate real-world scenarios, or adapt texts to student levels. Such affordances reposition the teacher as a designer of cognitive experiences, requiring new competencies in prompt engineering, scenario design, and multimodal thinking. Effective prompting involves anticipating not only what the AI will produce but also how learners will interpret and respond to that output. As such, it becomes a form of emergent pedagogical planning, one that blends algorithmic literacy with deep pedagogical insight.

2.3. Spontaneous Emission of Ideas: A Quantum-Educational Analogy

One of the most significant indicators of generative learning is the spontaneous emergence of insights—ideas that arise unexpectedly from cognitive engagement and system-level interaction (Feldman, 2016; Kounios & Beeman, 2014). This phenomenon is grounded in the psychological concept of "Aha! moments," in which the brain suddenly reorganizes information to solve a complex problem (Bowden, Jung-Beeman, Fleck, & Kounios, 2005). In the context of this study, these insights are viewed as emergent properties of a complex system where learning is not a linear result of instruction, but a non-linear leap in understanding facilitated by the environment (Csikszentmihalyi, 1996; Davis & Sumara, 2008).

To connect the gap between abstract systems theory and classroom practice, we propose a quantum-inspired metaphor as an analytical illustration. Just as electrons emit photons when they change energy states, students in a well-configured didactic field can emit "photons of thought" creative, novel, and profound ideas that emerge unpredictably yet meaningfully. In this analogy, students are likened to electrons, and the learning environment is a dynamic quantum field.

The teacher acts as a Higgs-like configurator, an agent whose invisible influence enables interactions, attracts student attention, and gives "mass" or coherence to otherwise intangible concepts. The didactic nucleus composed of curricular objectives (protons) and reflective questions or conceptual tensions (neutrons), exerts an attractive force that draws students into meaningful interaction. Cognitive tension, triggered by the interplay between structured content and open-ended inquiry, increases the likelihood of insight. While metaphorical, this framework helps explain how high-quality prompts, immersive narratives, and collaborative structures converge to generate emergent learning phenomena within distributed AI-mediated systems, in which the teacher's role is shifted toward the orchestration of these cognitive "energy states" (Fawns, 2022; Molenaar, 2022).

3. Methodology

This study employed an exploratory mixed-methods design to investigate the transformation of the teacher's role in AI-mediated classrooms, particularly focusing on pedagogical prompting and the emergence of insights during a collaborative escape room activity. The methodology integrated quantitative observation of cognitive events with qualitative analysis of instructional design and classroom dynamics, allowing a holistic understanding of the phenomenon.

3.1. Participants and Context

The study was conducted at the Institución Educativa José Antonio Galán, a public school in the municipality of Puerto Boyacá, Boyacá, Colombia. The participant sample consisted of 84 students (aged 14–16) from three ninth-grade classrooms (Groups A, B, and C). The student population primarily belongs to mid and low socio-economic strata (Levels 1 and 2), representing a typical public educational setting in rural-industrial Colombia. The intervention was integrated into the Arts Education curriculum and aligned with the National Curricular Guidelines for Artistic and Cultural Education issued by the Ministry of National Education (2022). This specific context was chosen to evaluate the effectiveness of GenAI-mediated tools in environments with historically limited access to advanced educational technology.

3.2. Intervention Design: AI-Mediated Educational Escape Room

The core intervention involved implementing a digital escape room designed with Gamma.AI, a generative AI tool guided by a detailed pedagogical prompt. The escape room consisted of three sequenced challenges of increasing complexity, each implicitly engaging multiple intelligences and culminating in a final open-ended riddle.

The prompt guiding the AI was carefully structured to include the following elements:

- Progressive cognitive complexity across challenges (1 to 4 multiple intelligences activated).
- A recurring reflective question ("Why are you trapped?") to prompt metacognitive engagement.
- Culturally embedded narrative, based on regional elements and folklore from the Boyacá department, ensuring the narrative was culturally situated and relevant to the students' identity.
- Full student autonomy, minimizing teacher intervention and maximizing student agency.
- Open response formats (Poetry, song, reflective text, artistic concept) for the final riddle, enabling synthesis and transdisciplinary thinking.

This design aligns with the theoretical model of the classroom as a distributed system: the teacher's role is embedded in the configuration of the didactic field, not in continuous instruction.

3.3. Data Collection

Data collection employed both quantitative and qualitative strategies.

- Quantitative
 - a. The frequency of insight moments was determined through classroom observation and post-session analysis of student-written responses. "If an idea was audibly expressed by a student and subsequently reformulated with substantial novelty or triggered a measurable shift in peer responses (e.g., reinterpretation of the challenge, divergence from initial approaches), it was classified as an observable insight moment. During each challenge, students responded in writing to the guiding question "Why are you trapped?", using individual answer sheets. If

an idea was heard aloud and later appeared in multiple sheets especially in different handwriting it was classified as an observable insight moment.

b. The complexity of final responses was also assessed, particularly in relation to how students integrated diverse elements (e.g., narrative, cultural references, creative formats) in their solutions to the culminating challenge.

- Qualitative

a. The design and evolution of pedagogical prompts were documented, alongside observations of student interaction with AI-generated content.

b. The teacher's role was also examined through a process of structured self-observation and reflective journaling during and after the activity.

c. Classroom dynamics, including dialogue excerpts and group interactions, were recorded to capture indicators of distributed cognition and spontaneous idea emission.

d. In addition to observing classroom dialogue, the teacher conducted a post-session review of student responses and triangulated them with in-situ observations. This allowed for identifying the spread and contagion of specific ideas across the class. Furthermore, the design and evolution of the pedagogical prompts were documented to examine how these influenced the dynamics of idea generation and collaborative interaction.

To support intersubjective validity, a second educator independently reviewed a sample of student response sheets to corroborate the identification of insight moments based on the defined criteria.

A complete version of the original prompt used in Gamma.AI is included in Appendix A. This prompt was refined iteratively and structured to generate an immersive and culturally grounded learning experience, ensuring alignment with the study's pedagogical objectives.

3.4. Data Analysis

Insight moments were identified through a combination of real-time observation and retrospective analysis of student response sheets. An idea was classified as an insight if (1) it was clearly articulated aloud by one or more students, and (2) it was subsequently replicated either literally or in paraphrased form by multiple peers in their written answers. This method allowed for distinguishing between isolated ideas and those that generated a systemic shift in the classroom's cognitive landscape. Thematic analysis was applied to the responses to uncover patterns of idea propagation, complexity, and symbolic integration, following the framework of Braun and Clarke (2006).

3.5. Ethical Considerations

The study was conducted in accordance with the ethical standards of the Institutional Review Board (IRB) of INCCA University of Colombia and received formal authorization from the Principal and Academic Council of Institución Educativa *José Antonio Galán*. Since the participants were minors, informed consent was obtained from their legal guardians, and verbal assent was secured from all students. Data were anonymized to ensure the privacy of the participants, complying with Colombian Law 1581 of 2012 on personal data protection. The intervention posed no risk to the students' physical or psychological well-being, and its design prioritized educational autonomy and welfare.

4. Results

This section presents the key findings of the study, integrating quantitative measurements of insight moments and complexity levels of student responses, alongside qualitative observations of teacher behavior and classroom dynamics. The results are structured around four thematic axes: (1) frequency of insight moments, (2) complexity of final student responses, (3) the teacher's role as a designer of the didactic field, and (4) patterns of student interaction and idea emergence.

4.1. Frequency of Insight Moments

A total of 32 insight moments were identified across the three ninth-grade groups. Each insight was defined as an idea audibly stated during the activity and later written independently by multiple students in response to the basal (or guiding) question, "Why are you trapped?" Group B exhibited the highest frequency (17), followed by Group A (8) and Group C (7).

This suggests that certain ideas had contagious properties, shaping not only peer thinking but also the trajectory of the learning environment as a distributed cognitive system. This distribution suggests a non-linear propagation of ideas, where Group B functioned as a high-emission but low-synthesis environment, consistent with theories of cognitive friction in complex systems (Davis & Sumara, 2006).

4.2. Complexity of Final Responses

The final challenge of the escape room required students to synthesize their experiences through open-ended creative outputs. Complexity was defined as the integration of multiple narrative elements, disciplinary concepts, and symbolic references. Groups A and C produced a high number of complex responses, 21 and 23, respectively, while Group B produced only 7. This contrast is notable given that Group B exhibited the highest frequency of insight moments. The findings suggest that frequent individual insights do not necessarily correlate with higher levels of conceptual synthesis at the group level, a point that will be explored further in the discussion.

Table 1 illustrates the contrast between the frequency of insight moments and the complexity of final student responses across groups, highlighting that higher insight frequency does not necessarily correspond to higher response complexity.

Table 1. Insight frequency and high-complexity final responses by group.

Group	Insights moments (IM)	High-Complexity Final Responses (HCFR)
A	8	21
B	17	7
C	7	23

Note: Insight Moments (IM) refer to ideas audibly externalized by a student during classroom interaction and subsequently replicated or reformulated in two or more independent written response sheets.

High-Complexity Final Responses (HCFR) refer to student outputs that integrate three or more distinct dimensions, including narrative coherence, cultural or regional references, and transdisciplinary symbolic creativity

4.3. The Teacher as Designer of the Didactic Field

Qualitative observations revealed a fundamental transformation in the teacher's role during the activity. Rather than serving as an explicit source of knowledge, the teacher functioned as a silent configurator of the learning environment. When students sought clarification, the teacher consistently redirected them to the AI-generated material or encouraged autonomous interpretation (e.g., “Read it again and go with what you think is correct”). This strategy reinforced student agency and minimized direct instructional interference, while still maintaining a latent teacher presence that shaped the overall architecture of the experience.

4.4. Student Interaction and Spontaneous Idea Emission

Student interactions played a central role in the emergence of insights. When a student verbalized a new idea, whether a solution, an interpretation, or a creative hypothesis, it often triggered observable shifts in group dynamics: classmates revised their thinking, debated possibilities, or built upon the original idea. These ripple effects validated the insight as a perturbation that restructured the collective cognitive field.

Notably, some of the most complex and creative responses did not align with the “correct” AI-generated solutions but introduced novel and plausible reinterpretations of the task. These responses illustrate the spontaneous emission of ideas: emergent, contextually grounded contributions that extended beyond the instructional script. In several instances, students anticipated future challenges or reframed the central metaphor of the escape room itself. These unanticipated contributions serve as evidence of transdisciplinary cognition and the generative power of the teacher-configured environment.

The recurrence of specific insights across multiple student responses indicates a pattern of cognitive resonance, where ideas spread horizontally within the group. These shared formulations were not instructed or suggested by the AI or teacher but arose organically within peer interactions. The writing of these insights on individual sheets, after hearing them publicly, reflects how spontaneous verbalizations restructured the shared cognitive field a key characteristic of the “emission effect” described in the theoretical framework. This mechanism also served as a natural amplifier of conceptual breakthroughs, suggesting that insight is not only individual but social and distributed.

These findings also resonate with Vygotsky's theory of mediated learning and the Zone of Proximal Development (Vygotsky, 1978), wherein cognitive progress is catalyzed through social interaction. The replication of spontaneously emitted ideas across students suggests that insights may serve as symbolic mediators within peer learning, facilitating internalization through distributed cognition.

5. Discussion

This study explores the reconfiguration of the teacher's role within AI-mediated learning environments through the deliberate design of pedagogical prompts that stimulate the spontaneous emergence of ideas in collaborative, gamified contexts. Rather than positioning artificial intelligence as a content-delivery mechanism, the findings foreground its function as a catalyst within carefully structured cognitive ecosystems. Learning, in this framework, does not unfold as linear knowledge transmission but emerges from the dynamic interaction among students, prompts, narrative constraints, and technological mediation.

The results point to a paradigmatic shift in pedagogical practice: from instructional control toward environmental configuration. The teacher's agency is exercised not through direct explanation or immediate intervention, but through the pre-structuring of conditions that enable insight, negotiation, and symbolic synthesis to arise unpredictably. This perspective aligns with complexity-oriented and post-digital approaches to education, which conceptualize learning as an emergent, distributed, and relational process rather than an individual accumulation of information (Davis & Sumara, 2006; Fawns, 2022; Morin, 2001).

By situating prompt design at the core of instructional decision-making, this study contributes to ongoing debates about the role of educators in the age of generative AI. It suggests that the pedagogical value of AI lies less in its capacity to provide answers and more in its ability to destabilize habitual patterns of thinking, provoke cognitive tension, and sustain collective meaning-making processes over time (Luckin, 2018; Molenaar, 2022). In doing so, the study reframes teaching as the orchestration of a probabilistic learning field in which insight and complexity emerge through interaction rather than prescription.

5.1. From Knowledge Transmitter to Field Configurator

The qualitative data provide strong evidence for a reconceptualization of the teacher's role, shifting from the traditional figure of knowledge transmitter to what can be described as a field configurator of learning conditions. Rather than occupying the center of instructional activity, the teacher in this study deliberately withdrew from direct content delivery and instead shaped the epistemic environment in which learning could emerge. This repositioning did not diminish pedagogical authority; on the contrary, it relocated authority from explicit instruction to the design of constraints, prompts, and symbolic trajectories that structured student engagement.

Within the AI-mediated learning experience, the teacher's presence became implicit rather than explicit. Influence was embedded in the architecture of the task, the sequencing of prompts, and the narrative scaffolding that guided student exploration. This form of pedagogical action aligns with systemic and complexity-oriented perspectives on education, which conceptualize learning as an emergent phenomenon arising from interactions

among agents, tools, and representations rather than from linear transmission processes (Davis & Sumara, 2006; Senge, 1990). In this sense, the teacher functions less as a source of knowledge and more as a designer of the conditions under which cognition can self-organize.

The transition from transmitter to field configurator reflects a broader shift toward hybrid educational systems in which human and artificial intelligence operate in symbiosis. AI, in this configuration, does not replace the teacher but assumes responsibility for lower-level cognitive operations such as information provision, prompt variation, and generative stimulation. This redistribution of cognitive labor enables the teacher to focus on higher-order pedagogical functions, particularly the orchestration of learning environments that promote inquiry, uncertainty, and creative recombination (Luckin, 2018; Molenaar, 2022). The teacher's "invisibility" thus emerges as a strategic pedagogical stance rather than a passive withdrawal.

From a postdigital perspective, this orchestration can be understood as a form of latent agency. The teacher establishes the initial conditions of the learning system defining boundaries, affordances, and tensions without predetermining specific outcomes. As in complex adaptive systems, small design decisions at the outset can have disproportionate effects on the trajectories that unfold (Davis & Sumara, 2006). The AI-mediated prompts acted as perturbations within this system, but their pedagogical effectiveness depended on the prior configuration established by the teacher. In this sense, AI functioned as a catalytic element rather than an autonomous instructional agent.

Importantly, this model challenges deeply entrenched assumptions about control and visibility in teaching practice. Traditional pedagogical paradigms often equate effective teaching with constant presence, explanation, and correction. The findings of this study suggest the opposite: by relinquishing immediate control and allowing the learning field to evolve dynamically, the teacher enabled richer forms of student sense-making. Learning did not collapse into teacher-approved pathways but diversified into multiple interpretative and symbolic routes, some of which only stabilized over time.

This reconceptualization also has implications for how teaching expertise is understood and evaluated. Expertise, in this framework, is not measured by the volume or clarity of explanations but by the capacity to anticipate emergent dynamics and design environments that sustain productive cognitive tension. The teacher's role as field configurator requires a deep understanding of disciplinary structures, learner variability, and the affordances and limitations of AI systems. It is therefore a highly demanding form of pedagogical practice, albeit one that operates largely below the surface of observable classroom interaction.

In summary, the qualitative findings support a shift from instructional centrality to systemic configuration, positioning the teacher as an invisible yet decisive architect of learning conditions. In AI-mediated classrooms, teaching becomes less about directing cognition and more about cultivating ecological conditions from which insight, creativity, and transdisciplinary understanding can emerge.

5.2. Pedagogical Prompting as a New Form of Planning

The iterative refinement of prompts in response to student interactions revealed that pedagogical prompting cannot be understood as a fixed script or a pre-defined instructional sequence. Instead, it emerged as a dynamic and adaptive form of instructional design that evolves in real time, shaped by the cognitive and social responses of learners. In this context, prompting operates as a form of indirect pedagogical governance: rather than telling students what to think or do, the teacher designs linguistic and narrative conditions that orient exploration while preserving epistemic openness.

Pedagogical prompting functions as a cognitive orchestration tool. Through carefully calibrated prompts, the teacher aligns the learning experience with curricular competencies while simultaneously allowing for divergence, interpretation, and creative risk-taking. This dual-function alignment without closure marks a significant departure from traditional lesson planning models, which tend to rely on linear progression and predetermined outcomes. The findings of this study, therefore, call for a reconceptualization of lesson planning in AI-enhanced contexts, shifting from static sequencing toward what can be described as responsive field design, in which instructional decisions are continuously adjusted based on emergent learner behavior.

The study further demonstrates that prompt engineering constitutes an advanced and intellectually demanding form of instructional work. As Markauskaite and Goodyear (2017) argue, contemporary teaching increasingly involves complex forms of knowledge work that extend beyond content expertise into the design of learning systems. Pedagogical prompting exemplifies this shift: the teacher must not only understand the subject matter but also anticipate how specific formulations, tones, and narrative framings will interact with both the AI system and the students' cognitive dispositions.

Unlike traditional lesson plans, which often assume predictability and instructional control, pedagogical prompting operates under conditions of uncertainty. This aligns with the concept of investigative prompting proposed by Zamfirescu-Pereira et al. (2023), where the form and style of prompts are deliberately crafted to provoke sense-making rather than provide solutions. In this study, the teacher had to anticipate how the AI's linguistic style, generative tendencies, and degrees of ambiguity would perturb students' cognitive states, sometimes amplifying confusion, sometimes catalyzing insight. Such perturbations were not pedagogical failures but productive disturbances that activated inquiry and collaborative negotiation.

This process resonates strongly with connectivism learning theory (Siemens, 2005), which conceptualizes learning as the ability to navigate, form, and reconfigure networks of information, ideas, and relationships. In this framework, prompts act as nodes that structure the learning network, while AI functions as a dynamic intermediary that expands the range of possible connections. Students are not guided along a single path but are required to navigate a landscape of possibilities, making sense of emerging patterns through interaction and dialogue.

Crucially, the pedagogical power of AI in this study did not stem from its capacity to provide answers, but from its configuration as a cognitive challenger. As Baidoo-Anu and Ansah (2023) suggest, when AI is pre-designed to resist immediate resolution and instead pose counter-questions, ambiguities, or narrative tensions, it ceases to function as a passive informational tool. Instead, it becomes a catalyst for critical inquiry and collective meaning-making. This finding reinforces the argument that the educational value of AI lies not in automation but in

intentional pedagogical design.

From this perspective, pedagogical prompting can be understood as a form of meta-pedagogy: teaching about thinking by shaping the conditions under which thinking unfolds. The teacher's expertise is expressed not through explanation but through linguistic precision, narrative foresight, and sensitivity to emergent cognitive dynamics. This redefines instructional planning as an ongoing, adaptive practice one that requires teachers to read the learning field continuously and recalibrate prompts in response to evolving patterns of engagement.

In sum, the findings position pedagogical prompting as a central competence in AI-mediated education. It is neither a technical skill nor a mere add-on to existing practices, but a transformative mode of planning that integrates curriculum, cognition, and technology into a coherent yet open-ended learning ecology.

5.3. Interpreting Insights and Complexity: Dual Pathways of Emergent Learning

One of the central contributions of this study lies in its analytical distinction between two dimensions of cognitive emergence: the frequency of insight moments and the complexity of final student productions. The empirical results demonstrate that these dimensions do not necessarily covary. Group B, which exhibited the highest frequency of audibly externalized insights, produced the lowest number of high-complexity final responses. Conversely, Groups A and C, despite displaying fewer observable insight moments, generated outputs characterized by greater conceptual integration, symbolic density, and transdisciplinary coherence.

This divergence suggests the existence of at least two distinct pathways of emergent learning within AI-mediated classrooms. The first pathway is characterized by frequent spontaneous ideation, where individual students rapidly emit novel ideas that temporarily reorganize classroom discourse. Such moments resemble what cognitive psychology defines as classic insight events or "Aha! moments" (Bowden et al., 2005; Kounios & Beeman, 2014). These events are highly visible, socially contagious, and energizing, often producing short-lived cognitive reconfigurations at the collective level.

The second pathway is marked by a slower, less visible process of collaborative synthesis. In this trajectory, fewer insights are publicly articulated, yet the collective products exhibit greater depth, coherence, and symbolic richness. Learning unfolds through prolonged negotiation, accumulation of partial ideas, and delayed integration, rather than through rapid ideational bursts. This pathway aligns with complexity-oriented views of learning, where understanding emerges over time through interaction rather than instant cognitive breakthroughs (Davis & Sumara, 2006; Morin, 2001).

The contrast between Group B (high insight frequency, low complexity) and Groups A and C (low insight frequency, high complexity) provides a compelling illustration of this duality. Group B's high density of insight moments suggests a state of heightened cognitive excitation, where novel ideas are generated and externalized at a rapid pace. However, drawing on Feldman (2016) simplicity principle, it is plausible that this rapid ideational flow produced a form of cognitive noise, limiting opportunities for consolidation, abstraction, and symbolic integration. In such conditions, ideas may remain fragmented, preventing the emergence of complex, transdisciplinary structures.

By contrast, the learning trajectory observed in Groups A and C resonates with Csikszentmihalyi (1996) notion of the incubation phase of creativity. Here, insight is not absent but delayed, internalized, and gradually refined through collective interaction. Fewer ideas are externalized, yet those that eventually surface carry greater "conceptual mass," integrating narrative coherence, cultural references, and symbolic meaning. This process reflects what (Henriksen, Creely, Henderson, & Mishra, 2021) describe as creativity supported by technology not through acceleration of idea production, but through the cultivation of environments that allow ideas to mature and interconnect.

From a systemic perspective, both pathways represent valid expressions of emergent cognition within distributed learning systems. However, they demand different interpretative lenses. High-frequency insight should not be automatically equated with deep learning, nor should the absence of visible insights be interpreted as cognitive stagnation. Technologically mediated learning often produces forms of understanding that are collective, delayed, and difficult to capture through surface-level indicators.

These findings challenge conventional educational assumptions that privilege immediacy, participation frequency, and verbal productivity as proxies for learning quality. Instead, they support a more nuanced view in which learning is understood as a probabilistic and non-linear process, shaped by social interaction, symbolic negotiation, and temporal dynamics (Davis & Sumara, 2008; Nicolescu, 2005). In GenAI-mediated classrooms, teachers must therefore learn to recognize not only the visible sparks of insight, but also the slower, less observable processes through which complex understanding emerges.

5.4. The Quantum-Educational Analogy Revisited

The quantum-educational analogy remains a productive conceptual tool for interpreting the indirect yet structurally decisive role of the teacher in AI-mediated learning environments. Rather than functioning as a literal transfer of concepts from physics to education, the analogy operates as a transdisciplinary language that enables the description of emergent, non-linear, and probabilistic learning phenomena that resist explanation through traditional instructional models. In this sense, the metaphor of the Higgs-like teacher captures how pedagogical influence can be both non-visible and structurally essential.

Just as the Higgs field confers mass upon otherwise weightless particles, the teacher's prompt design confers pedagogical coherence upon an otherwise diffuse flow of student ideas. Prompts operate as latent conditions that enable ideas to acquire "weight" that is, relevance, continuity, and symbolic density within the learning system. The spontaneous emergence of student contributions, conceptualized metaphorically as "photons," illustrates how meaningful ideas can be emitted unpredictably, reorganizing the cognitive dynamics of the classroom. This unpredictability reinforces the view of learning environments as probabilistic systems, consistent with complexity-based approaches to education (Davis & Sumara, 2006; Davis & Sumara, 2008).

The classroom, when mediated by generative AI, cannot be adequately described as a linear cause effect system. Instead, it functions as an adaptive cognitive field in which local interactions generate global patterns. From this perspective, the teacher does not control learning outcomes directly but shapes the initial and boundary conditions

under which learning emerges. This aligns with Molenaar (2022) notion of hybrid educational systems, where human and artificial intelligences co-configure learning trajectories through continuous interaction rather than hierarchical control.

The metaphor of the didactic nucleus further clarifies this dynamic. Content objectives can be understood as stabilizing forces analogous to protons, while reflective tensions, ambiguities, and narrative provocations function as destabilizing forces analogous to neutrons. Together, these elements create a pedagogical core capable of attracting, perturbing, and sustaining student thinking. Insight does not arise from equilibrium alone, but from productive instability, echoing Csikszentmihalyi (1996) description of creativity as emerging from tension between structure and freedom.

Importantly, this framework does not reduce learning to metaphorical abstraction. Rather, it offers a way to conceptualize observable phenomena such as delayed insight, uneven participation, and collective synthesis that are difficult to interpret through outcome-based or transmission-oriented models. Feldman (2016) simplicity principle helps explain why rapid idea emission may sometimes inhibit deeper integration, while slower, less visible processes of synthesis may result in more complex final outputs. These dynamics are better understood as field effects than individual cognitive events.

Critics may argue that quantum metaphors lack empirical grounding in educational research. However, this critique assumes that educational theory must rely exclusively on linear, reductionist models. As Nicolescu (2005) argues, transdisciplinary knowledge operates across multiple levels of reality, each requiring its own descriptive language. When educational phenomena involve cognition, technology, culture, and symbolism simultaneously, as in AI-mediated classrooms, no single disciplinary framework is sufficient. Metaphorical reasoning thus becomes not a weakness, but a methodological necessity.

This position aligns with Morin (2001) call for an education capable of embracing complexity, uncertainty, and non-linearity. By framing the classroom as a probabilistic field rather than a production line, the quantum-educational analogy directly challenges the industrial “factory model” of schooling. Such a shift is particularly relevant in the context of the Fourth Industrial Revolution (Schwab, 2016), where adaptive intelligence, creativity, and systems thinking are increasingly central educational goals.

Finally, the analogy provides a conceptual bridge between pedagogical theory and emerging debates on AI in education. As Holmes et al. (2019) and Fawns (2022) suggest, the integration of AI requires new epistemological frameworks that move beyond instrumental views of technology. Understanding the teacher as a field configurator rather than a content transmitter allows for a more nuanced interpretation of agency, responsibility, and design in postdigital learning environments.

In sum, the quantum-educational analogy does not claim explanatory dominance but interpretive relevance. It offers a transdisciplinary vocabulary capable of capturing the emergent, distributed, and uncertain nature of learning in AI-mediated classrooms, precisely the dimensions that traditional pedagogical models struggle to explain.

5.5. Implications for AI Integration in Education

The findings of this study generate several critical implications for the integration of artificial intelligence in contemporary educational contexts. First, the results reinforce the idea that AI should not be conceptualized as a replacement for teachers but rather as a transformative element that reconfigures their professional role. In AI-mediated learning environments, the teacher’s function shifts from direct content transmission toward the design of cognitive, narrative, and symbolic conditions that enable emergent learning processes. This perspective aligns with research that conceptualizes education as a complex, adaptive system in which learning arises from interaction rather than linear instruction (Davis & Sumara, 2006; Morin, 2001).

In this framework, teachers operate as environmental designers and prompt engineers, shaping the didactic field within which human and artificial intelligence interact. Rather than delivering information, educators configure the initial conditions that allow insight, collaboration, and symbolic synthesis to emerge. This finding resonates with Luckin (2018) argument that AI should assume lower-level instructional functions, freeing teachers to focus on higher-order orchestration of learning environments. Similarly, Molenaar (2022) emphasizes that hybrid human–AI systems require educators to actively regulate the distribution of cognitive agencies across learners, tools, and tasks.

These results have significant implications for teacher education. Traditional models of teacher preparation often centered on disciplinary knowledge and classroom control are insufficient for AI-enhanced pedagogical ecosystems. Instead, teacher training must include competencies in prompt design, narrative curation, and cognitive modeling. Such competencies enable educators to anticipate how AI-generated outputs may perturb students’ cognitive states and guide these perturbations toward productive learning trajectories. This aligns with Markauskaite and Goodyear (2017) conception of teaching as complex knowledge work, as well as with recent research highlighting the pedagogical importance of investigative prompting in human–AI interaction (Zamfirescu-Pereira et al., 2023).

From a theoretical standpoint, these findings also support a shift away from instrumental views of educational technology. When AI is pre-configured as a “challenger” rather than an “answer generator,” it becomes a catalyst for inquiry and conceptual exploration rather than a passive resource (Baidoo-Anu & Ansah, 2023). This repositioning of AI aligns with connectivism perspectives, in which learning is understood as the formation and reconfiguration of networks of meaning rather than the internalization of predefined content (Kop & Hill, 2008; Siemens, 2005).

The implications extend beyond pedagogy to educational research and assessment. The emergent and distributed nature of learning observed in this study challenges outcome-based evaluation models that privilege individual, static measures of achievement. Instead, learning manifested through collective idea propagation, delayed synthesis, and symbolic integration across groups. This supports calls for assessment reform in the age of artificial intelligence, emphasizing process-oriented indicators and the tracing of idea evolution rather than isolated performance metrics (Lodge, Smith, Thompson, & Taylor, 2023).

Consequently, assessment practices must evolve to capture not only what students know but how ideas

emerge, circulate, and consolidate within AI-mediated learning environments. Static examinations are insufficient to account for learning processes that are probabilistic, collaborative, and non-linear. As Salas-Pilco (2020) argues, AI-enhanced education demands evaluative frameworks capable of recognizing cognitive, social, and symbolic dimensions of learning simultaneously.

Finally, this study suggests that teacher education must move beyond the narrow framework of digital literacy toward what can be described as algorithmic pedagogy (Fawns, 2022). In this paradigm, educators learn not merely to operate AI tools but to intentionally “program” the didactic field through language, narrative tension, and symbolic constraints. This reconceptualization positions teachers as epistemic agents who actively shape the interaction between human cognition and artificial systems, ensuring that AI integration remains pedagogically intentional and ethically grounded (Holmes et al., 2019; Nicolescu, 2005).

5.6. Risks of Pedagogical Misinterpretation in Emergent Learning Systems

One of the most critical implications of the findings concerns the potential misinterpretation that teachers may make when observing different emergent learning patterns across groups. In traditional pedagogical frameworks, Group B, characterized by a high frequency of observable insight moments, could easily be interpreted as the most successful or cognitively active group. Conversely, Groups A and C, which displayed fewer public insight emissions but produced more complex final responses, might be perceived as less engaged or slower learners. This interpretation, however, would be fundamentally misleading within an emergent, AI-mediated learning system.

As Biesta (2015) warns, equating visible activity with educational value reflects a reductive logic of *learnification*, where what can be easily observed or counted is mistaken for what is educationally meaningful. In the context of this study, Group B’s frequent insight moments signal high cognitive excitation but not necessarily deep integration or symbolic consolidation. If a teacher were to intervene prematurely by rewarding speed, amplifying rapid ideation, or steering the group toward immediate closure the system’s natural trajectory toward higher-order synthesis could be disrupted. Such intervention risks stabilizing the system at a surface level of creativity, preventing the emergence of complexity.

In contrast, the learning dynamics observed in Groups A and C suggest a slower, less visible pathway toward complexity, one that depends on latency, negotiation, and collective meaning-making. From a complexity-theory perspective, this delay is not a deficit but a necessary condition for emergence (Davis & Sumara, 2006). Teachers unfamiliar with non-linear learning processes may misinterpret silence, hesitation, or reduced verbal output as disengagement, thereby intervening in ways that collapse the system’s exploratory space. As Morin (2001) emphasizes, complex systems require tolerance for uncertainty, delay, and ambiguity; premature regulation often leads to simplification rather than understanding.

This is where the metaphor of the teacher as a Higgs-like field becomes pedagogically consequential. When the teacher acts as a stabilizing yet non-intrusive field through carefully designed prompts, narrative tension, and epistemic openness, the learning system is allowed to self-organize and progressively acquire “mass,” understood here as conceptual density and symbolic coherence. However, when the teacher abandons this Higgs-like role and reverts to directive control over-explaining, validating too early, or privileging certain forms of participation, the field collapses into a deterministic structure. In such cases, emergent pathways toward complexity are suppressed, and learning outcomes become homogenized and predictable.

From a transdisciplinary perspective, this misinterpretation reflects a deeper epistemic issue. Nicolescu (2005) argues that transdisciplinary knowledge operates across multiple levels of reality and cannot be fully apprehended through linear indicators alone. Insight frequency belongs to one level of observation, while symbolic integration and transdisciplinary coherence belong to another. Treating one level as superior obscures the relational nature of learning and reinforces reductionist assessment practices. This finding aligns with recent calls to rethink evaluation in AI-enhanced education, shifting attention from immediate outputs to the evolution of meaning across time and interaction (Lodge et al., 2023).

Therefore, a central pedagogical risk identified in this study is not technological but interpretative. Teachers who lack a systemic and complexity-informed lens may inadvertently inhibit the very forms of learning that AI-mediated environments are capable of supporting. Recognizing the legitimacy of multiple emergent trajectories and maintaining a Higgs-like pedagogical posture becomes essential for allowing learning systems to transition from excitation to complexity, from idea emission to transdisciplinary understanding.

5.7. Limitations and Future Research

This study was conducted in three classrooms within a single educational institution, which necessarily limits the generalizability of the findings. While this contextual specificity allowed for a rich and situated analysis of classroom dynamics, it also constrains the extent to which the observed patterns can be extrapolated to other educational levels, institutional cultures, or socio-economic contexts. Additionally, one of the primary qualitative methods employed was auto-observation by the teacher-researcher. Although this approach provided deep insider insight into the pedagogical processes and decision-making involved, it may introduce interpretative bias and limit external validation.

Future research would benefit from methodological triangulation, incorporating student interviews, focus groups, external classroom observers, and multimodal data sources such as video analysis or learning analytics. Longitudinal designs could further illuminate how insight trajectories and complexity of learning outputs evolve over time, particularly as students become more accustomed to AI-mediated pedagogical environments.

Several promising avenues for future research emerge from this study. First, comparative analyses of different prompting strategies could clarify how variations in linguistic framing, narrative tension, or cognitive provocation influence the frequency, timing, and depth of insight moments. Second, the role of collaboration and social contagion in the emergence and propagation of ideas warrants closer examination, particularly in relation to how insights circulate, stabilize, or dissipate within peer networks.

Third, the low-insight, high-complexity pathway identified in Group C raises important questions about alternative modes of learning that prioritize delayed synthesis over immediate ideation. Future studies could investigate whether this pattern can be replicated across different disciplines, age groups, or cultural contexts, and

whether it is associated with specific forms of collective regulation or cognitive pacing.

Finally, further research should explore how AI-generated tasks interact with diverse cognitive profiles, learning preferences, and socio-cultural backgrounds. Understanding how students with different abilities, linguistic repertoires, or cultural frames engage with AI-mediated prompts is essential for ensuring that such pedagogical approaches are inclusive and equitable. Addressing these questions will contribute to a more robust theoretical and empirical foundation for the integration of generative AI in education.

6. Conclusion

This study provides empirical and conceptual evidence that the teacher's role in AI-mediated classrooms is undergoing a fundamental reconfiguration from a central transmitter of knowledge to a configurator of learning environments. Through the design and implementation of an AI-generated educational escape room, we observed how prompt-driven pedagogical design can foster emergent phenomena such as spontaneous idea emission, collective knowledge construction, and transdisciplinary synthesis.

The results demonstrate that pedagogical prompting, when strategically aligned with narrative, cognitive, and cultural elements, constitutes a powerful form of instructional design. In these AI-enhanced environments, learning does not unfold linearly but arises through interaction, iteration, and perturbation within a distributed system. The teacher, in this model, does not disappear but operates through invisible orchestration, shaping the “didactic field” that enables students to generate insights, reinterpret challenges, and reorganize knowledge collaboratively.

Importantly, the study reveals that high-quality learning outcomes may follow diverse cognitive trajectories: some driven by frequent insight moments, others by slower integrative processes. The recognition of these dual pathways calls for new frameworks in educational assessment, ones that value not only the quantity of ideas but also their systemic impact and emergent coherence.

In this context, the metaphor of the teacher as a Higgs boson offers a compelling image: the educator does not push knowledge into motion but generates the very conditions that give conceptual “mass” and coherence to student thinking. Ideas like photons are emitted spontaneously when the field is well-configured. This metaphor helps articulate a future-facing pedagogy in which teachers design not just lessons but cognitive ecologies, leveraging AI not as a content generator but as a co-agent in the orchestration of insight.

As educational systems grapple with the integration of generative technologies, this study contributes to a deeper understanding of how pedagogical design, AI mediation, and human cognition can be synergistically aligned to prepare learners for the complexity and unpredictability of the 21st century.

7. Statements and Declarations

- **Funding Statement:** This publication was supported by institutional research funds from INCCA University of Colombia, issued through Constitutive Act No. 385 of April 29, 2025, within the framework of the National System of Science, Technology and Innovation (SNCTeI). The article processing charge (APC) was covered through this institutional funding mechanism.
- **Institutional Review Board (IRB) Statement:** This study was approved by the Institutional Review Board and the Ethics Committee of INCCA University of Colombia. The intervention was also authorized by the Academic Council of Institución Educativa José Antonio Galán in Puerto Boyacá, Colombia. All procedures followed the ethical standards of the 1964 Helsinki Declaration and its later amendments.
- **Informed Consent Statement:** Verbal informed consent was obtained from all participants (students), and written informed consent from their legal guardians, as the participants were minors. All data were anonymized to protect participant confidentiality and comply with Colombian Statutory Law 1581 of 2012 on personal data protection.
- **Transparency Statement:** The author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.
- **Data Availability Statement:** The qualitative and quantitative datasets generated and analyzed during the current study are not publicly available due to the privacy of the minor participants, but are available from the corresponding author on reasonable request.
- **Authors' Contributions** Christian Esteban Hidalgo Valbuena was solely responsible for the conceptualization, methodological design, software implementation (AI prompting), data collection, formal analysis, and the writing and original draft preparation of the manuscript.
- **Disclosure of AI Use and AI-Assisted Technologies:** The author used Gamma AI (v2023) to generate the instructional content and the narrative structure of the educational escape room described in the methodology. The pedagogical prompt used for this purpose is fully documented in Appendix A. Additionally, the author used Google Gemini to refine the English phrasing. All outputs were reviewed, edited, and verified by the author, who takes full responsibility for the intellectual content of the paper.
- **Competing Interests** The author declares that there are no financial or personal relationships with other people or organizations that could inappropriately influence or bias this work.

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Appendix A.

The following prompt was used to generate the AI-mediated educational escape room implemented in the study, using the generative tool Gamma.AI. It was carefully crafted to ensure alignment with pedagogical objectives, progressive complexity, and cultural relevance to the students' local context in Boyacá, Colombia.

Prompt (used in Gamma.AI):

Role and Output Format: Act as a highly creative and experienced educational escape room designer. Your task is to generate a comprehensive, self-contained, and ready-to-use presentation outline for a high school 'Art and Culture' class (ages 13–15). This presentation should serve as the entire escape room experience, requiring no direct verbal interaction from the teacher during student play. All instructions, puzzles, and narrative elements must be clearly presented within the slides for student autonomy. Crucially, ensure all factual information, cultural references, and puzzle logic are derived from academically rigorous and verifiable sources.

Critical Negative Constraints:

- DO NOT include any direct explanations or definitions of pedagogical theories, educational concepts, or psychological frameworks (e.g., Multiple Intelligences, complexity theory, learning styles, transdisciplinarity) on the slides or in the student-facing content. These concepts are for the educator's design, not for the students to explicitly learn from the presentation.
- DO NOT answer the basal question yourself, nor provide example answers. The basal question is solely for the students to respond to.

Core Design Principles:

- Progressive Complexity: The escape room must feature three distinct challenges, each progressively increasing in cognitive complexity.
- Consistent Basal Question Presentation: After each challenge, clearly present the single reflective basal question: "Why are you trapped?" Frame it as a clear instruction for the student to write their answer (e.g., "After solving this challenge, reflect and write down your answer to: 'Why are you trapped?'"). Ensure the narrative implicitly supports the recurrence of this question.
- Engaging and Contextualized Narrative: Develop a captivating and intrinsically connected storyline that immerses students and fosters a strong sense of engagement and purpose. Crucially, integrate elements of the culture, folklore, history, or geography of Boyacá, Colombia, into the story and/or puzzles to make the experience deeply relevant and relatable to the students' local context.
- Gaming Experience Focus: Prioritize compelling mechanics, intriguing puzzles, and a smooth narrative flow to maximize the students' interactive gaming experience.

Challenge Structure & Multiple Intelligences (MIs) Integration (Implicit):

- Challenge 1: Designed to implicitly engage one specific Multiple Intelligence.
- Challenge 2: Designed to implicitly engage two different Multiple Intelligences.
- Challenge 3: Designed to implicitly engage four different Multiple Intelligences. (Note: Ensure the challenge descriptions imply the use of these MIs without stating them explicitly to the students.)

Final Riddle & Holistic Response:

The experience culminates in a final riddle designed to allow students to 'escape' by formulating a holistic and integrated response.

This final response should implicitly encourage the integration of knowledge, skills, and perspectives from various domains (e.g., art, history, local culture, problem-solving), and can be expressed in diverse formats (e.g., a song, a poem, reflective text, visual art description). (Note: Avoid using the word 'transdisciplinary' in the student-facing description of this task.)

Targeted Competence (MEN Curricular Orientation):

The entire escape room design should implicitly support the development of the following key competence in students, as per the Ministry of National Education (MEN) curricular orientation for artistic and cultural education:

"I develop analytical characteristics for more elaborate works from a wide repertoire of artistic productions, considering technical, stylistic, and cultural context-related aspects of the arts."

Output Format Request (Detailed Presentation Outline):

Provide a structured outline of the presentation slides, including:

- Slide 1: Title Slide (Escape Room Title, Briefing for Students).
- Slide 2–X: Narrative introduction to the story (ensuring Boyacá cultural integration where appropriate).
- For Each Challenge (repeated for Challenge 1, 2, 3):
 - Challenge Title/Number.
 - Story continuation/setup for the puzzle.
 - Clear instructions for the puzzle/task.
 - Puzzle content itself (e.g., text for code, image description for visual puzzle, song link/lyrics for musical puzzle).
- Crucially, a dedicated section for the Basal Question:
"Task: Reflect and answer 'Why are you trapped?' in your notebook/sheet."
- Final Riddle Section:
 - Story culmination/setup for the riddle.
 - Clear instructions for the final holistic and integrated response.
 - Examples of response formats (song, poem, text, drawing description).
- Conclusion Slide: (e.g., "Congratulations! You escaped!").

Ensure the narrative flows seamlessly between slides and challenges.