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Reframing creative learning: a conceptual framework for design literacy in the GenAI era

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Abstract

Introduction. Generative artificial intelligence (GenAI) is reshaping how creative learning engages with information. GenAI systems extend access and accelerate ideation, yet they also introduce epistemic unreliability, diminished originality, and ethical ambiguity. This research examines how design learning across formal, non-formal, and informal settings are destabilised by GenAI's mediation of information and argues for a framework to sustain design literacy in the GenAI era.

Method. This study employs a conceptual framework–building approach, drawing on information science, AI literacy, and design pedagogy to articulate four planes of competency: epistemic, operational, ethical–legal, and reflective. It is developed through integrative literature review and abductive synthesis, clustering concepts across disciplines.

Analysis. Within these planes, nine action components are identified: provenance tracing, uncertainty tagging, cross-modal triangulation, plausibility checks, prompt engineering, iterative prototyping with AI, bias and harm review, authorship disclosure, and reflective critique. Their application is illustrated through scenarios across contexts varying formality.

Results. The framework shows how these competencies preserve curiosity, iteration, and originality while mitigating misinformation, bias, and overreliance on GenAI.

Conclusion. This study proposes a conceptual framework for GenAI-impacted creative learning, reframes design literacy as information practice, and outlines a research agenda for empirical validation in curricula, cultural programs, and informal learning.

Introduction

In recent years, generative artificial intelligence (GenAI) has rapidly penetrated educational and creative design fields. In education, GenAI tools promise to transform learning by providing scalable personalised support, diversifying, and innovating assessment methods (Yan et al., 2024, p. 1839). In parallel, design disciplines are increasingly leveraging GenAI as a co-creative tool. For example, in architecture studios, text-to-image generators are being used to produce visual concepts, offering alternative ways towards inspiration and rapid prototyping (Copper et al., 2024, p. 150). Institutionalised education has started to integrate AI competencies into curricula, recognising that arts and humanities fields like cultural studies and design also need to prepare learners for AI-augmented practice (Schauer & Simbeck, 2024, p. 39). AI represents an intersection of digital technology with learning and creative workflows – a convergence that brings both opportunities and unfamiliar challenges.

Problem statement

The rise of GenAI have raised concerns about the destabilisation of conventional creative learning processes and their information practices. Educators are alarmed that over-reliance on AI tools may undermine learners' agency, critical thinking, and originality. Initial studies caution that uncritical dependence on GenAI can erode creativity and problem-solving skills (Yan et al., 2024, p. 1840). Additionally, there is scholarly evidence that unchecked use of GenAI yields derivative or unethical work, as learners might accept AI-generated outputs without sufficient reflection or personal iteration (Copper et al., 2024, p. 150). The integrity of information use in design learning is also at stake. GenAI models can produce incorrect or biased content, blurring the line between fact and fabrication and potentially misguiding learners (Mills et al., 2024, p. 4). This challenge is reminiscent of earlier shifts in the digital information landscape at the emergence of digital libraries. Researchers back then observed fundamental changes in how users sought and interacted with information resources, necessitating refined literacy and evaluation skills (Wilson & Maceviciute, 2012, p. 120). Similarly, today's GenAI has already established itself as a powerful and convenient instrument for creative learning. However, to safeguard the essence of '*design literacy*', learners must be compelled to cultivate adaptive approaches to information synthesis, a process for which no clear evaluative framework currently exists.

Scope

The implications of GenAI for creative learning spans across formal, non-formal, and informal learning contexts. Formal design learning refers to structured programs in schools and universities, with examples of architecture or graphic design curricula. Non-formal design learning encompasses organised but outside-the-classroom activities such as workshops held in museums and libraries, professional development courses, or community maker programs. Informal learning covers family or self-directed and ad-hoc practices that occur in everyday life—from hobbyist projects to learning through social networks. All three domains are integral to the development of design competence. With growing public access to open access and commercial GenAI models- all are being reshaped.

Design thinking and creativity are recognised as essential skills for navigating 21st-century challenges (Yorgancıoğlu et al., 2025, p. 1). Scholars have long argued that design should be part of general education due to its role in fostering problem-solving and adaptability. As early as the 1970s it was asserted that design in education meets an '*urgent need for the survival as well as the happiness of mankind*' (Baynes, 1974, p. 46). Today, with rapid technological and societal changes, this claim is even more pertinent. The influence of GenAI on how people learn and practice in design can span across any layer of institutional education, to serendipitous lifelong learning. This study examines how these diverse modes of creative learning can be evaluated under a common conceptual framework. The aim is to ensure that, even with GenAI integration, the essence of creative learning and the capacity-building of learners are preserved and, ideally, enhanced.

Research objective

Given the twin imperative to leverage AI's benefits and mitigate its risks, this research aims to develop a conceptual framework for sustaining design literacy in the era of GenAI. Design literacy now refers to a broad set of knowledge, skills, and mindsets that enable individuals to engage creatively and critically in ideating something new. Recent discourse portrays design literacy as an expansion of design thinking, integrating not only creative skills but also critical reflection, ethical awareness, and collaborative knowledge-building (Yorgancıoğlu et al., 2025, p. 2). In the context of AI, sustaining '*design literacy*' should mean ensuring that creative learners maintain their human-centered creative capacities even when using AI tools.

The objective of the proposed framework is to address strategies to preserve and enhance critical thinking, originality, and educated information practices when AI, GenAI in particular, is embedded in design work. For example, it should emphasise competencies like AI literacy: understanding and evaluating GenAI outputs – as a component of design literacy. The secondary objective is to ensure that designers remain in control of the creative process rather than deferring to or being led by AI. It can also incorporate principles of responsible design practice, echoing calls for critical and responsible design education that instil ethical and social considerations into every creative effort (Lutnæs, 2020, p. 12).

Literature and background

In addition to database keyword searches, a berry-picking strategy was used to iteratively trace reference lists of foundational and high-impact articles in the domain of creative learning, learning science, artificial intelligence, design education and human computer interaction. Through this process, 20 articles were reviewed. The literature consistently indicates that information literacy, design literacy, and AI literacy are distinct yet increasingly interconnected competencies. This section synthesises existing conceptualisations of each term and identifies the associated gaps in current research.

Information literacy

Information literacy is the ability to recognise when information is needed and to locate, evaluate, and use it effectively and ethically. Within structured learning, this involves equipping learners to assess the quality and context of sources. Conventional information literacy emphasises structured search and evaluation of information, while creative learning disciplines often require additional modes of synthesis. As Appleton et al. (2017) note, art and design students benefit when these foundations are extended through '*radical*' information and communication strategies incorporating drawing, studio projects and creative enquiry.

Design literacy

Design literacy refers to the capability to formulate new idea iterations and understanding how that process shapes both digital and physical environments. Lutnæs (2021) describes it as recognising design's impacts, both positive and negative, and approaching real-world problems as complex challenges that demand sustainable innovation. Learners with design literacy are therefore better prepared to investigate whether and how technologies such as AI contribute to or undermine long-term human and environmental well-being (Lutnæs, 2021).

AI literacy

This is the most recent of these literacies. Long and Magerko (2020) define it as '*a set of competencies that enables individuals to evaluate AI technologies critically; communicate and collaborate effectively with AI; and use GenAI as a tool.*' (p. 1) It includes understanding GenAI's capabilities and limits, anticipating its ethical risks, and using it responsibly (Yan et al., 2024).

For centuries, information synthesis and creativity were grounded in human intelligence. With AI emerging as a parallel to its human counterpart, AI literacy now extends the boundaries of both information and design literacy that have traditionally been solely human-centred. By taking on roles once entrusted to human cognition, GenAI introduces a psychological shift in how learners engage with knowledge and creativity.

Learner's psychological shift

This shift is also sharpened by the post-truth era, which began before AI's mainstream adoption. Learners today have grown up in information environments where misinformation spreads quickly and trust in facts is fragile. Chinn et al. (2021) describe this as an '*epistemically unfriendly*' world and argue that education must explicitly cultivate the dispositions and abilities needed to seek accurate and well-justified ideas. This calls for systematic learning on how to question assumptions, weigh evidence, and apply critical reasoning- which are components of information literacy. In creative learning, educators often assume that exposure to ideas naturally fosters creativity. Yet the combined pressures of post-truth dynamics and GenAI's opaque, '*black box*' outputs demand deliberate instructional design that reforms learner mindsets and strengthens habits of evaluation (Chinn et al., 2021).

Identification of research gap

The concept of design literacy remains broad and abstract, with earlier studies offering only provisional syntheses rather than a settled definition (Lutnæs, 2021, p. 139). By contrast, AI literacy has attracted a lot of discussions recently, yet its role in design education is less developed—even though publicly available GenAI systems are now applied to design tasks more frequently than many other forms of work.

A further limitation in existing literature is that the accounts of design literacy seldom acknowledge the importance of information literacy, even though fields such as architecture, graphic communication and industrial design depend heavily on information to guide decision-making. This gap is especially notable in 'AI-*enabled design*' because information is also the primary building block and output of GenAI, making the relationship between these literacies even more critical. Little research examines how strengthening information and AI literacies can help guard learners from misinformation or reshape learners' response to design problems.

Current scholarship remains fragmented, highlighting the need for an integrated framework that connects these literacies to the psychological and epistemic shifts caused by? a post-truth, AI-driven era.

Methodology

Based on the set definitions and identified research gap, this study employs an extended integrative literature review across information science, AI literacy, and design pedagogy to develop the conceptual framework. Recent scholarship on creative learning and technology (e.g., Ng et al., 2021; Lutnæs, 2021), along with related education research including UNESCO's cultural-arts education guidelines, was analysed. Using iterative abductive reasoning, recurring concepts such as literacy, creativity, tool use, and ethics were identified and thematically clustered.

These thematic clusters informed the formulation of '*planes*', conceptualised as distinct modes of judgment through which creative learning with generative AI can be examined. Parallel notions of design literacy (Lutnæs, 2021) and AI or digital literacy (Ng et al., 2021; Mills et al., 2024) were compared and synthesised into composite constructs that operate across multiple planes. Open coding and conceptual mapping were used to extract definitions and evaluative dimensions, following the integrative review approach outlined by Vermeulen and Hémond (2025). Key concepts were '*extracted, compared, and synthesised across disciplinary boundaries*' (Vermeulen & Hémond, 2025, p. 358), with overlapping ideas refined iteratively.

This analytical process also led to the identification of '*action components*' as recurring evaluative and reflective criteria that operate across planes. Action components can be clustered in different permutations and combinations to support different '*planes*' to evaluate creative learning outcomes in specific instructional contexts. To ensure conceptual breadth, the review deliberately spanned formal, non-formal, and informal learning contexts, aligning with calls for learning ecosystems that integrate school-based, community-based, and self-directed settings (UNESCO, 2024, p. 6). Conceptual framework building was selected as an appropriate method for organising cross-disciplinary theory in emerging areas such as AI-impacted creativity (Vermeulen & Hémond, 2025, p. 350).

The framework development process is illustrated in Figure 1.

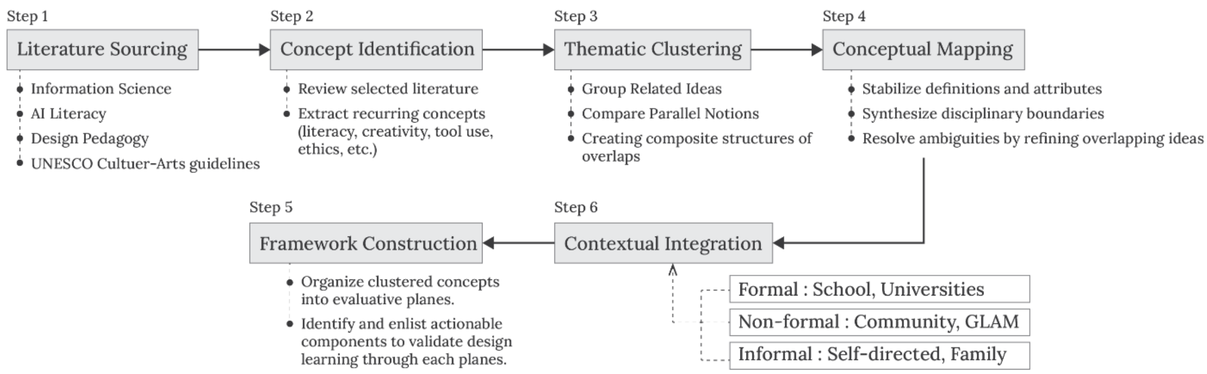

Figure 1. Methodology flow in the development of conceptual framework.

Conceptual framework

The resulted conceptual framework is visualised in Figure 2. Each design learning task is designed to move through the four **planes of competency**, using a combination of the **nine action components**. Not all components might need to be applied at once or for a specific '*plane of competency*'; rather, they may be used in different combinations across iterations.

Epistemic plane

The epistemic plane would be responsible for ensuring that AI outputs are accurate and credible. Action components here can include **provenance tracing**, which is tasked to track the origin of data and AI outputs to confirm authenticity (Mills et al., 2024, p. 4), and **cross-modal triangulation**, which compares results across different modalities (e.g., text, image, and video) to support consistency (Ng et al., 2021, p. 213). Learners can also engage in **uncertainty tagging** by attaching confidence scores to model outputs (Mills et al., 2024, p. 5) and conduct **plausibility checks** using domain knowledge and common sense to reject outputs that contradict established facts (Yan et al., 2024, p. 1842).

Operational plane

The operational plane emphasises skilful use of GenAI in design tasks. Here, **prompt engineering** involves crafting input instructions to guide GenAI responses (Ng et al., 2021, p. 214), while **iterative prototyping** with GenAI can allow learners to rapidly generate, test, and refine design solutions in successive cycles (Schauer & Simbeck, 2024, p. 44). By experimenting with prompts and reviewing outputs, learners would be able to harness GenAI's power effectively while understanding its limitations.

Ethical–legal plane

The ethical–legal plane ensures accountability and transparency. Learners may perform **bias and harm reviews** to identify and mitigate discriminatory or harmful AI behaviours (Mills et al., 2024, p. 7). They also need to engage in **authorship disclosure**, explicitly noting when AI has contributed to content or decisions (UNESCO, 2024, p. 11). This plane helps learners develop habits of ethical responsibility and compliance with legal requirements.

Reflective plane

The reflective plane cultivates habits of self-awareness and critique. Through **reflective critique**, learners would continually be able to evaluate why certain choices and uses of AI were made and whether they function in specific contexts or not. As Maus (2021, p. 64) notes, critical reflection '*addresses the 'why' of action and the reasons and consequences of what we do.*' This component supports deeper learning and encourages students to question assumptions, improving their design literacy over time.

Nine action components across planes

Provenance tracing: Involves recording the origin and history of data or AI outputs to verify authenticity (Mills et al., 2024).

Uncertainty tagging: Assigns confidence scores to AI outputs so learners can assess reliability (Mills et al., 2024).

Cross-modal triangulation: Compares outputs across modalities (text, images, etc.) to ensure consistency (Ng et al., 2021).

Plausibility checks: Uses domain expertise and common sense to reject implausible or contradictory AI outputs (Yan et al., 2024).

Prompt engineering: Trains learners to formulate and refine prompts that guide models toward accurate, relevant responses (Ng et al., 2021).

Iterative prototyping with AI: Involves generating design variants with AI and refining them over successive cycles (Schauer & Simbeck, 2024).

Bias and harm review: Guides learners to examine AI outputs for unfair biases or harms and propose mitigations (Mills et al., 2024).

Authorship disclosure: Requires transparent acknowledgement of AI contributions in content or solutions (UNESCO, 2024).

Reflective critique: Compels learners to reflect on their understanding of the learning process and the methods to improve the creative outcomes. (Ng et al., 2021)

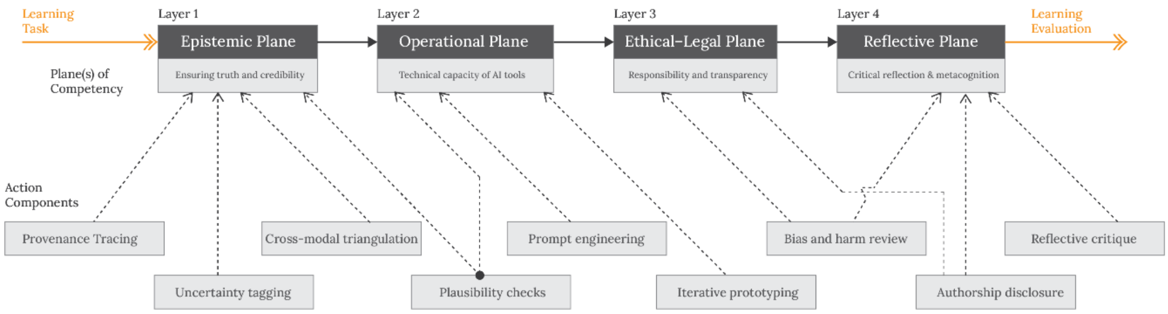

Figure 2. General visualisation of the interrelations among '*planes of competency*' and '*action components*'. The arrangement shown is illustrative and may be reorganised or re-clustered depending on the learning context.

Application and analysis

To illustrate the framework in practice, we present a graduate-level architectural design task as a representative creative learning scenario involving generative AI. '*Architectural design*' is used deliberately because it requires the integration of creative judgment, technical reasoning, and professional accountability, allowing the framework's planes and action components to be made explicit.

The task involves designing a two-bedroom residential floor plan for the arid, sun-exposed climate of the Southwestern United States. While domain-specific, the task reflects a broader class of design problems common across creative disciplines. The learner contributes design intent, spatial priorities, and disciplinary judgment. Generative AI is used to generate alternative layouts and spatial configurations based on prompts defined by the learner. External tools and expertise such as climate datasets, solar analysis software, and building codes serve as authoritative references and are introduced independently of the AI system, ensuring that technical validation and regulatory compliance remain human-centered.

On the **epistemic plane**, the learner evaluates the credibility and relevance of AI-assisted information. *Provenance tracing* is used to examine the sources and assumptions embedded in AI-generated references to climate or environmental performance. *Uncertainty tagging* supports the identification of outputs that rely on generalised or probabilistic assumptions. Plausibility checks enable judgment about whether proposed layouts respond realistically to site orientation, heat exposure, and spatial logic, without substituting for expert simulation tools.

On the **operational plane**, *prompt engineering* is used to specify constraints such as orientation, shading intent, and spatial adjacency, guiding the generation of alternative layouts. *Iterative prototyping* with AI allows the learner to refine designs across multiple cycles, supporting exploration while maintaining authorship over final decisions.

On the **ethical-legal plane**, evaluation focuses on governance, accountability, and professional responsibility. *Bias and harm reviews* assess whether AI-generated layouts reproduce inappropriate defaults or misleading design conventions for the given context. Authorship disclosure clarifies how AI outputs contribute to the learner's design process, while legal requirements such as building codes are addressed through instruction and evaluation rather than assumed to be handled by AI.

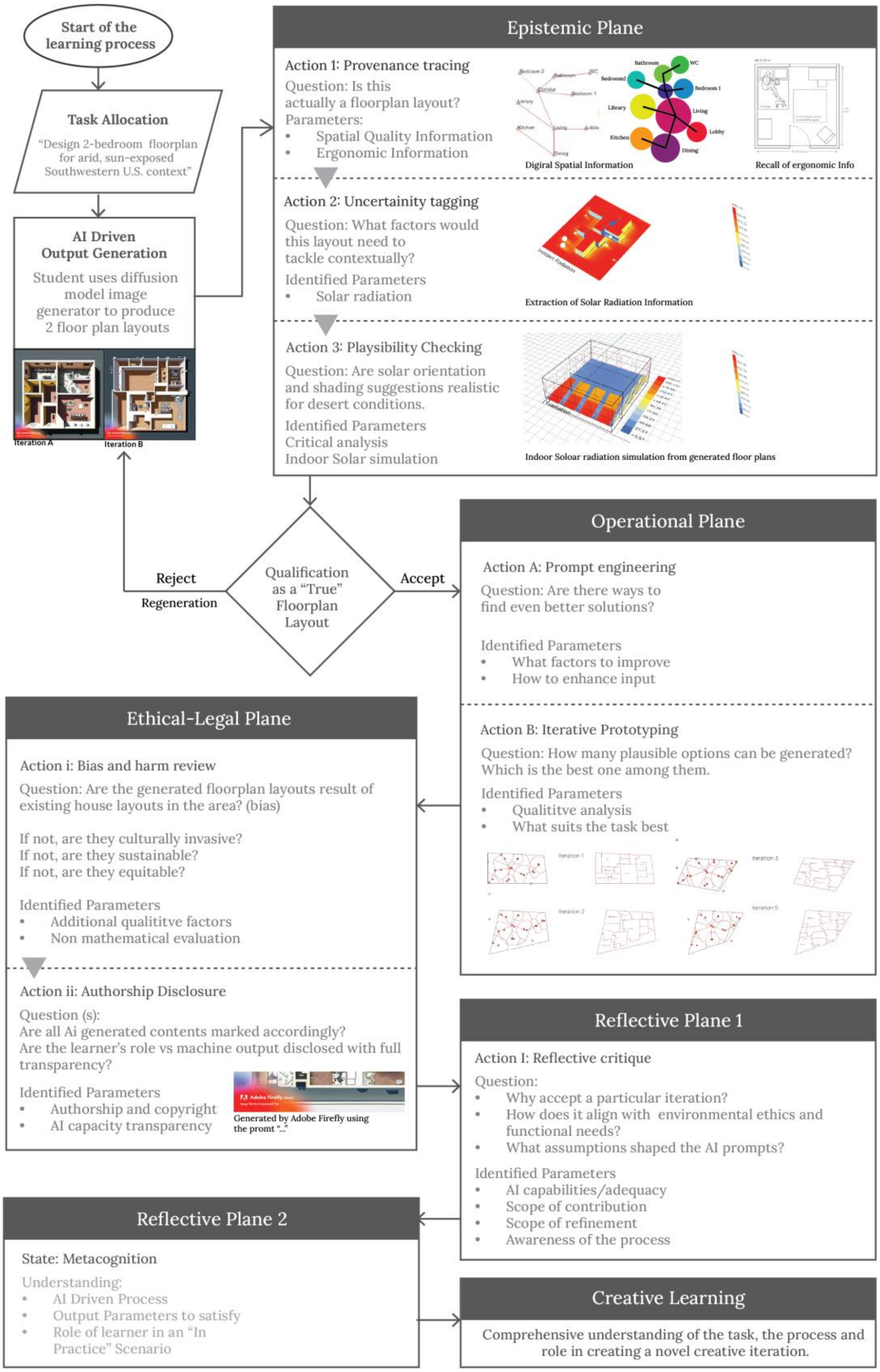

Figure 3. Process diagram of a creative learning task showing how the four planes of competency and action components guide the use of GenAI in generating contextually aware floorplan layouts.

The **reflective plane** supports metacognitive engagement by prompting the learner to articulate why certain AI-assisted options were accepted, modified, or rejected, and how these decisions align with functional goals and professional values. Figure 3 illustrates one possible configuration of planes and action components for this task. The arrangement is illustrative and may be reorganised or re-clustered depending on the learning context and design scenario.

Implications

In curriculum development, design programs should be able to embed the four planes of competency so that creative exploration is consistently paired with information evaluation, ethical responsibility, and reflective practice. In cultural and non-formal education, memory institutions including galleries, libraries, archives, and museums (GLAM) could adopt the framework to structure design learning where AI use is transparent, and information provenance is emphasised. In informal and lifelong learning, individuals can be able to transfer action components such as uncertainty tagging, plausibility checks, and reflective critique into everyday creative practices, strengthening their information behaviours. For policy and tool design, the framework is expected to guide future standards that require bias reviews, authorship disclosure, and provenance tracking. Collectively, these directions suggest design literacy may evolve as an information centred competency across multiple learning contexts.

Research agenda and future directions

Based on the proposed conceptual framework, future research can extend and refine it through applied studies, methodological development, and gradual empirical grounding. Immediate priorities lie in testing the framework across adjacent design disciplines where creative learning, tool use, and evaluative judgment are already central, such as UX design, industrial design, and architecture. Applying the framework in these contexts will help examine how planes and action components operate across different design workflows, levels of constraint, and instructional settings, and which components require domain-specific adaptation.

Building on this applied work, subsequent research can explore extensions to broader creative domains such as visual arts, film, music, and writing, where notions of authorship, iteration, and AI collaboration take different forms. Comparative studies across disciplines can clarify which action components transfer consistently, how planes are reconfigured in different cultural or informal learning contexts, and how creative learning outcomes are articulated beyond design education.

As the framework matures through repeated application, empirical studies can be introduced to support validation and refinement. These may include classroom-based studies comparing framework-informed instruction with existing practices, targeted investigations of specific action components, and longitudinal observations of how learners' judgment, agency, and reliance on AI evolve over time. Complementary efforts may also focus on developing lightweight assessment tools—such as plane-aligned rubrics, reflective prompts, or portfolio structures to support instructional use and enable comparison across contexts.

Figure 4 summarises these future research directions, emphasising progressive application, refinement, and evaluation of the framework across disciplines and learning environments.

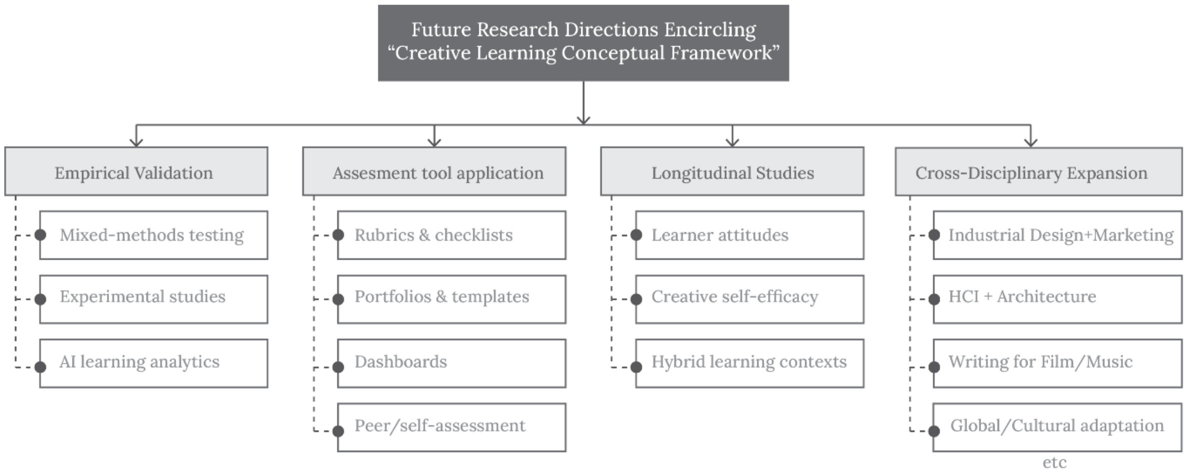

Figure 4. Branching diagram of future research directions stemming from the 'Creative Learning Conceptual framework', spanning validation, tools, factors, and cross-disciplinary applications.

Conclusion

This paper proposes a conceptual framework that integrates information literacy, AI literacy, and design pedagogy into four planes of competency with nine action components for facilitating AI-supported design learning. The framework contributes a structured way to evaluate creative learning across formal, non-formal, and informal contexts, ensuring that design literacy can be sustained in the post-AI era. Its significance lies in reframing design learning as an information centered practice that balances creativity with epistemic, ethical, and reflective accountability. Continued inquiry and cross-disciplinary collaboration between design and information science will be essential to refine, validate, and extend this framework for global educational contexts.

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