RESEARCH STATEMENT

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For problems with myriad possible approaches, there are three main questions one might ask: How do I get started, how do I accomplish my goal, and how do I move forward? In creative work, novices especially tend to get stuck on each of these challenges, fixating on whether an idea is "correct." ***The primary insight of my research is that helping people get "unstuck" is a matter of attention, and attuning people to the right level of detail at the right time will catalyze creativity.*** Creative thinking can be seen as analogous to simulated annealing, starting with a "hot" exploratory phase of broad solution search and gradually "cooling" to exploitation and narrowing the search space [6, 7] (Figure 1). With so many possibilities and uncertainties, a common cognitive bias is to "cool" too soon, settling on the first adequate idea that comes to mind or fixating on low-level details, leading to under-exploration of potentially better ideas [5]. It is a challenge of knowing both *what* and *how* to explore, seeing the metaphorical forest for the trees.

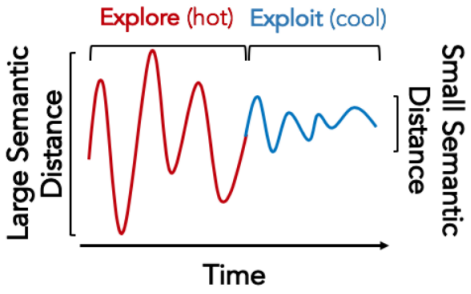

Figure 1. Like simulated annealing, effective creative thinking begins with a "hot" exploration phase followed by a "cool" exploitation phase.

As a cognitive science and human-computer interaction researcher, ***I aim to amplify dialogic, exploratory thinking in creative problem-solving***. I develop tools and methods that give novices strategies and adaptive conceptual suggestions for exploring new ideas in creative work. I make both theoretical and practical contributions to how we think about creativity support by empirically investigating interventions to catalyze exploration and developing interactive and adaptive tools that help people exercise their creative potential.

Bringing Structure to Unstructured Exploration

Novices often get stuck on a narrow focus because they lack strategies for effective and productive exploration in creative problem-solving. Exploration without structure can feel too abstract and difficult. I examine what types of structure can help people better attend to the right level of detail in exploration. One simple strategy is giving scaffolds that structure ideation into the exploration and exploitation stages. In a design experiment, I gave participants metaphorical "Thinking Hats" [2] for exploration and exploitation to help structure brainstorming. I found that the explore Thinking Hat led to more original designs as well as more diverse ideation during brainstorming while the exploit Thinking Hat led to more practical designs and narrower ideation [8]. These simple metaphorical frames gave a structured focus to exploration and exploitation. Participants also reported that the Thinking Hats gave them a "role" to play, helping them better explore or exploit at the right times.

Another strategy for helping people attend to high-level exploration is by removing low-level details altogether, leaving an abstract, conceptual representation. I investigated this strategy in the domain of sketching. Novices often go straight to their final drawing and make overly

detailed sketches. In contrast, experts use sketches as an exploratory tool, laying out high-level composition before concerning themselves with details. I distilled this expert strategy into an interactive abstraction method called SkimpleSketch, which abstracts visual elements of a sketch to simple shapes such as rectangles and squares. These shapes can be moved or resized to represent the spatial layout of a sketch rather than the details of the sketch itself, changing a sketch from a static representation to a dynamic one. In a study with groups collaboratively drawing together, groups that used SimpleSketch reported a key theme of malleability, being able to move pieces of their sketch around without the need for sketching and trying different ideas [11]. Removing the necessity to sketch with any level of fidelity changed the act of sketching from showing how something looks to how something works [1]. My current work examines how this abstraction strategy affects dialogue in critique and exploring alternatives.

Adaptive Suggestions Provide Contextual Assistance

Examples are a powerful way to help people explore alternatives and try new approaches in creative work. Yet knowing what to attend to when using examples and how to apply them still requires domain knowledge that novices often do not have. One of the greatest challenges and opportunities within creativity support and learning is giving the right assistance at the right time. Suggestions presentation is similar to search systems, providing the most relevant results at the right moments. For something as ambiguous as creative work, how do we capture a user's intent and context to show the right help? I explore this through presenting contextual, adaptive suggestions based on an individual's context in their work.

When beginning creative work, a blank "page" -- while allowing for infinite potential -- can be overwhelming for novices who might not have an idea of how to get started. I developed Shöwn, a Wizard-of-Oz prototype that presents suggestions and examples at the right moments to help users explore ideas for drawing comic panels. The benefit of a Wizard-of-Oz prototype is the ability to evaluate simple recognition heuristics to determine user context and which suggestions to show and when. For example, if the user is drawing the same composition for two panels in a row, Shöwn gives a suggestion asking the user to "*Consider the framing for this panel*" alongside examples of different types of panel compositions (Figure 2). In a comparison between Shöwn's adaptive suggestions and a non-adaptive presentation of examples, adaptive suggestions helped novices draw both more clear and creative comics [10]. Importantly, users also reported that the adaptive presentation of suggestions helped show examples they wouldn't have considered otherwise. In contrast, novices with non-adaptive examples rarely thought to explore the examples. Rather than prescribing any particular template or method to use, adaptive suggestions give an awareness of different ideas and

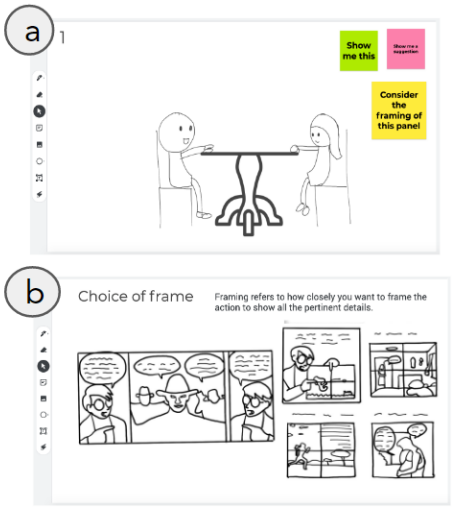

Figure 2. While a user is drawing, Shöwn a) presents a conceptual suggestion and b) directs the user to examples of that suggestion.

considerations to explore at specific, relevant moments while giving the user the agency to make their own creative decisions.

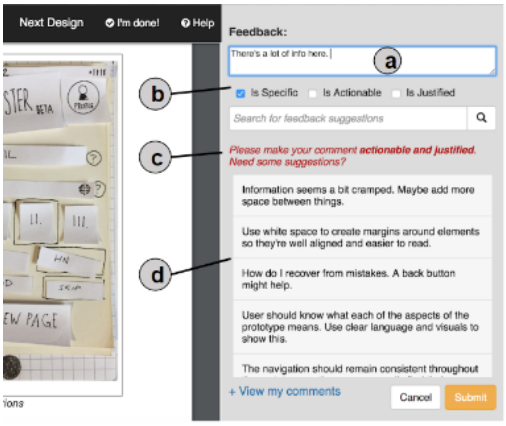

Figure 3. CritiqueKit features: a) a text box where the reviewer types their feedback, b) an interactive guidance panel that updates based on the characteristics of the typed feedback, c) prompts to ensure a reviewer's comment fits the guidance panel categories, and d) a reusable feedback suggestions box that adapt based on the unchecked guidance panel classifications.

After executing an idea, the next step is receiving critique to move forward. Good feedback is generally specific, actionable, and justified [12]. But good feedback is rare because people are often unaware of what makes for good feedback and focus on superficial features. CritiqueKit is a web application that incorporates two scaffolds to help reviewers improve their feedback in real-time (Figure 3)[4, 9]. First, the interactive guidance panel checks if draft feedback is specific, actionable, and/or justified through a simple keyword search mechanism (*e.g.* phrases like "you should" indicating actionability). Second, a suggestions box displays previously-given expert feedback that adapts based on the guidance panel categorizations. I originally hypothesized that the presence of suggestions would improve feedback quality. Contrary to this hypothesis, I found that non-adaptive suggestions alongside an interactive guidance panel yielded no differences in the quality of feedback compared to not having these scaffolds. I realized that interactive guidance and suggestions should be interdependent, leading to the addition of adaptive suggestions. A second experiment demonstrated that interactive guidance combined with adaptive suggestions resulted in more specific, actionable, and justified feedback [9]. Interestingly, simple keyword classifications of feedback to capture real-time context were beneficial and preferable to a complicated algorithm. To date, CritiqueKit has been used by 14 teaching assistants and instructors with feedback given to over 300 students in two design courses.

From my work with both Shöwn and CritiqueKit, I find that adaptive, contextual assistance need not be complex. For ambiguous tasks like exploration, it is more about drawing attention to high-level concepts at the right moments.

Research Agenda

Here, I outline future directions I am most excited about.

Intelligent Coaching for Creative Work: Computational power enables rapid exploration of alternatives and the production of highly-polished executed creative work. The biggest opportunity I see for AI-augmented creative work is how computers can serve as computational coaches to help people explore and evaluate the conceptual, ambiguous parts of the creative process. Advances in intelligent tutoring demonstrate the value of contextualized, adaptive help for domains such as math, statistics, and physics. I plan to take this further and fully realize computational coaching interactions and systems for creative domains. My work thus far has used Wizard-of-Oz methods for prototyping interactions

between AI systems and people for creative work points towards fully realizing computational coaching interactions and systems for creative domains.

Bridging the Digital and Physical Worlds: We have made great strides in digital tools for creative work. But much of our exploration and learning takes place in the physical world through our manipulation of objects and building of tools and structures. I am interested in exploring the interplay of tangible and digital materials in creativity. I see great opportunity in scaffolding digital fabrication in the making community, broadening generative design, and designing tangible user interfaces for exploration.

Developing Exploratory Thinking as a Skill: Part of my research and teaching agenda is to emphasize critical thinking and problem-solving skills that are often not explicitly taught. I believe developing these skills begins early in life. One current project examines exploration as a learning tool in helping preschool-aged children recognize and understand patterns. I am interested in furthering this line of work and developing pedagogical methods to teach and assess exploratory thinking skills and understanding the impact on creative problem-solving abilities for people and communities of all ages and backgrounds.

Conclusion

Our information-driven society comprises an abundance of uncertainty, ambiguity, and information, in which we can often get lost in the woods. It is increasingly tempting to "cool" too soon, settling on what little certainty we can find. ***Through my research, I hope to help people "see the forest for the trees" through better understanding creative cognition and developing tools that support exploration***. I plan to continue interdisciplinary academic research as well as far-reaching industry research collaborations. Ultimately, I envision a future in which our pedagogy and support tools enable people to practice everyday creativity in their endeavors.

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