

Narrative as a Cognitive Scaffold for Human-Centered Design Education: A Case Study of Schema Change in Interaction Design Students

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ABSTRACT

Human-centered design (HCD) education has long faced a gap: while students can readily produce ideas, they struggle to integrate scattered concepts into coherent interaction design works. This study examines whether narrative pedagogy can help interaction design students develop such integrative cognitive capacity, with two aims: (1) to analyze how students' creativity schemas across the four ION dimensions change under narrative pedagogical intervention, and (2) to examine the role of narrative pedagogy as a cognitive scaffold in shaping students' design thinking. The study adopts Kim's CATs model as its primary framework, using ION thinking combined with Creative Attitudes, and draws on Meisiek et al.'s schema-change modes for describing cognitive change. Situated in an eight-week Story Creativity and Narrative Design course at National Yunlin University of Science and Technology, Taiwan, this qualitative multiple-case study tracked three interaction design students through pre-, mid-, and post-course semi-structured interviews, with intercoder reliability checked across three independent coders. Findings reveal changes across all four dimensions: the basis for judging work shifted from personal feeling to design purpose; the starting point for ideation shifted from direct personal association to first defining the audience and then constructing content; the way of organizing design elements shifted from juxtaposition to causal chaining; the use of emotion and playfulness shifted from passive reception to active deployment for conveying messages. Among these, metaphorical thinking was the only capability emerging during the course, while others were refined mid-course and internalized post-course, persisting after the instructor's scaffolding was withdrawn — this temporal pattern provides concrete empirical support for the claim of narrative as scaffold, and this structure aligns with the integrative capacity required by interaction design practice. The study therefore argues that narrative in HCD education should be reframed from a communication skill to a scaffold for design cognition; for design educators, this means narrative practice can serve as a practical pedagogical intervention for cultivating integrative design capacity.

Keywords: Narrative pedagogy, Cognitive scaffolding, Design process, Schema change, Human-centered design education, Qualitative case study

INTRODUCTION

Research Background

Narrative is widely recognized as an effective communicative mode in design, bringing emotional resonance to design works (Lewis, 2011). Stories frame issues in memorable ways, capture attention, render complex information accessible, and build emotional connections that inspire reflection and action (Abbott, 2002). In the design field, narrative techniques (e.g., shaping plots, characters, and atmospheres to convey themes and concepts) have been shown to function as effective communicative tools (Cross, 2011). In human-centered design (HCD) and interaction design contexts, narrative structure may further serve as a conceptual tool for organizing interaction experiences: the use process of an interactive product can be understood as a story that the user enters and unfolds (Lloyd, 2000).

Beyond serving as a communicative bridge in the design process, narrative is itself a creative activity. Creativity involves both the generation of novel ideas and their concrete realization (Runco and Jaeger, 2012), while narration is the process of transforming creative concepts into stories with temporal and causal structure (Bruner, 1986). Amabile (1996) noted that creativity development involves imagination, the ability to integrate diverse information, problem identification skills, and attitudinal traits such as curiosity and openness.

However, in design education, students often struggle to deepen their initial concepts into structured, coherent design works (Cross, 2011; Lloyd, 2000). Green et al. (2024) conceptualize creativity as a process from idea generation through evaluation to concrete realization; from this perspective, this challenge reflects a gap between “idea generation” and “structural integration”: students possess divergent thinking capacity but lack effective methods for organizing and integrating ideas. Narrative structure requires creators to weave scattered elements (events, characters, motives) into a coherent whole encompassing temporal sequencing (Abbott, 2002), causal logic (Chen and Bornstein, 2024), and multi-perspective coordination (Bruner, 1996), corresponding to the integrative capacity students appear to lack. This phenomenon motivates the present study’s question: can narrative serve as a cognitive scaffold to help design students develop integrative capacity?

Research Motivation

Narrative’s role in design education has garnered increasing scholarly attention. Talan’s (Talan, 2021) meta-analysis indicated that digital storytelling can promote students’ creative thinking and academic performance. Mou’s (2024) study further found that combining visual storytelling with creative thinking training significantly enhances design students’ creative self-efficacy.

Nevertheless, the mechanism by which narrative promotes the development of design creativity remains insufficiently explored (Mariani and Ciancia, 2023). In the HCI/UX education context, MacDonald et al. (2024) note that although narrative is regarded as a core professional competence, its multidimensional manifestation across different design contexts makes

narrative pedagogy a challenge that has not yet been fully addressed. Existing research has focused primarily on measuring pedagogical effectiveness, while the developmental process of “how creative capacity develops” — particularly how narrative supports the change of students’ creativity schemas — remains without systematic investigation (Mariani and Ciancia, 2023). Addressing this research gap is the main motivation of the present study.

Research Purpose and Questions

Grounded in the foregoing background, this study examines the influence of narrative pedagogy on the creativity development of design students. The core research question is: what is the influence of narrative pedagogy on design students’ creativity? The study is situated in the Story Creativity and Narrative Design course, with two objectives: (1) to analyze the schema change process of students’ creativity, using a process-oriented research method to examine how students’ creative thinking patterns and cognitive frameworks across the four ION dimensions change dynamically during the narrative pedagogy activities; (2) to examine the role of narrative pedagogy as a cognitive scaffold — how narrative pedagogy, through guiding students to integrate scattered ideas and construct meaningful links between concepts, facilitates creativity development — and to derive implications for HCD and interaction design education.

LITERATURE REVIEW

The possibility of narrative serving as a cognitive scaffold for design students’ creativity rests on three layers of theoretical grounding: an understanding of what constitutes creativity, an understanding of cognitive scaffolding mechanisms, and an understanding of how narrative intervenes in cognitive processes.

Creativity, Cognitive Frameworks, and Scaffolding in Design Education

Contemporary research widely adopts Runco and Jaeger’s (2012) standard definition of creativity as the capacity or output that is both novel and appropriate. Kim’s (2016) CATs model further articulates this through ION thinking (Kim and Williams, 2020), which subdivides creative thinking into three modes: Inbox (critical analysis), Outbox (divergent thinking), and Newbox (integrative innovation). For readers familiar with HCD process models, the cognitive operations corresponding to ION’s three modes parallel the capabilities required at the analysis, divergence, and integration stages of the human-centered design process (Brown, 2008). The present study adopts ION thinking combined with Creative Attitudes as the analytic framework (see Section 3.1).

Scaffolding, introduced by Wood, Bruner, and Ross (1976) and originating in Vygotsky’s (1978) zone of proximal development, was extended by Pea (2004) to a distributed-intelligence perspective in which cognition is distributed across tools and symbolic systems. From this view, narrative

structure can itself be regarded as a cognitive tool. Acar et al. (2019) further indicate that moderate constraints can promote creativity, and Tromp and Baer (2022) propose a constraint-based creativity pedagogy framework. Narrative structure offers this kind of moderate constraint.

Narrative as a Cognitive Tool: Schema and Schema Change

Bruner (1986; 1991) distinguishes paradigmatic thinking from narrative thinking; subsequent research further indicates that narrative thinking involves multiple cognitive features, including the organization of temporal sequence (Abbott, 2002), the inference of causal relations (Chen and Bornstein, 2024), and the coordination of multiple perspectives (Bruner, 1986).

Fletcher and Benveniste (2022), drawing on training experience with the U.S. Department of Defense, Fortune 50 companies, and graduate and professional school students, argue that narrative may serve as an alternative training pathway to divergent thinking, grounded in different neural processes. This line of research provides initial support for advancing narrative from a ‘cognitive mode’ to a ‘teachable cognitive strategy.’

Understanding how narrative pedagogy changes students’ ways of thinking requires examining how cognitive structures themselves adjust. The schema concept, proposed by Piaget (1952), involves assimilation and accommodation as core mechanisms; Koh and Leung (2019) further note that future-oriented schemas particularly support creative cognition. In the design thinking education context, Meisiek et al. (2023) draw on Rumelhart and Norman’s three schema-learning modes: accretion (adding instances under the existing schema), tuning (refining details while preserving the original structure), and restructuring (reorganizing the schema to accommodate new possibilities); they find tuning to be the main learning mode in design thinking education. The present study adopts this three-mode framework as analytic vocabulary for describing students’ schema change during the narrative pedagogy intervention.

Narrative in Interaction Design Education

The HCD process is itself narrative in structure: designers must imagine user scenarios, envision experience journeys, and articulate design decisions through narrative (Lloyd, 2000). Interactive products further require designing multiple paths and branching experiences that users may traverse (Koenitz, 2015). Narrative thus serves HCD education in two interlocking roles—as a communicative instrument helping designers articulate design intent, and as a cognitive tool shaping how designers organize user experience.

In design education, Lee et al. (2023), using an architecture design studio as the research site, found that storytelling enhances students’ emotional engagement and promotes coherent thinking from ideation to visualization to expression. Mariani and Cancia (2023), adopting an Interactive Digital Narrative (IDN) perspective, propose that creativity development emerges through iterative cycling between paradigmatic and narrative thinking, conceptually echoing the schema-change trajectory examined here.

Mou's (2024) study found that combining visual storytelling with creative thinking training significantly enhances design students' creative self-efficacy. However, existing research has largely focused on outcome measurement; how narrative practice serves as a cognitive scaffold supporting students in producing effective human-centered interaction design remains underexplored (2023).

METHODOLOGY

This study adopts a qualitative multiple-case design, with each element—from the research setting and course structure to the interview procedure and data analysis—oriented toward tracking the processual changes in students' creativity.

Research Design and Analytic Framework

This study employs a qualitative multiple-case design, using Braun and Clarke's (2006; 2019) thematic analysis as the primary analytic strategy. The analytic framework draws on Kim's (2016) CATs model—specifically the four-dimension framework of ION thinking (Inbox, Outbox, Newbox) plus Creative Attitudes—because it captures both processual changes in creativity development and the cognitive-affective dimensions. Because this study focuses on classroom pedagogy rather than environmental factors, only the thinking-skills and attitudes components are adopted.

Research Site and Participants

The research site was the Story Creativity and Narrative Design course at the Department of Digital Media Design, National Yunlin University of Science and Technology. The eight-week studio-based course covered story-structure analysis, character development, plot construction, and narrative design practice. Three students enrolled in the course served as research participants, recruited through purposive sampling; sample size was guided by Malterud et al.'s (2016) information-power principle (three interviews per participant, nine in total). Creswell and Poth (2018) similarly note that three to five participants suffice to yield rich analytic material in focused, in-depth qualitative inquiries.

Course Design

The course was organized into three units guided by ION thinking: Unit 1 Inbox training (Weeks 1–2) used Little Red Riding Hood for analyzing multi-version story structures; Unit 2 Outbox training (Weeks 3–6) focused on divergent narrative proposals; Unit 3 Newbox training (Weeks 7–8) integrated prior learning into concrete creative outputs (interactive video, AI-generated content, games). The instructor's presence followed a progressively-fading scaffolding structure: instructor-led demonstration → methods and tools → consultative role.

Interviews

Semi-structured in-depth interviews served as the primary data-collection method, conducted across three stages: pre-, mid-, and post-course. Eight interview questions (Q1–Q8) were designed across the four dimensions (the three ION thinking modes plus Creative Attitudes). Each interview lasted approximately 20–40 minutes and was fully audio-recorded and transcribed verbatim. The three-stage interview questions are listed in Table 1.

Table 1. Interview questions across three stages.

No.	Interview Question	ION Dimension
Q1	In your past experience, how have stories influenced your design decisions?	Inbox
Q2	What do you think Little Red Riding Hood primarily conveys?	Inbox
Q3	In your view, how could the story of Little Red Riding Hood become more compelling?	Outbox
Q4	How would you use public familiarity with Little Red Riding Hood to market a ‘pedestrian-priority crosswalk’ concept?	Outbox
Q5	In interactive media design, how can narrative techniques make a design more interactive and vivid?	Newbox
Q6	How do emerging technologies and media narrative forms influence user experience?	Newbox
Q7	Please share a creative work or activity you found impressive. Why did you find it creative?	Creative Attitudes
Q8	What does “telling stories through design” mean to you?	Creative Attitudes

Data Analysis

Data analysis followed Braun and Clarke’s (2006) six-phase procedure. Three researchers independently conducted open coding, with intercoder reliability checked using Holsti’s (1969) coefficient. After repeated calibration, the mean reliability across the three interview stages reached 0.76, 0.76, and 0.80 (overall mean 0.77), exceeding the 0.70 threshold (2002). Codes agreed upon by all three coders were grouped into the four ION dimensions, ultimately yielding mutually agreed-upon concepts. Research quality was ensured through quotation density and cross-checking across three independent coders.

FINDINGS

The following sections present core findings and evidentiary bases for each of the four analytic dimensions (Inbox, Outbox, Newbox, and Creative Attitudes); each section is organized along the pre-, mid-, and post-course axis, with a closing section synthesizing students’ overall schema-change patterns through the lens of narrative scaffolding.

Critical Thinking (Inbox): From Intuition to Analysis

The core transformation in this dimension is a shift in the basis of judgment: from “how it feels to me” toward analytic criteria. Pre-course, all three participants’ responses to stories remained at the intuitive level: D-1 attributed the gap to personal knowledge volume (“Maybe I haven’t read enough books” D-1A_Q2); D-2 extracted moral lessons directly (“to take the safer main road” D-2A_Q2); D-3 used sensory impact as the criterion (“especially dramatic” D-3A_Q3). The shared pattern: they could feel quality but could not articulate its basis.

After Unit 1 training, all three progressed from “I can’t say why something was bad” to distinguishing form from content and recognizing their own habitual ways of thinking. D-2’s transformation was the most representative, layering naming-the-old-habit, explaining-the-mechanism-of-change, and describing-the-new-practice:

“Before, when I thought about stories without having taken related courses, I just thought however I wanted to think. ... After taking this course, I pay more attention to narrative arc. ... Now it’s more structured ideation. I might first have a framework, and then think about events, characters, and their narrative arc.” (D-2B_Q5).

D-2 did not merely report “before X, now Y” but identified how the change occurred, indicating that D-2 had begun using an analytic framework to evaluate their own thinking process. Naming the old habit of “thinking however I wanted” marked the moment when a previously implicit framework was first objectified. Post-course, D-1’s critical framework had developed into a self-constructed design principle: “The purpose should come first; the story serves that purpose” (D-1C_Q7). This three-layer relationship was not directly taught in the course, indicating that the adjusted analytic framework had begun to integrate into D-1’s thinking.

Divergent Thinking (Outbox): From Association to Strategy

The core transformation in this dimension lies in a change in the starting point and method of ideation: from direct personal association toward methodical divergence guided by structural frames. Pre-course, all three participants’ responses to the Q4 cross-domain translation task remained at the preliminary stage of fluent imagination: D-1 directly transplanted characters into a traffic scenario; D-2 drew from personal fear; D-3 attempted character mapping but found it unsatisfactory. The shared pattern: ideas originated from direct personal associations, with no consideration of method or audience.

After Unit 2 training, changes emerged in all three. D-1 naturally articulated the old habit: “Normally I follow logic, but this time at the start I wrote completely randomly” (D-1B_Q4); the unfamiliarity of the new method allowed D-1 to recognize “how I normally think” for the first time. D-3 not only described the experience but identified why the method worked: “Forcing them to be related” (D-3B_Q5).

Post-course, D-2 first inferred audience characteristics and then reverse-engineered the format: “First, you need to confirm who you are speaking to. ... Converting it into a comic might attract more adolescents” (D-2C_Q1),

exemplifying the core feature of flexible imagination. D-3's lateral thinking had become "subconscious" (D-3C_Q5), shifting from mid-course deliberate application to post-course automatic use without prompts. The transformation lies not in the quantity of ideas but in the change in starting point and method: from direct personal association toward methodical divergence guided by structural frames and audience considerations.

Innovative Integration (Newbox): From Fragments to Integration

Newbox thinking concerns integration and innovative practice. In Storytelling, all three participants' pre-course narrative organization remained at fragmentary collage. D-1's storytelling logic originated from compositional arrangement ("what to look at first and what next" D-1A_Q1); D-2 used topic-by-topic juxtaposition ("saving electricity is one page ... I thought of air conditioning" D-2A_Q1). Mid-course, D-2 began linking ideas through causal logic: "hunter → catching criminals → news → reporters" (D-2B_Q2), shifting from "adding whatever came to mind" to "because A, therefore B, therefore C."

With Storytelling established, all three developed distinct integrative modes through Boundary-crossing and Elaboration in the post-course phase. D-1 mapped deepfake technology onto Little Red Riding Hood's "disguise" motif: "two fakes deceiving each other, and the final reveal is that both are actually fake" (D-1C_Q2), and articulated the design logic: "The persona is something everyone recognizes; within the plot, you layer in the design purposes" (D-1C_Q3). D-2 employed a modular architecture: "The beginning and ending remain roughly the same, but there are many different events in the middle" (D-2C_Q4). D-3 designed a detective-style interactive narrative:

"In our story, suspicious clues are planted everywhere. ... A little boy suddenly tells Little Red Riding Hood that the man in the suit is suspicious, and if they want to go to grandmother's house, this path is a shortcut—but no one told the boy that Little Red Riding Hood was going to grandmother's house, and how did the boy know the shortcut?" (D-3C_Q3).

D-3's detective perspective combined with mystery game constitutes Boundary-crossing; layered clue embedding and moral-dilemma integration demonstrate Elaboration. Notably, metaphorical thinking followed a markedly different trajectory from the other sub-indicators: completely absent pre-course, first appearing mid-course (D-1's "two toy soldiers to represent psychological states" D-1B_Q1), with D-3 post-course tracing "metonymy upon metonymy" in peer work (D-3C_Q6). While the other sub-indicators progressed from shallow to deep refinement, metaphorical thinking emerged as a "from nothing to something" structural appearance, forming a clear contrast with the gradual refinement observed in the other dimensions.

Creative Attitudes: From Experiencing to Deploying

Among the sub-indicators, transformations in Emotional engagement and Playfulness were most clearly evident. In Emotional engagement, D-3 exhibited the most complete trajectory: pre-course as a passive spectator ("as

if they were real, actually existing people” D-3A_Q7); mid-course connecting emotion with design function (“design has warmth ... to put yourself in someone else’s shoes” D-3B_Q8); post-course discovering that assignments could carry personal expression:

“I can secretly embed my own story in the assignment. ... The game’s content comes from my own personal experiences. ... If they can truly understand this game, I will feel gratified.” (D-3C_Q7)

D-3 demonstrated self-monitoring of perspective shifts (“I want to say something different”) and was already imagining the receiver (“if they can really play through it”). D-2’s trajectory differed, treating emotion as a communication tool: “while they’re experiencing these emotions, they’re also able to understand what you want to convey” (D-2C_Q7). On playfulness, all three experimented with exaggeration and absurdity mid-course; post-course, D-2 incorporated comic-style dialogue and memes into safety education comics (D-2C_Q2). The three students’ use of emotion and playfulness all underwent a shift: from passive reception of content pre-course to active deployment as design means for conveying messages post-course.

Narrative Scaffolding and Patterns of Schema Change

If narrative structure functions as scaffolding in the Wood-Bruner-Ross sense (1976), the ways of thinking that students acquire should bear narrative’s hallmarks. D-2’s shift from “adding whatever came to mind” to causal-logic linking corresponds to the causal reasoning that narrative requires; D-2’s “first establishing a framework, then thinking about narrative arc” composition style reflects the temporal sequencing inherent in narrative; D-3’s control of clue-disclosure pacing from the player’s standpoint exercises the perspective-taking capacity narrative demands.

Across the four dimensions, students’ schema changes exhibit a common pattern: criteria of judgment shifted from intuition to analysis; ideation methods shifted from personal association to audience-first consideration; ways of organizing elements shifted from fragmentary juxtaposition to causal chains and layered narrative linking; the handling of emotion and playfulness shifted from passive reception to active deployment for design purposes — the common structure across these changes is that students’ existing thinking schemas were not replaced but rather underwent localized modification while the original architecture was preserved. This matches Meisiek et al.’s (2023) description of the tuning mode: refining the internal operations of existing schemas while preserving structure.

Of note, these capabilities persisted after the instructor stepped back. D-1 independently formulated the design principle “purpose comes first, story serves that purpose,” content that was not directly taught; D-3’s lateral thinking has become something D-3 does “subconsciously,” without external prompting. The core of scaffolding theory is temporary support: if students continue to function independently after the support is withdrawn, the scaffolding has fulfilled its function. Whether this constitutes stable internalization requires longer-term tracking.

CONCLUSION AND DISCUSSION

Conclusion

This study takes the cognitive change of three interaction design students across an eight-week narrative pedagogy course as cases to address the research question of the influence of narrative pedagogy on design students' creativity. Through three-stage interview analysis (pre-, mid-, post-course), all three students showed observable change across the ION three thinking modes and creative attitudes: critical thinking shifted from intuitive judgment to analysis using design purpose as the standard (e.g., D-1's self-constructed principle "purpose comes first, story serves that purpose"); divergent thinking shifted from personal association to first defining the audience and then constructing content (e.g., D-2 shifting from "I find it interesting" to "first confirm who you're telling it to"); innovative integration shifted from fragmentary juxtaposition to linking design decisions through causal chains and layered narrative, with metaphorical thinking — previously absent — emerging during the course; emotion and playfulness shifted from passive reception to active deployment as design means for conveying messages. These cross-dimensional changes converge on a common pattern: through operating with narrative structure, students were able to articulate in language their previously implicit thinking habits, allowing those habits to be perceived and gradually adjusted.

For the existing literature, this study addresses the gap noted by Mariani and Ciancia (2023) regarding the integration of narrative pedagogy with cognitive process research: it adopts a process-oriented approach to concretely show how narrative influences the operation of students' creativity schemas, rather than relying solely on pedagogical effectiveness as an indicator. The findings also respond to MacDonald et al.'s (2024) concern regarding the unclear mechanisms of narrative pedagogy in HCI/UX education, providing an empirical basis for repositioning the role of narrative training in HCD education.

Discussion

As noted in the Newbox analysis, metaphorical thinking is the only sub-indicator entirely absent pre-course and first appearing during the course. The study speculates that the core operation of adaptation tasks (establishing meaningful correspondences between the original story and a new context) may have provided the venue for metaphorical thinking's first emergence. If this inference holds, it suggests that "strengthening" and "awakening" may require different pedagogical strategies. From the perspective of Meisiek et al.'s (2023) three modes, this non-incremental emergence is closer to restructuring rather than the tuning shown in other dimensions, implying that narrative pedagogy may simultaneously activate different schema-change modes across different cognitive dimensions.

Why did all three subordinate story to design purposes post-course? This phenomenon may stem from a core concern of design as a discipline: design education has long emphasized solving user problems and persuading audiences to take action (Cross, 2011). From the perspective

of Meisiek et al.'s (2023) three modes, the three participants' approaches remain closer to tuning rather than restructuring at the framework level: narrative capacity has been integrated as a refinement of their existing design-process schema rather than as a reorganization of it. From the design-process perspective, this tuning-level integration is not a limitation — it means that the cognitive capacities cultivated by narrative pedagogy directly serve their interaction design practice: D-2's causal reasoning serves the logical design of interaction flows; D-3's clue-disclosure pacing control and moral-dilemma design exemplify the design of user experience pacing in interaction design.

Implications for HCD Education and Design-Process Pedagogy

First, narrative can serve as a potential cognitive scaffold in HCD courses' design processes. As discussed in "Narrative Scaffolding and Patterns of Schema Change" section, students continued post-course to spontaneously deploy the integrative capacity that narrative training developed, and these capacities correspond structurally to the integrative capacity required by the HCD design process. Building on this, HCD and interaction design course design could experiment with adjusting narrative practice from an auxiliary communication skill into a scaffold for the design process, dialoguing with core modules such as user research and prototyping, and embedded in courses such as HCD introduction, interactive narrative, and experience design.

Second, constraint-based pedagogical design is feasible for cultivating design-process cognition. The schema change observed in this study did not unfold through theoretical exposition but through students' hands-on operation of narrative constraints—fixed narrative structures, cross-domain translation tasks, and constraint-based story rewriting. All three participants first became aware of their existing design-process habits through encountering "unfamiliar methods," echoing Tromp and Baer's (2022) constraint-based creativity pedagogy framework. For HCD educators, this supports the feasibility of "productive constraints" as a core instructional tool for design-process cognition. For HCD practitioner training, Meisiek et al.'s (2023) schema-change framework may also apply to contexts in which experienced designers re-objectify established methods to incorporate emerging design contexts; this extension awaits empirical validation.

Limitations and Future Research Directions

This study has several limitations: it focuses on three design-background students; employs retrospective interviews; lacks a control group; and the researchers' theoretical framework may serve simultaneously as analytic tool and interpretive filter. Future research could employ longitudinal tracking to observe whether post-course design-process cognition persists, compare design-background and non-design-background students, and use instructional experiments to clarify which features of cross-context translation tasks are critical to the emergence of metaphorical thinking. Additionally, the mapping between narrative's structural features and key HCD-process capabilities suggests a tool-design research direction worth

exploring: whether HCD process tools could integrate explicit narrative-structure constraints to support designers' integrative thinking in early-stage design—a speculative direction that awaits validation.

GENERATIVE AI DISCLOSURE

Generative AI tools were used to assist with sentence-level English polishing and document formatting (e.g., table layout) to improve readability. All research activities, including literature selection, citation verification via Crossref and publisher databases, data coding and analysis, and conceptual development, were performed independently by the author.

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