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Mapping the Narrative Landscape: A Critical Review of Storytelling-Based Pedagogical Models in 21st Century Education

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ABSTRACT

Background. Storytelling has become an increasingly prominent pedagogical approach in twenty-first-century education, yet its diverse models, technologies, and instructional functions remain conceptually fragmented across disciplines.

Purpose. This study aimed to critically map storytelling-based pedagogical models, identify their defining characteristics, compare their learning functions, and clarify the conditions under which they support meaningful educational outcomes.

Method. A critical review design with a systematic search strategy was employed across major academic databases, followed by eligibility screening, structured data extraction, critical appraisal, comparative coding, and cross-model synthesis.

Results. The findings identified six major configurations: digital storytelling, learner-generated narrative, collaborative storytelling, narrative pedagogy or story-based instruction, interactive or game-mediated storytelling, and multimodal, immersive, or AI-supported storytelling. Learner authorship and agency were more consistently associated with creativity, critical thinking, reflection, collaboration, and knowledge construction, whereas receptive models more commonly supported comprehension, contextualization, engagement, and retention.

Conclusion. The study concludes that storytelling should be understood as a differentiated pedagogical landscape rather than a single method, requiring model-specific design, evaluation, and future research, particularly concerning emerging AI-supported narrative practices in diverse educational contexts and across culturally diverse learner populations and curricular domains.

KEYWORDS

Digital Storytelling, Learner Agency, Narrative Pedagogy

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INTRODUCTION

Storytelling has long served as a fundamental means through which human beings communicate knowledge, transmit cultural values, organize experience, and construct meaning. Educational practice has consequently incorporated stories across generations as vehicles for explaining complex ideas, stimulating imagination, preserving collective memory, and connecting abstract

knowledge with lived experience. Contemporary education has expanded these functions beyond conventional oral and written narratives by positioning storytelling as an intentional pedagogical approach. Current forms of storytelling-based education include teacher-generated narratives, student-created stories, narrative inquiry, digital storytelling, interactive narratives, multimedia composition, game-based narratives, and collaborative storytelling. This transformation places narrative practices within broader discussions of learner-centered education, experiential learning, knowledge construction, and meaningful participation (Gaspari, 2024; Mohsin, 2024).

Twenty-first-century education has intensified interest in storytelling because learning environments increasingly require students to integrate disciplinary knowledge with communication, creativity, collaboration, critical thinking, digital literacy, and social awareness. Storytelling offers pedagogical possibilities that correspond with these expectations because learners can become active producers, interpreters, and negotiators of meaning rather than passive recipients of information. Digital storytelling has particularly expanded the educational role of narrative by combining text, images, audio, animation, video, and other multimodal resources. Existing systematic evidence indicates that educational digital storytelling has been applied across primary, secondary, and higher education and has been associated with cognitive, affective, linguistic, technological, social, and academic outcomes (Q. Tan, 2024; Zhao, 2026).

Technological transformation has further diversified the narrative landscape through mobile applications, interactive media, social platforms, immersive environments, digital games, and increasingly artificial-intelligence-supported content creation. These developments have altered who constructs educational stories, how stories are represented, how learners interact with narratives, and how narrative activities are integrated into curricula. Storytelling can now function as instructional content, a learning activity, an assessment product, a reflective practice, or a participatory process through which students construct their own representations of knowledge. The widening range of narrative practices creates significant opportunities for education, while simultaneously making it more difficult to determine which storytelling models are pedagogically distinct, theoretically grounded, and supported by credible evidence (Marienko, 2024; Tong, 2024).

The increasing popularity of storytelling in education has generated a heterogeneous body of literature in which similar practices are described using different concepts and substantially different approaches are occasionally grouped under the same terminology. Terms such as *storytelling, digital storytelling, narrative pedagogy, story-based learning, narrative learning, educational storytelling,* and *multimodal storytelling* are frequently used across disciplinary contexts without consistent conceptual boundaries. Such terminological fragmentation creates difficulty in distinguishing storytelling as an instructional technique from storytelling as a broader pedagogical model. A critical problem therefore concerns the absence of sufficient conceptual clarity regarding how storytelling-based pedagogies can be classified according to their theoretical foundations, learner roles, narrative structures, technological modalities, and intended learning processes.

Empirical research also tends to emphasize the positive outcomes of storytelling while providing less systematic scrutiny of the conditions under which these outcomes occur. Previous reviews have identified benefits related to engagement, motivation, academic learning, language development, technological competence, reflection, and social interaction, yet concerns remain regarding methodological diversity, measurement consistency, implementation quality, and the predominance of favorable outcome reporting. A major systematic review of educational digital storytelling explicitly identified an overly positive pattern within the literature, while research on narrative pedagogy has cautioned that the concept can be too broad to permit confident conclusions

regarding universal effectiveness. Educational researchers therefore require more than a catalogue of benefits; they need a critical examination of the evidence supporting different narrative models (Škola, 2024; Stasolla, 2024).

Disciplinary fragmentation represents another significant problem. Storytelling-based approaches have developed within language education, literacy, teacher education, healthcare education, social sciences, humanities, mathematics, science education, inclusive education, and educational technology, often with limited conceptual dialogue across these domains. Recent reviews continue to examine digital storytelling within individual areas such as educational technology, mathematics, and English language learning, demonstrating both growing scholarly interest and continued disciplinary segmentation. Such fragmentation makes it difficult to understand the broader pedagogical landscape, identify transferable design principles, or determine whether apparently different models share underlying mechanisms of narrative learning (Ndlovu, 2024; F. F. Y. Tan, 2024).

The primary objective of this critical review is to map and critically examine the principal storytelling-based pedagogical models employed in twenty-first-century education. The review seeks to move beyond a narrow focus on digital storytelling by considering a wider spectrum of narrative approaches, including oral and written storytelling, narrative pedagogy, story-based instruction, learner-generated storytelling, collaborative narrative construction, digital storytelling, interactive narrative, game-mediated storytelling, and multimodal forms of narrative learning. The intended mapping will clarify how these approaches are conceptualized, how they differ in pedagogical organization, and which theoretical assumptions underpin their use within contemporary educational environments.

A second objective is to compare storytelling-based models according to their pedagogical characteristics and reported learning functions. Particular attention should be directed toward narrative authorship, learner agency, teacher roles, mode of participation, media configuration, degree of interaction, collaborative structure, disciplinary context, assessment practices, and intended outcomes. The analysis should examine whether storytelling primarily positions learners as listeners, interpreters, co-constructors, creators, performers, or critical readers of narratives. Such comparison can reveal how shifts in narrative agency correspond with different pedagogical purposes, ranging from knowledge acquisition and comprehension to reflection, identity formation, creativity, communication, collaboration, and critical meaning-making (Cante, 2024; Spence, 2024).

The review also aims to critically evaluate the quality, limitations, and educational implications of the existing evidence rather than assuming that storytelling is inherently effective because it is engaging or technologically innovative. Attention should be given to methodological rigor, theoretical coherence, outcome measurement, implementation conditions, cultural representation, accessibility, digital inequality, learner diversity, and ethical considerations surrounding narrative production. Recent evidence demonstrates continuing expansion of digital storytelling and reported cognitive and affective benefits, but also indicates a need for clearer understanding of effective design across disciplines and learning outcomes. The review therefore seeks to determine not merely whether storytelling works, but what forms of storytelling appear pedagogically meaningful, for whom, under which conditions, and for what educational purposes (Gatto, 2025; Krabokoukis, 2025).

Existing reviews have substantially advanced understanding of digital storytelling, but their analytical boundaries often remain centered on specific technologies, disciplines, populations, or learning outcomes. Earlier systematic work categorized educational digital storytelling according to

several orientations and diverse outcome domains, while more recent reviews have examined its relationship with twenty-first-century skills, educational technology, mathematics learning, language education, and inclusive pedagogy. These contributions are valuable, yet they do not fully provide an integrated mapping of the broader family of storytelling-based pedagogies that includes non-digital, participatory, reflective, disciplinary, multimodal, and technologically mediated narrative approaches.

A conceptual gap persists in understanding the relationships among different storytelling models. Existing research frequently evaluates individual interventions without determining whether their learning effects arise from narrative structure itself, learner authorship, collaborative activity, multimedia production, reflective interpretation, technological novelty, or combinations of these components. Digital storytelling, for example, may simultaneously involve narrative composition, project-based learning, media literacy, collaboration, reflection, and technological production. Attribution of learning outcomes exclusively to "storytelling" may therefore obscure the actual pedagogical mechanisms responsible for change. A critical comparative framework is needed to distinguish the narrative component from the instructional architectures within which narrative activity is embedded (Wu, 2025; Yu, 2025).

A critical-evaluative gap is also visible in the tendency of the literature to prioritize benefits while paying less sustained attention to limitations, unintended consequences, and contextual inequalities. Increased engagement does not automatically indicate deeper learning, technological sophistication does not necessarily produce pedagogical quality, and learner-generated narratives are not inherently inclusive or empowering. Narrative activities may reproduce dominant cultural representations, marginalize certain voices, expose personal experiences, create additional cognitive demands, or disadvantage learners with restricted technological access. Questions concerning privacy, authorship, cultural authenticity, accessibility, algorithmic mediation, and AI-assisted narrative production are becoming increasingly relevant. A contemporary review should therefore evaluate storytelling pedagogies through educational, technological, social, cultural, and ethical lenses rather than through outcome effectiveness alone (Huang, 2024; Lee, 2024).

The principal novelty of the proposed review lies in conceptualizing contemporary storytelling education as a narrative pedagogical landscape rather than treating digital storytelling or individual narrative strategies as isolated instructional techniques. The study can develop an integrative taxonomy that locates storytelling models across several analytical dimensions, including narrative authorship, pedagogical agency, media modality, interaction structure, teacher–student positioning, degree of technological mediation, learning purpose, and assessment orientation. Such a framework would permit systematic comparison among models that are frequently discussed in separate disciplinary literatures. The resulting map could clarify where models overlap, where they remain theoretically distinct, and how narrative practices have evolved alongside changes in twenty-first-century learning environments (Cheung, 2024; Rishu, 2024).

A second novelty lies in shifting the analytical question from "Does storytelling improve learning?" toward "How, why, when, and under what pedagogical conditions does storytelling contribute to learning?" This reframing is important because accumulated evidence already suggests that storytelling can support multiple forms of learning, while the field still requires stronger explanation of mechanisms, contextual contingencies, and design quality. The proposed review can distinguish between storytelling used to transmit knowledge and storytelling used to generate knowledge, between teacher-authored and learner-authored narratives, and between receptive, participatory, reconstructive, and transformative forms of narrative engagement. Such differentiation offers a more theoretically meaningful account of storytelling than a generalized

claim that narrative practices enhance motivation or academic performance (Peng, 2024; Yeni, 2024).

The study is justified by the rapid diversification of educational media and the increasing importance of narrative competence within digitally mediated learning cultures. Generative artificial intelligence, immersive technologies, multimodal authoring platforms, and collaborative digital environments are likely to further blur distinctions between storyteller, audience, learner, author, and technology. Educational research consequently needs a critical framework capable of evaluating new narrative practices without equating technological innovation with pedagogical advancement. Mapping the narrative landscape can provide scholars with a clearer conceptual vocabulary, assist educators in selecting storytelling models aligned with specific learning purposes, guide researchers toward more rigorous comparative studies, and establish an analytical foundation for evaluating emerging AI-supported and multimodal storytelling practices. The review therefore contributes not only by organizing existing knowledge but by redefining the questions through which storytelling-based pedagogy should be examined in twenty-first-century education (Guo, 2025; Tosun, 2025).

RESEARCH METHODOLOGY

This study employed a critical review design supported by a systematic literature search to map, compare, and critically evaluate storytelling-based pedagogical models used in twenty-first-century education. The critical review approach was selected because the study sought to move beyond descriptive aggregation of previous findings and develop an interpretive understanding of how different storytelling models are theoretically constructed, pedagogically organized, and empirically supported. The review examined storytelling not as a single instructional technique but as a heterogeneous family of pedagogical practices encompassing oral and written storytelling, narrative pedagogy, story-based learning, digital storytelling, learner-generated narratives, collaborative storytelling, interactive narratives, multimodal storytelling, game-mediated narratives, and emerging technology-supported forms of narrative learning. The analytical orientation was informed by the Search, Appraisal, Synthesis, and Analysis framework associated with critical review methodology (Gadaza, 2025; Hadjipanayi, 2024).

The review incorporated systematic procedures for literature identification, screening, eligibility assessment, and documentation to reduce arbitrary selection and strengthen methodological transparency. Reporting procedures were informed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Kompatsiaris, 2024; Stacchio, 2024), particularly in documenting database searches, duplicate removal, title and abstract screening, full-text eligibility assessment, and final study inclusion. PRISMA was used as a transparency framework rather than as a justification for treating the study as a conventional effectiveness-focused systematic review. The interpretive component remained central because the primary objective was to develop a critical mapping of the conceptual relationships, pedagogical mechanisms, evidentiary strengths, limitations, and emerging directions within the narrative pedagogy landscape.

The unit of analysis consisted of individual scholarly publications addressing storytelling as an explicit educational or pedagogical practice. Analysis was organized around several interconnected dimensions: theoretical foundation, form of storytelling, narrative authorship, learner agency, teacher role, media modality, degree of technological mediation, interaction structure, educational level, disciplinary context, learning objectives, reported outcomes, assessment approaches, and methodological quality. Particular attention was given to whether learners

functioned primarily as recipients, interpreters, co-constructors, creators, performers, or critical evaluators of narratives. This multidimensional structure enabled the review to distinguish pedagogically different models that might otherwise be grouped under the general label of storytelling.

The population of the review comprised peer-reviewed scholarly literature on storytelling-based pedagogical practices published in the twenty-first century. The search covered publications from January 2000 to August 2026 to capture both the development of established narrative pedagogies and the emergence of digitally mediated, multimodal, immersive, and artificial-intelligence-supported storytelling practices. Relevant literature was retrieved from Scopus, Web of Science Core Collection, ERIC, and Education Source because these databases provide broad coverage of educational research, educational technology, psychology, language education, teacher education, and interdisciplinary scholarship. Reference lists of highly relevant review articles and included studies were also examined to identify potentially important publications not retrieved through the primary database searches.

The sample consisted of all publications that satisfied the predetermined eligibility criteria after duplicate removal and multistage screening. Eligible studies were required to examine storytelling or narrative construction as a substantive component of teaching and learning; involve formal, non-formal, or technology-mediated educational contexts; provide sufficient information regarding pedagogical design, implementation, theoretical rationale, or learning outcomes; and be published as peer-reviewed journal articles or scholarly review papers in English. Empirical qualitative, quantitative, mixed-methods, design-based, and intervention studies were eligible because the review aimed to investigate the conceptual and methodological diversity of the field rather than privilege one research paradigm. Seminal conceptual articles were retained when they provided substantial theoretical foundations or introduced influential storytelling-based pedagogical models (Kompatsiaris, 2024; Treco, 2024).

Publications were excluded when storytelling appeared only incidentally, functioned exclusively as entertainment without an identifiable educational purpose, or referred to narrative merely as a research data collection technique rather than a pedagogical approach. Studies focused exclusively on clinical narrative therapy, commercial marketing, organizational communication, or non-educational media were excluded unless they directly examined teaching or learning. Conference abstracts, editorials, book reviews, dissertations, non-peer-reviewed materials, inaccessible full texts, and publications lacking sufficient methodological or pedagogical detail were also excluded. The final number of included studies was determined by the eligibility process rather than by a predetermined numerical sample target, and the complete selection trajectory was documented through a PRISMA-style flow diagram.

Data collection and analysis were supported by four researcher-developed instruments: a search documentation protocol, an eligibility screening form, a structured data extraction matrix, and a critical appraisal framework. The search documentation protocol recorded the database, search date, search string, applied restrictions, and number of retrieved records to ensure reproducibility. The eligibility screening form translated the inclusion and exclusion criteria into standardized decisions during title, abstract, and full-text assessment. The data extraction matrix captured bibliographic information, country and educational context, research design, participant characteristics, educational level, discipline, storytelling terminology, theoretical framework, pedagogical model, narrative authorship, technological modality, learning activities, assessment methods, reported outcomes, and major limitations (Billman, 2024; Deng, 2024).

The critical appraisal framework was designed to assess both methodological credibility and pedagogical contribution because conventional risk-of-bias instruments alone would not adequately address the diverse conceptual and methodological literature included in the review. Empirical studies were examined according to clarity of research questions, appropriateness of design, adequacy of participant or data descriptions, transparency of intervention procedures, validity of measurement or qualitative analysis, alignment between evidence and conclusions, and acknowledgement of limitations. Conceptual and review studies were evaluated according to theoretical coherence, clarity of definitions, comprehensiveness of evidence, analytical depth, and contribution to the conceptualization of storytelling pedagogy. Quality assessment was used to inform the weight assigned to individual studies during interpretation rather than to eliminate all studies falling below an arbitrary numerical threshold.

A pedagogical mapping matrix constituted the principal analytical instrument for developing the narrative landscape. Each included study was coded according to narrative source, narrative authorship, learner participation, degree of interactivity, collaboration, media modality, technological intensity, teacher positioning, intended learning function, and dominant educational outcome. Narrative authorship differentiated teacher-authored, externally authored, collaboratively authored, and learner-generated stories. Participation was classified along a continuum from receptive engagement to interpretive, participatory, constructive, and transformative narrative activity. The coding framework was refined iteratively during analysis to accommodate pedagogical forms that were not adequately represented by the initial categories. Independent coding of a subset of studies by two reviewers was used to examine interpretive consistency, with disagreements resolved through discussion and refinement of category definitions.

The review procedure began with the formulation of the review questions and operational definitions of storytelling-based pedagogy. Preliminary searches were conducted to identify terminology used across educational disciplines and to refine the final search vocabulary. Database searches combined terms related to storytelling and narrative practices with terms associated with education and pedagogy. Representative concepts included “storytelling,” “digital storytelling,” “narrative pedagogy,” “story-based learning,” “educational storytelling,” “learner-generated storytelling,” “collaborative storytelling,” “interactive storytelling,” and “multimodal storytelling,” combined with terms such as “education,” “teaching,” “learning,” “pedagogy,” “instruction,” “student,” and “classroom.” Search syntax was adapted to the indexing conventions of each database while retaining the same conceptual structure across sources.

Retrieved references were consolidated in a reference management database and duplicates were removed before screening. Titles and abstracts were assessed against the predetermined eligibility criteria, followed by full-text evaluation of potentially relevant publications. Reasons for exclusion at the full-text stage were documented to increase transparency. Screening decisions were independently checked on a subset of records to reduce subjective selection bias. Citation chaining was subsequently performed through backward examination of relevant reference lists and targeted identification of influential studies repeatedly cited across the corpus. Newly identified records underwent the same eligibility process as database-retrieved publications (Li, 2024; Mo, 2024).

Data extraction was conducted after the final corpus had been established. Each article was read in full and coded using the structured extraction and pedagogical mapping matrices. Descriptive mapping was initially conducted to identify publication trends, educational sectors, disciplinary concentrations, geographical distributions, research designs, technologies, and commonly reported outcomes. Conceptual analysis then examined how storytelling was theoretically defined and how narrative roles were distributed among teachers, students, peers,

technologies, and pre-existing narrative materials. Studies using similar terminology but substantially different pedagogical architectures were separated, while approaches using different labels but sharing comparable mechanisms were examined for conceptual convergence (Berg, 2024; Isaacs, 2024a).

Critical synthesis proceeded through iterative comparison, thematic categorization, and conceptual abstraction. Evidence was organized around major storytelling-based pedagogical configurations and compared according to theoretical foundations, instructional mechanisms, learner agency, technological mediation, learning outcomes, methodological strength, and implementation limitations. Contradictory findings and negative or neutral outcomes were retained rather than subordinated to predominantly positive evidence. Particular attention was given to distinguishing improvements plausibly associated with narrative mechanisms from outcomes that might instead arise from project-based learning, collaboration, multimedia production, technological novelty, or increased instructional time.

The final analytical stage involved constructing an integrative map of storytelling-based pedagogical models in twenty-first-century education. Models were positioned according to the relationships among narrative authorship, learner agency, interaction, modality, technological mediation, and pedagogical purpose. Cross-model comparison was used to identify areas of conceptual overlap, distinctive pedagogical mechanisms, evidence gaps, and emerging trajectories associated with immersive media and generative artificial intelligence. The synthesis sought to answer not merely whether storytelling supports learning, but how particular narrative configurations operate, which educational purposes they are best positioned to serve, what evidence supports their use, and under which contextual conditions their benefits or limitations become most apparent. The resulting framework was refined through repeated comparison with the included literature to ensure that the proposed taxonomy remained grounded in the evidence rather than being imposed independently of the reviewed studies.

RESULT AND DISCUSSION

The systematic search yielded 1,536 records from Scopus, Web of Science Core Collection, ERIC, Education Source, and supplementary citation searching. Removal of 376 duplicate records resulted in 1,160 unique publications for title and abstract screening. Screening excluded 811 records because storytelling was not treated as a substantive pedagogical practice, the educational context did not meet the eligibility criteria, or the publication type was outside the review scope. Full texts were assessed for 349 publications, of which 257 were excluded because of insufficient pedagogical information, incidental use of narrative, inaccessible full text, non-peer-reviewed status, or lack of relevance to teaching and learning. The final analytical corpus consisted of 92 publications addressing storytelling-based pedagogical models in twenty-first-century education. The selection profile is summarized in Table 1.

Table 1. Literature Identification, Screening, and Final Review Corpus

Review Stage	Number of Records	Percentage of Initial Records
Records identified	1,536	100.0
Duplicate records removed	376	24.5
Titles and abstracts screened	1,160	75.5
Records excluded after initial screening	811	52.8
Full-text publications assessed	349	22.7

Full-text publications excluded	257	16.7
Studies included in the final review	92	6.0

The included literature demonstrated substantial diversity in educational setting, research design, and pedagogical configuration. Higher education represented the largest context with 37 studies (40.2%), followed by secondary education with 23 studies (25.0%), primary education with 19 studies (20.7%), and teacher professional development or other educational settings with 13 studies (14.1%). Quantitative designs accounted for 29 studies (31.5%), qualitative approaches for 24 studies (26.1%), mixed-methods research for 21 studies (22.8%), and design-based or developmental research for 10 studies (10.9%). Eight publications (8.7%) consisted of conceptual or review-based contributions retained because they provided influential frameworks for distinguishing narrative pedagogical models. The distribution shows that storytelling research has developed across educational sectors but remains especially concentrated in technology-rich and higher-education environments.

The chronological distribution revealed a gradual movement from predominantly teacher-directed and text-based storytelling toward digitally mediated, learner-generated, collaborative, and interactive narrative practices. Publications from the earlier period of the review more frequently treated storytelling as a strategy for presenting curricular content, contextualizing abstract concepts, or supporting language comprehension. Later studies increasingly positioned students as narrative producers who combined disciplinary content with personal interpretation, visual representation, audio, video, animation, interactive media, or digital collaboration. The change suggests that the pedagogical meaning of storytelling expanded alongside broader transformations toward constructivist, participatory, and technology-mediated education.

The expansion of digital storytelling did not eliminate traditional narrative pedagogy. Teacher-led oral narratives, case stories, reflective narratives, and disciplinary storytelling continued to appear across the corpus, particularly in professional education, humanities, language learning, and contexts where narrative interpretation was more important than multimedia production. The evidence therefore does not support a simple evolutionary assumption in which technologically advanced storytelling replaced earlier approaches. The narrative landscape was better characterized by diversification, with traditional, digital, collaborative, multimodal, interactive, and emerging AI-supported forms coexisting and serving different pedagogical purposes.

Six broad pedagogical configurations were identified through iterative coding and conceptual comparison. Digital storytelling constituted the largest category, comprising 31 studies (33.7%). Learner-generated narrative models accounted for 16 studies (17.4%), collaborative or co-constructed storytelling for 13 studies (14.1%), and narrative pedagogy or story-based instruction for 12 studies (13.0%). Interactive and game-mediated storytelling appeared in 10 studies (10.9%), while multimodal, immersive, or emerging AI-supported storytelling accounted for another 10 studies (10.9%). The categories were defined by dominant pedagogical architecture rather than terminology alone because publications using identical labels often differed substantially in learner authorship, interaction, and instructional purpose.

Table 2. Distribution and Pedagogical Characteristics of Storytelling-Based Models

Pedagogical Model	Studies n (%)	Dominant Learner Role	Typical Modality	Prominent Learning Functions
Digital storytelling	31 (33.7)	Creator/producer	Video, audio, image, text	Engagement, digital literacy, comprehension, creativity
Learner-generated narrative	16 (17.4)	Author	Written/multimodal	Reflection, agency, knowledge construction
Collaborative storytelling	13 (14.1)	Co-author	Digital/face-to-face	Collaboration, communication, negotiation
Narrative pedagogy/story-based instruction	12 (13.0)	Listener/interpreter	Oral, written, case narrative	Conceptual understanding, reflection
Interactive/game-mediated storytelling	10 (10.9)	Participant/decision-maker	Games, branching narratives	Problem solving, engagement, decision making
Multimodal/immersive/AI-supported storytelling	10 (10.9)	Co-creator/interactor	XR, multimodal, generative AI	Creativity, personalization, multimodal literacy

Learning outcomes were multidimensional and frequently overlapped within individual publications. Academic achievement or conceptual understanding was reported in 57 studies (62.0%), engagement or motivation in 61 studies (66.3%), creativity in 49 studies (53.3%), digital or multimodal literacy in 45 studies (48.9%), critical thinking in 42 studies (45.7%), and communication or collaborative competence in 38 studies (41.3%). Reflection, identity development, perspective-taking, or personal meaning-making appeared in 29 studies (31.5%). The distribution indicates that the literature has moved considerably beyond the assumption that storytelling primarily facilitates memory or attention. Contemporary narrative pedagogy is increasingly associated with cognitive, affective, social, creative, technological, and identity-related dimensions of learning.

Exploratory inferential analysis was conducted on the coded corpus to examine whether selected pedagogical characteristics were systematically associated with reported learning outcomes. Student-authored or collaboratively constructed storytelling models were more frequently associated with higher-order learning outcomes, including critical thinking, creativity, reflection, and problem solving, than models dominated by teacher-authored or externally prepared narratives. Higher-order outcomes were identified in 39 of 51 student-authored or co-constructed studies compared with 20 of 41 predominantly receptive or externally authored studies. A chi-square test indicated a statistically significant association between narrative authorship and higher-order learning outcomes, $\chi^2(1, N = 92) = 7.58$, $p = .006$, Cramér's $V = .29$.

Table 3. Exploratory Relationships Between Pedagogical Characteristics and Reported Outcomes

Pedagogical Relationship	χ^2	df	p	Cramér's V	Interpretation
Student/co-authorship × higher-order learning	7.58	1	.006	.29	Moderate association
High technological mediation × engagement	9.10	1	.003	.31	Moderate association
Collaboration × academic achievement	0.65	1	.419	.08	Weak/non-significant

association

Technologically intensive storytelling was also significantly associated with reported engagement outcomes, $\chi^2(1, N = 92) = 9.10$, $p = .003$, Cramér's $V = .31$. The relationship between collaborative storytelling and academic achievement was not statistically significant, $\chi^2(1, N = 92) = 0.65$, $p = .419$, indicating that collaborative structure alone did not reliably correspond with improved achievement. These tests should not be interpreted as causal estimates because the unit of analysis was the publication and outcome coding was based on reported study findings rather than standardized effect sizes. The inferential analysis instead provides exploratory evidence that authorship and technological mediation may differentiate the educational functions of storytelling models.

Cross-model comparison revealed a consistent relationship between learner agency and the complexity of reported learning outcomes. Models positioning students primarily as listeners or recipients were commonly associated with comprehension, knowledge retention, contextualization, and emotional engagement. Models positioning learners as authors or co-authors were more frequently connected with creativity, reflection, communication, critical thinking, disciplinary knowledge construction, and digital literacy. Interactive models added decision making and problem solving by requiring learners to influence narrative progression. The relationship suggests that the educational function of storytelling changes as learners move from receiving narratives toward constructing and transforming them.

Technological mediation displayed a more complex relationship with outcomes. Multimedia and interactive technologies were strongly associated with engagement, creative production, and digital competence, but technological sophistication did not consistently correspond with stronger conceptual learning. Studies reporting positive outcomes frequently described pedagogical scaffolding, narrative coherence, iterative production, feedback, and explicit connections between storytelling tasks and curricular goals. Studies with less convincing results tended to rely more heavily on technological novelty or production activity without clearly explaining how narrative processes supported disciplinary learning. The observed pattern indicates that technology functions as an affordance for narrative pedagogy rather than an independent mechanism of educational effectiveness.

A representative cluster of teacher-led narrative models illustrated the receptive end of the pedagogical landscape. These studies typically used stories, cases, historical narratives, or teacher-created digital materials to contextualize concepts and make disciplinary content more meaningful. Students primarily listened, viewed, discussed, or interpreted existing narratives. Stronger outcomes were commonly reported for engagement, conceptual understanding, emotional connection, and recall, while evidence for learner agency or creative knowledge construction was comparatively limited. This cluster demonstrated that receptive storytelling remained pedagogically valuable when narrative structure enabled learners to connect abstract content with human experience, context, and causality.

A contrasting cluster involved learner-generated, collaborative, interactive, and emerging AI-supported narratives. Students in these environments developed storylines, selected representations, negotiated narrative decisions, combined media, revised scripts, and communicated disciplinary knowledge through authored products. Interactive approaches sometimes required learners to make decisions that altered narrative outcomes, while emerging generative-AI applications supported brainstorming, character development, language generation, visualization, or alternative narrative pathways. The strongest cases preserved student decision-making and critical evaluation rather than

delegating authorship to technology. These configurations positioned storytelling as a process of knowledge production rather than merely a vehicle for delivering instructional information.

The differences between receptive and productive models appear to arise from the cognitive and social demands embedded in narrative authorship. Listening to a well-constructed educational story can organize complex material into a coherent sequence, activate emotion, provide contextual cues, and facilitate memory. Producing a story requires learners to select information, establish causal relationships, identify an audience, translate disciplinary concepts into narrative form, evaluate representations, and revise meaning. Collaborative production adds negotiation, perspective-taking, shared decision making, and communication. The greater frequency of higher-order outcomes in learner-authored models can therefore be understood as a consequence of the additional intellectual work demanded by the production process rather than storytelling authorship alone.

Emerging AI-supported storytelling created both pedagogical opportunities and conceptual tensions. Generative systems could reduce technical barriers, facilitate rapid ideation, support multilingual expression, generate alternative story structures, and enable adaptive narrative experiences. Heavy reliance on automated generation could simultaneously reduce the cognitive processes that make storytelling educationally productive if students merely accepted machine-generated narratives without critical evaluation or meaningful authorship. The relevant pedagogical distinction was therefore not simply between AI-supported and non-AI storytelling. More consequential differences concerned who controlled narrative decisions, who evaluated generated content, and whether technological assistance extended or displaced learners' interpretive and creative work.

The integrated findings portray twenty-first-century storytelling pedagogy as a differentiated narrative landscape rather than a single instructional method. Six broad configurations were identified, ranging from teacher-directed narrative instruction to learner-generated, collaborative, interactive, multimodal, immersive, and emerging AI-supported models. Reported benefits extended across achievement, engagement, creativity, digital literacy, critical thinking, communication, collaboration, reflection, and identity-related learning. Variation across these outcomes was associated more strongly with the pedagogical architecture of storytelling—particularly authorship, learner agency, interaction, and scaffolding—than with the presence of narrative or digital technology alone.

The central interpretive finding is that storytelling becomes pedagogically more transformative as learners gain meaningful responsibility for constructing, questioning, negotiating, and revising narratives, provided that this agency is supported by coherent instructional design. The evidence does not justify treating every storytelling intervention as inherently learner-centered, innovative, or effective. Teacher-directed narrative remains valuable for particular learning purposes, while technologically intensive storytelling can become pedagogically superficial when media production overshadows conceptual learning. The mapped landscape therefore shifts the analytical focus from asking whether storytelling "works" toward examining who authors the narrative, how learners participate, what pedagogical mechanisms are activated, which technologies mediate those processes, and what forms of learning the resulting narrative architecture is capable of supporting.

The findings portray storytelling-based pedagogy in twenty-first-century education as a heterogeneous landscape rather than a single instructional method. Six broad configurations emerged from the reviewed literature: digital storytelling, learner-generated narrative, collaborative storytelling, narrative pedagogy or story-based instruction, interactive or game-mediated

storytelling, and multimodal, immersive, or emerging AI-supported storytelling. These configurations differed substantially in narrative authorship, learner participation, technological mediation, instructional purpose, and expected learning outcomes. Such diversity demonstrates that the educational value of storytelling cannot be adequately explained by the presence of narrative alone. Pedagogical architecture determines whether a story functions primarily as a vehicle for transmitting information, facilitating interpretation, supporting collaborative knowledge construction, or enabling learners to produce and transform knowledge.

The reviewed evidence also showed that storytelling-based models were associated with a broad range of educational outcomes. Engagement and motivation represented the most frequently reported outcomes, while academic achievement, conceptual understanding, creativity, digital literacy, critical thinking, communication, collaboration, reflection, and identity-related learning were also prominent. The breadth of these outcomes indicates that narrative pedagogies operate across cognitive, affective, social, technological, and reflective domains. The findings challenge a narrow conception of storytelling as merely a motivational strategy used to make lessons more interesting. Contemporary applications increasingly position narrative activity as an instructional environment within which learners organize information, interpret experiences, communicate disciplinary understanding, and negotiate relationships between knowledge and personal meaning.

Learner agency emerged as an especially important differentiating feature across the mapped models. Approaches in which learners primarily received or interpreted stories tended to emphasize comprehension, contextualization, memory, and emotional engagement. Approaches requiring learners to author, co-author, revise, or interactively shape narratives were more frequently associated with creativity, critical thinking, reflection, communication, problem solving, and knowledge construction. The exploratory association between student authorship and higher-order learning outcomes reinforces this pattern, although it should not be interpreted causally because publication-level coding does not isolate the effects of authorship from other instructional features. Narrative production appears pedagogically important because it changes the learner's role from audience member to active meaning-maker.

Technological mediation constituted another central but more ambiguous pattern. Digital and interactive storytelling models were frequently associated with engagement, multimodal literacy, and creative production, yet technological complexity did not consistently correspond with deeper conceptual learning. Stronger studies tended to connect technology with narrative planning, disciplinary reasoning, collaboration, revision, and reflective activity rather than treating media production as an end in itself. The overall findings therefore suggest that technology expands what storytelling can do, but does not automatically improve what students learn. Narrative coherence, instructional alignment, learner responsibility, scaffolding, and purposeful interaction remain more pedagogically consequential than the novelty of the technological platform.

The findings are broadly consistent with Wu and Chen's systematic review of educational digital storytelling, which demonstrated that digital storytelling was used across educational levels and produced affective, cognitive, conceptual, academic, technological, linguistic, social, and identity-related outcomes. Their analysis also distinguished multiple orientations ranging from more appropriative uses to agentive, reflective, reconstructive, and reflexive forms. The present review extends that earlier classification by positioning digital storytelling as one part of a wider narrative pedagogical landscape and by comparing it with non-digital, collaborative, interactive, multimodal, and emerging technology-supported models. The broader mapping reinforces the argument that storytelling cannot be treated as a pedagogically uniform category.

The strong relationship observed between narrative production and twenty-first-century competencies also corresponds with the systematic qualitative review by Isaacs and colleagues. Their synthesis of 18 studies concluded that creating digital stories consistently engages twenty-first-century skills, with especially notable contributions to critical thinking, creativity, and collaboration. The present findings support this pattern but provide an additional qualification: the relevant mechanism appears to be less the digital character of storytelling than the intellectual demands created by authorship, design, negotiation, and revision. Learners become cognitively active when they must decide what information belongs in a story, how ideas are connected, which representations are appropriate, and how meaning should be communicated to an audience.

The distinction between receiving and creating stories is further supported by recent research examining digital storytelling and self-regulated learning. Gita, Ferede, and Tondeur found that learners involved in creating digital stories demonstrated stronger self-regulatory processes than learners who primarily received digital storytelling materials created by others. Planning, goal setting, research, imagination, monitoring, and reflection were identified as important processes involved in narrative production. The present review reaches a compatible conclusion by showing that student-generated models tend to activate a broader range of learning functions than predominantly receptive configurations. The similarity between these findings suggests that narrative authorship may operate partly through increased metacognitive responsibility rather than through creative expression alone.

The findings differ from interpretations that portray digital storytelling as almost uniformly beneficial. Wu and Chen previously identified what they described as an overwhelmingly positive pattern in the literature, raising concern that unsuccessful, neutral, or problematic implementations may receive less scholarly visibility. More recent evidence provides a more differentiated picture. A review combining meta-analysis and qualitative synthesis reported small-to-moderate positive effects on cognitive and affective learning while also identifying technical challenges and the time-intensive demands of digital story production. The current mapping strengthens this more critical interpretation by showing that technology, collaboration, and authorship produce different outcomes depending on instructional design and implementation conditions. Storytelling should therefore be evaluated as a pedagogical configuration rather than presumed effective because it contains narrative or multimedia elements.

The diversity of identified models signifies that storytelling has undergone a fundamental pedagogical transformation. Traditional educational storytelling often positioned knowledge within narratives produced by teachers, textbooks, or cultural sources, while many contemporary models transfer substantial narrative authority to learners. Students increasingly determine characters, perspectives, sequences, media, representations, and conclusions. This transition marks a broader movement from storytelling as instructional transmission toward storytelling as participatory knowledge construction. Narrative activity becomes pedagogically significant not simply because students encounter stories, but because learners are increasingly invited to determine how knowledge itself is organized and represented through narrative forms.

The relationship between authorship and higher-order outcomes signifies that learner agency should be treated as a central analytical variable in future storytelling research. Categories based only on media format, such as digital versus non-digital storytelling, may obscure more important differences in what students are actually required to do. Two activities may both use digital storytelling while one involves watching an instructor-produced video and another requires weeks of research, scripting, collaboration, production, feedback, and revision. Treating these activities as equivalent because both are “digital storytelling” reduces conceptual precision. The pedagogical

question should therefore concern the distribution of narrative authority and cognitive responsibility rather than the technological label attached to the activity.

The coexistence of traditional and technologically advanced storytelling signifies that educational innovation is not inherently evolutionary in the sense that newer media replace older pedagogies. Oral storytelling, written narratives, cases, and teacher-generated stories remain useful when the educational objective involves explanation, contextualization, emotional connection, or interpretation. Interactive media, digital production, and immersive environments become valuable when they add educational functions that simpler formats cannot provide. The relevant criterion is pedagogical fitness rather than technological novelty. Such a conclusion challenges technology-deterministic assumptions that equate increasing digital sophistication with increasing instructional quality.

The emerging presence of generative artificial intelligence signifies a new transformation in narrative authorship that deserves particular scrutiny. Previous technological innovations primarily changed the media through which stories were created or experienced, while generative systems can now participate directly in ideation, scripting, representation, revision, and narrative generation. Educational benefits may arise when AI supports brainstorming, feedback, multilingual expression, or iterative experimentation. Educational risks arise when the system performs the interpretive and compositional work that learners were intended to undertake. Recent research on AI-supported learning similarly stresses that productive outcomes depend on the interaction among learners, teachers, technologies, and regulatory processes rather than the presence of AI itself.

The first implication concerns how educators select storytelling approaches. Teachers should not begin with the question of which storytelling technology is available, but with the learning process that students need to experience. Teacher-directed stories may be appropriate for introducing concepts, illustrating dilemmas, providing memorable contexts, or activating emotional engagement. Learner-generated storytelling may be more appropriate when the instructional objective involves synthesis, creative representation, reflection, or disciplinary communication. Collaborative narrative production may support negotiation and perspective-taking, while interactive narratives may be particularly suitable for decision making, scenario analysis, and problem solving. Pedagogical objectives should therefore determine the narrative configuration rather than technology determining the lesson (Bell, 2024; Morris, 2025).

The second implication concerns instructional design. Storytelling tasks require explicit alignment among narrative activity, disciplinary content, assessment criteria, and intended learning outcomes. A visually attractive digital story should not automatically be considered evidence of conceptual understanding. Assessment needs to distinguish media quality from disciplinary reasoning, narrative coherence, evidence use, critical interpretation, collaboration, and reflective insight. Teachers may also need to provide scaffolds for story structure, information selection, media literacy, copyright awareness, source evaluation, and revision. Evidence from recent syntheses confirms positive cognitive and affective outcomes while simultaneously showing that digital story production may create substantial technical and temporal demands.

The third implication concerns teacher roles. Increased learner authorship does not diminish the pedagogical importance of teachers; it changes the form of teacher involvement. Narrative-centered classrooms require educators to design meaningful tasks, establish boundaries, support disciplinary accuracy, facilitate reflection, monitor collaboration, provide feedback, and help students evaluate representations critically. Research on digitally supported self-regulated learning similarly indicates that effective educational technology depends on dynamic interaction among teacher guidance, learner regulation, and technological affordances. Storytelling pedagogy should

consequently avoid a false opposition between teacher-centered and learner-centered practice. Structured learner agency often requires sophisticated instructional guidance (Menhas, 2024; Munaro, 2024).

The fourth implication concerns educational equity and ethics. Storytelling can provide opportunities for voice, identity exploration, cultural representation, and participation, but these possibilities should not automatically be equated with inclusion. Learners differ in technological access, language proficiency, media-production experience, willingness to disclose personal experiences, and cultural understandings of appropriate storytelling. Narrative tasks may unintentionally privilege students with greater digital resources or encourage forms of personal disclosure that create discomfort or vulnerability. AI-generated narratives introduce additional questions involving authorship, originality, representation, data privacy, cultural stereotyping, and intellectual ownership. Responsible storytelling pedagogy therefore requires ethical design alongside creative and technological innovation (Meimaridis, 2024; Pikhart, 2024).

The stronger association between learner authorship and higher-order learning can be explained by the cognitive demands inherent in constructing a coherent narrative. Story creation requires learners to identify relevant information, determine causal or temporal relationships, organize ideas around a meaningful structure, anticipate an audience, select representations, and evaluate whether the resulting narrative communicates the intended meaning. These processes demand transformation rather than reproduction of knowledge. Research linking digital storytelling with self-regulated learning similarly identifies planning, goal setting, information seeking, imagination, and reflection as central activities within story creation. Narrative authorship therefore creates an environment in which cognition and metacognition operate simultaneously.

The prominence of creativity and collaboration can be explained by the open-ended nature of many storytelling tasks. Narrative problems often allow multiple acceptable interpretations rather than a single predetermined solution. Students can experiment with perspective, sequence, metaphor, representation, voice, and media while negotiating how disciplinary knowledge should be translated for an audience. Collaborative storytelling adds social regulation because learners must justify choices, reconcile competing interpretations, distribute responsibilities, and construct shared meaning. The systematic synthesis of twenty-first-century skills in digital storytelling similarly identified creativity, critical thinking, and collaboration as particularly prominent outcomes, supporting the interpretation that these competencies arise from the production process itself (Berg, 2024; Mo, 2024).

The strong relationship between technological mediation and engagement can be explained partly by expanded modes of participation. Multimedia storytelling enables students to combine text, voice, images, movement, music, interaction, and visual design, giving learners more representational choices than conventional written tasks. Interactive environments can further provide immediate consequences, branching possibilities, and opportunities to inhabit multiple perspectives. Engagement should nevertheless be distinguished from learning. Novel media can increase attention without necessarily producing conceptual change, especially when production demands consume time that might otherwise be used for reasoning, feedback, or reflection. The technical and time-related challenges identified in recent reviews illustrate why technological richness does not guarantee instructional effectiveness.

The uneven effects of storytelling across studies can also be explained by the fact that storytelling rarely operates as an isolated intervention. Digital story projects often contain elements of project-based learning, collaborative learning, inquiry, multimedia composition, peer feedback, reflective writing, and technology training. Positive outcomes attributed to storytelling may

consequently emerge from several interacting instructional mechanisms. Wu and Chen's earlier review already showed that educational digital storytelling was frequently combined with other pedagogies, creating difficulty in attributing effects to narrative alone. The present mapping makes this problem more explicit and indicates that future research should specify which component of a storytelling activity is theoretically expected to produce each learning outcome (Kasemsarn, 2025; Linville, 2024).

Future research should move from broad questions about whether storytelling improves learning toward comparative investigations of specific narrative architectures. Studies should directly compare teacher-authored, learner-authored, collaboratively authored, and AI-assisted storytelling while controlling important instructional variables. Such designs could determine whether narrative authorship itself contributes to critical thinking, reflection, or knowledge retention, or whether observed advantages primarily arise from additional time on task, collaboration, media production, or teacher support. Experimental and quasi-experimental research would be particularly valuable when combined with qualitative analysis capable of explaining how learners experience different forms of narrative participation (Linville, 2024; Modi, 2024).

Longitudinal research should examine whether storytelling produces durable changes in learning rather than immediate engagement or short-term performance. Creativity, identity development, disciplinary understanding, communication competence, digital literacy, and self-regulated learning may develop across repeated cycles of narrative construction rather than through a single intervention. The 2025 review of digital storytelling and self-regulated learning specifically identifies incomplete evidence across cognitive, motivational, behavioral, and emotional regulatory domains. Repeated measurement and process-based research could clarify how narrative production influences these dimensions over time and whether skills acquired through storytelling transfer to other educational tasks.

Future reviews should also address the geographical, disciplinary, and methodological imbalances of the literature. Storytelling research has developed substantially across educational settings, yet evidence remains unevenly distributed across disciplines, countries, educational levels, and learner populations. Comparative studies across cultural contexts are needed because assumptions about voice, identity, collaboration, authorship, and appropriate narrative expression are culturally situated. Greater attention should also be given to negative, neutral, or mixed findings. The “rosy picture” identified in earlier digital storytelling scholarship remains an important warning against publication and interpretation practices that privilege successful applications while overlooking pedagogical difficulties (Isaacs, 2024b; Zhu, 2024).

Research on generative AI should become a major next step in mapping the narrative landscape. The crucial question is not whether AI can generate educational stories, because that capability is increasingly evident, but how AI changes the distribution of authorship, cognitive responsibility, creativity, and pedagogical agency. Studies should compare AI as an idea generator, feedback partner, linguistic scaffold, multimodal production assistant, collaborative co-author, and autonomous story generator. Evaluation should examine when AI expands learners' narrative possibilities and when it substitutes for the reasoning, interpretation, and creative decision making that make storytelling educationally valuable. The next generation of storytelling research should therefore focus less on technological novelty and more on preserving meaningful human authorship within increasingly intelligent narrative environments.

CONCLUSION

The most important finding of this critical review is that storytelling-based pedagogy in twenty-first-century education cannot be treated as a single instructional approach. The reviewed literature reveals a differentiated narrative landscape encompassing digital storytelling, learner-generated narratives, collaborative storytelling, narrative pedagogy, interactive or game-mediated storytelling, and emerging multimodal, immersive, and AI-supported models. The most distinctive pattern lies in the relationship between learner authorship and the complexity of learning outcomes. Models that position students as active authors, co-authors, or narrative decision-makers tend to support broader forms of learning, including critical thinking, creativity, reflection, collaboration, and knowledge construction, while predominantly receptive models more frequently support comprehension, contextualization, engagement, and retention. Technological sophistication alone does not guarantee deeper learning; pedagogical value depends more strongly on learner agency, narrative coherence, instructional alignment, scaffolding, and the meaningful distribution of authorship.

The principal contribution of this review is conceptual and methodological. Conceptually, the study proposes an integrative mapping of storytelling-based pedagogical models according to narrative authorship, learner agency, interaction structure, media modality, technological mediation, teacher positioning, and pedagogical purpose. This framework moves beyond classifications based only on technological format and provides a more precise basis for understanding why apparently similar storytelling activities may generate different educational outcomes. Methodologically, the combination of systematic literature identification, critical appraisal, comparative coding, and cross-model synthesis offers an analytical approach capable of examining both the strengths and limitations of heterogeneous narrative practices. The review therefore shifts the central question from whether storytelling is effective toward how, why, for whom, and under what pedagogical conditions particular forms of storytelling contribute to meaningful learning.

The review is limited by its reliance on English-language peer-reviewed publications, potential database and publication bias, substantial methodological heterogeneity across the included studies, and the difficulty of isolating storytelling effects from accompanying practices such as project-based learning, collaboration, multimedia production, and technology use. The rapid emergence of generative artificial intelligence also means that the evidence concerning AI-supported storytelling remains comparatively immature and may change quickly. Future research should employ comparative experimental and longitudinal designs to examine the specific effects of narrative authorship, learner agency, scaffolding, and technological mediation across educational levels and cultural contexts. Further studies should also investigate how AI functions as a narrative scaffold, collaborative partner, or autonomous generator, with particular attention to authorship, originality, cultural representation, cognitive responsibility, ethics, and learning quality. Such research would strengthen the empirical foundation for selecting and designing storytelling-based pedagogies that are pedagogically purposeful rather than technologically driven.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used Google Gemini to assist inimproving grammar, language quality, and overall readability of the text. After using this tool, the author(s) Carefully reviewed and edited the content as necessary and take full responbility for the content of the publication.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.
Author 4: Formal analysis; Methodology; Writing - original draft.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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