

Structurally Capturing the Reasoning Moves in AI-enabled Creativity Support Tool

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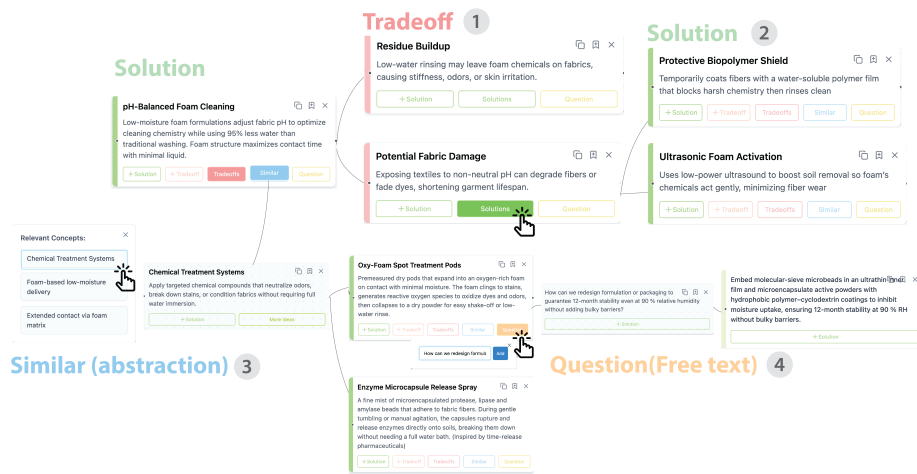


Fig. 1. **FlexMind Overview.** FlexMind captures creative activity traces by mapping user interactions to explicit reasoning moves. (1) **Trade-off analysis** records idea evaluation as potential risks; (2) **Mitigation generation** records refinement steps as candidate solutions; (3) **Abstraction to similar ideas** records branching into alternative solution spaces; and (4) **Card-level Q&A** records contextual reasoning linked to specific ideas. Together, these features produce structured reasoning moves that support creativity trajectory analysis.

Creativity tasks like ideation unfold through iterative reasoning moves, including evaluation, mitigation, branching, and navigation across alternatives, yet these processes are often implicit in existing creative activity traces. We argue that creativity support tools can be designed to make such reasoning moves explicit and traceable by design. We present FlexMind, an ideation tool structured around multi-threaded trade-off-mitigation chains that map user interactions to articulated reasoning moves. Using results from a controlled study, we demonstrate how the captured traces enable systematic analysis of critical dimensions of creative trajectories like ideation depth and breadth, and discuss implications for trace-aware creativity analysis.

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1 Introduction

Creative work is rarely a linear progression from idea to outcome. Instead, it unfolds through iterative reasoning in which creators evaluate emerging ideas, consider mitigations, branch into alternatives, and navigate among multiple lines of thought [5, 14–16]. These reasoning processes [2, 12] are central to ideation, where early ideas function as pre-inventive structures [6] whose value emerges through both deeper development of individual ideas (*ideation depth*) and broader exploration (*ideation breadth*) across alternatives.

Despite their importance, these reasoning processes are often implicit or invisible in the creative activity traces that current tools collect. Existing creativity analysis approaches primarily record observable actions, such as the interaction logs from co-creation sessions [3] and modeling creative activity as sequences of design moves using linkography [7], or produced artifacts, such as style clusters [1] or version histories [13].

While valuable, these traces are largely grounded in explicit artifacts and user behaviors, leaving the reasoning that underlies ideation difficult to analyze directly. As a result, critical reasoning moves, such as evaluating an idea to identify trade-offs, proposing mitigations, branching into new solution spaces, and navigating among parallel ideas, are often inferred indirectly [7, 9, 11]. When such moves are not explicitly represented, analyzing ideation depth, breadth, and creative trajectories becomes labor-intensive and error-prone.

This gap raises a fundamental challenge: **how can creative activity traces capture not only what creators do, but also the reasoning moves that structure ideation?** We explore a position that creativity support tools can be designed to make key reasoning moves explicit and traceable. We investigate this idea through **FlexMind** [17], an ideation tool structured around multi-threaded Trade-off → Mitigation chains. This structure grounds reasoning in reflective loop (evaluate-respond) [10] and the co-evolution of problem and solution spaces [4] where tradeoffs define the problem space and mitigations expand the solution space. By mapping user interactions to articulated reasoning moves, including evaluation, mitigation, branching, and navigation, FlexMind produces structured traces that directly encode part of the reasoning processes, enabling systematic analysis of dimensions like ideation depth and breadth without extensive manual efforts. Those intermediate reasoning steps also supported people’s ideation instead of just serving as analysis metrics [8]. Based on our study results, we demonstrate how to use the captured reasoning moves to analyze the ideation process and discuss the design implications for creativity trajectory analysis metrics.

2 FlexMind

FlexMind captures creative activity traces by mapping users’ interactions to articulated *reasoning moves* during ideation. Rather than only logging low-level actions (like writing down ideas, waiting for generations) or recording resulting artifacts, each interaction corresponds to a semantically defined step in creative reasoning, including evaluating an idea by identifying trade-offs, proposing mitigations, abstracting an idea to explore alternative solution spaces, and navigating among parallel idea threads.

Reasoning along an individual idea thread is captured using Trade-off → Mitigation chains. When clicking the **Tradeoff** button (Figure 1, 1), FlexMind prompts the LLM to analyze the idea in the context of the design brief and generate a small set of potential trade-offs, represented as red cards. Clicking the **Solution** button (Figure 1, 2) generates mitigation strategies grounded in both the selected trade-off and the original idea, shown as green cards and linked directly to the trade-off they address. Users can also add their own trade-offs or solutions using **+Tradeoff** or **+Solution**, allowing self-generated reasoning and domain knowledge to be captured alongside system-generated content. Users may also ask questions about specific nodes (Figure 1, 4); while less structured, these queries are stored with their

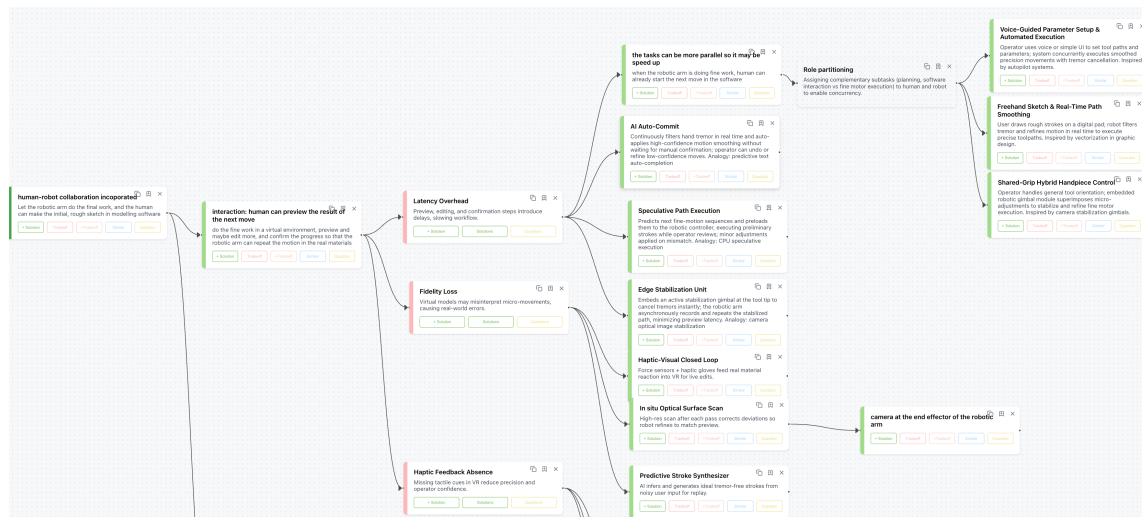


Fig. 2. Part of Expert1’s reasoning process for “designing solutions to compensate for hand tremor in fine work” from our case studies. FlexMind visualized their trade-off analysis for the initial solutions, and the corresponding mitigations, and the parallel idea branches the expert explored. Those supported the analysis of people’s reasoning process during ideation.

contextual links, preserving additional reasoning for analysis. Each deliberate user action is thus recorded as a reasoning move, and the resulting trace encodes ideation depth as a connected sequence of evaluative and generative steps.

FlexMind captures ideation breadth and navigation through category abstractions and a multi-threaded structure. When users click the **Similar** button on an idea card (Figure 1-3), the system extracts the high-level categories (concepts) from the idea and generates new solution branches for a selected category. This action records a reasoning shift from refining an existing idea to exploring alternative directions, and users’ category selections reflect their judgments about which solution spaces warrant further exploration. Transitions between threads are logged as part of the trace, preserving how users navigate among parallel lines of thought over time.

Together, these features produce structured creative activity traces that encode evaluation, refinement, branching, and navigation in a unified representation. While designed to support ideation, the primary contribution of this structure in this work is enabling systematic capture and analysis of creators’ reasoning processes during creative exploration.

3 Reasoning Move Analysis Demonstration

Using data from a within-subject controlled study with 20 design and engineering professionals working on the same task, and an expert case study with 6 professionals on their own tasks, we show how FlexMind captured participants’ reasoning moves (evaluation, and mitigation, branching, and navigation), and how the reasoning moves can be reconstructed into analyzable trace structures that make ideation processes legible. Importantly, the predefined reasoning moves in FlexMind did not constrain participants’ expression, but instead supported their ideation process, leading to better ideas. While the study also examined ideation outcomes, our focus here is on how reasoning-move traces can be constructed and analyzed; full outcome-based results are reported in [17].

Trace-Based Metrics for Analysis. The reconstructed traces supported the analysis of creative activity along three dimensions. *Ideation depth* was measured using branch length and longest path, reflecting how far individual ideas were

developed through successive moves. *Ideation breadth* was measured using the number of trees and the total number of information nodes, capturing the scope of exploration across distinct ideas and themes. *Navigation patterns* were characterized by transitions among branches, such as continuing within a branch, switching between branches, or initiating new branches. All metrics were computed directly from trace structure, rather than inferred from final artifacts or subjective reports, demonstrating how explicit ideation moves enable systematic analysis of creative processes.

Visualizing Creative Activity Traces. Figure 2 visualizes part of creative activity trace from Expert 1 in our case study, as they designed solutions to compensate for hand tremor in fine work. The expert engaged in a complex reasoning process, moving back and forth between ideas and trade-offs. Starting from an initial solution—human–robot interaction, where the human operates in a virtual environment and the robot replicates the motion physically—FlexMind structurally documented the identified trade-offs (e.g., latency), linked them to subsequent mitigations (e.g., allowing the user to begin the next task while the robot executes the current one), and captured branched idea threads (e.g., voice-based commands for robot control). The system also recorded the temporal order of actions, enabling analysis of ideation depth, breadth, and how experts identified and addressed flaws of ideas.

4 Toward Finer-Grained Capture of Creative Reasoning

By representing evaluation, mitigation, branching, and navigation as reasoning moves, FlexMind produces structured traces that make ideation processes legible and analyzable, as shown in our study results.

At the same time, this representation reflects a deliberate level of abstraction. The moves we used were sufficient to capture key evaluative and exploratory structure in the studied tasks, but they do not aim to represent all forms of creative reasoning. Different tasks may involve additional reasoning moves. Richer data sources, such as think-aloud protocols, could further increase trace granularity. Overall, our findings suggest an opportunity for creativity support tools to function as instruments for creativity research. By making core reasoning processes explicit and traceable by design, such systems can support data-rich analysis of creative activity while still supporting the creation process.

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