

PROTOLAB

UC San Diego
The Design Lab



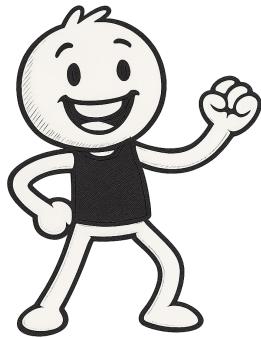
DesignWeaver

Dimensional Scaffolding for Text-to-Image Product Design

Sirui Tao, Ivan Liang, Cindy Peng, Zhiqing Wang, Srishti Palani, Steven P. Dow

Motivation

GenAI Lowers the Barrier for Novices



(Made with GPT 4o)



I want a chair



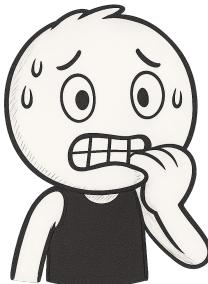
Search



Deep research



Challenges Novices Face in Prompting AI



(Made with GPT 4o)

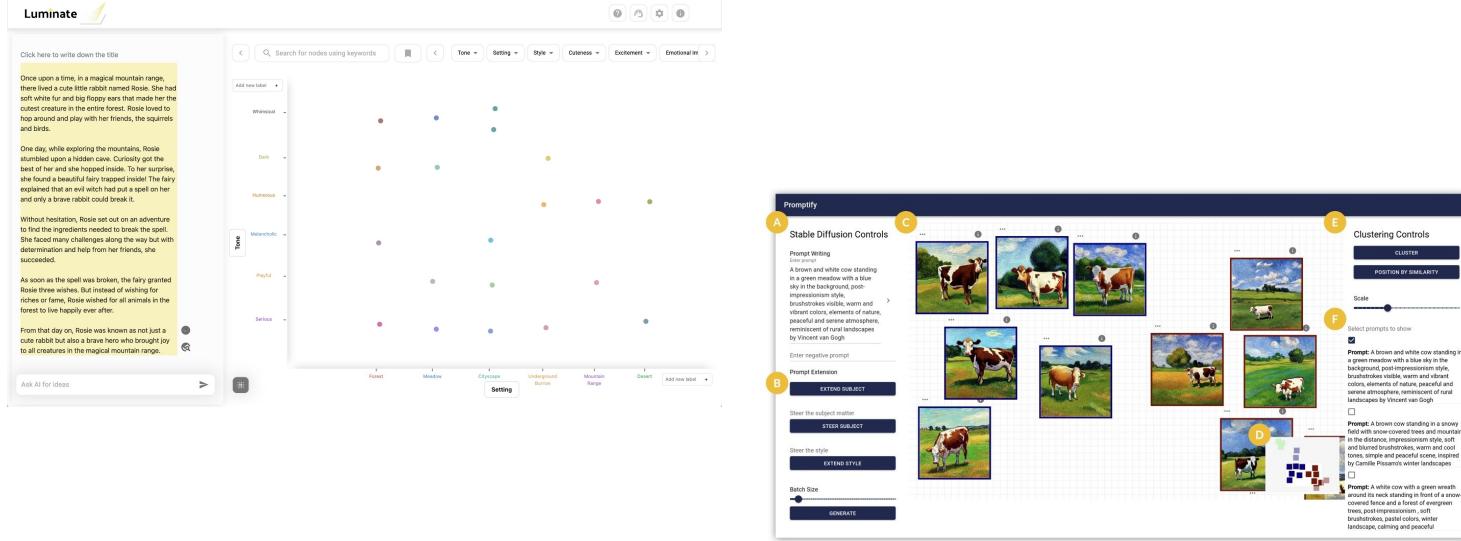
Challenge	When It Happens
 Task & Phrasing Uncertainty	Before prompting
 Ad-hoc Trial & Error	During prompting
 Failure Attribution Uncertainty	After output

Motivation

Interfaces to Support Prompting by Novices



(Made with GPT 4o)



The figure displays three screenshots of user interfaces designed to support novice users in generating prompts and images.

- Luminate:** A platform for structured generation and exploration of design spaces. It features a text input field for writing down a title, a story about a rabbit named Rosie, and a summary of her wishes. Below this is a semantic network graph where nodes represent concepts like "Forest", "Mountain", "Cows", etc., and their relationships are visualized as colored dots. A sidebar lists categories such as Whimsical, Dark, Humorous, Metaphorical, Peculiar, and Serious. A search bar at the top allows users to search for nodes using keywords.
- Promptify:** An interface for text-to-image generation. It includes "Stable Diffusion Controls" for prompt writing, steering the subject, extending the style, and adjusting batch size. It also features "Clustering Controls" for selecting prompts by similarity. The main area shows a grid of generated images of cows in various settings, each with a small preview and a detailed caption below it.
- AI Chains:** A diagram illustrating the process of generating travel-related prompts. It starts with a box labeled "City to visit" containing "Paris". This leads to two parallel "Ideation" boxes. The left one, labeled "A", lists "Types of interactions" such as Small talk, Transportation, and Accommodation. The right one, labeled "B", lists examples in English: "Do you like the weather?", "Where's the bus station?", "How do I go to the Louvre?", and "I will check out at noon.". Both lead to a final "Rewriting" box, labeled "C", which contains examples in French: "Vous aimez le temps?", "Où est la gare routière?", "Comment aller au Louvre?", and "je partirai à midi."

Suh et al. (2024). Luminate: Structured Generation and Exploration of Design Space with Large Language Models for Human-AI Co-Creation. CHI '24.

Brade et al. (2023). Promptify: Text-to-Image Generation through Interactive Prompt Exploration with Large Language Models. UIST '23.

Wu et al. (2022). AI Chains: Transparent and Controllable Human-AI Interaction by Chaining Large Language Model Prompts. CHI '22.

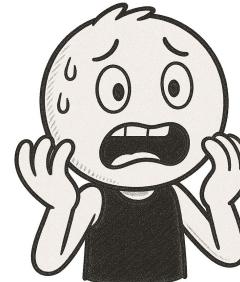
Novices Unfamiliar with Design Language

Here's what the novice designer has in mind...



How they might prompt a LLM

Show me a single dining chair that stacks with brown seat

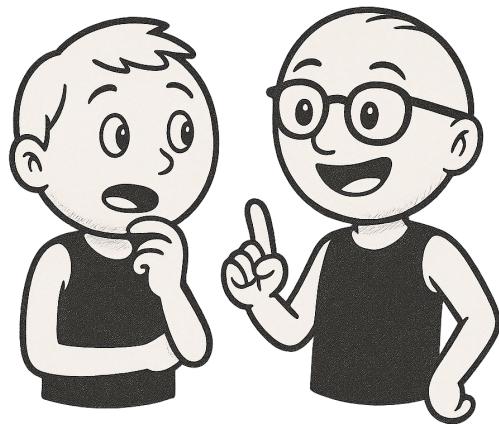


(Made with GPT 4o)

How they SHOULD prompt an LLM

Show me a **1980s-era Vintage Italian Modernist Stackable Dining Chair**, with **Bauhaus Design Chrome Tubular Steel and Brown Faux Leather seats**.

How do Experts Communicate with Clients?



(Made with GPT 4o)

Experts	Years of Experience	Design Domain(s)
E1	10	Architecture, Product
E2	21	Speculative, Architecture
E3	3	Furniture
E4	11	Furniture
E5	16	Product
E6	16	Industrial
E7	11	Industrial
E8	3	Product
E9	4	Product, Furniture
E10	3	Furniture
E11	5	Landscape Architecture
E12	6	Product, Industrial

4 Strategies Design Experts Leverage



Use Visual References



Present Multiple Alternatives



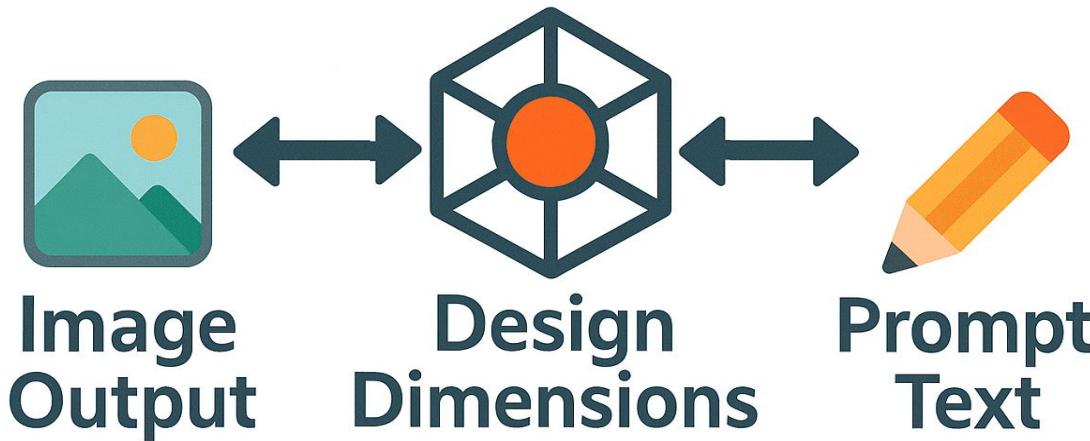
Negotiate Trade-offs Across Dimensions



Iterate to Refine Ideas and Expectations

Dimensional Scaffolding

A Structured Design Space with
Bidirectional Mapping of Dimensions



Key Feature

Bidirectional Mapping of Dimensions

DesignWeaver

Write prompts to generate product designs

This design features a minimalist aesthetic with clean lines. It emphasizes sustainability, incorporating eco-friendly and durable materials. Functionality is prioritized through ergonomic, lightweight, and sturdy features. Comfort is addressed with ergonomic lumbar support, a cushioned seat with memory foam, padded armrests, and a reclining backrest. The color scheme includes bright primary colors and earthy neutrals, creating a calming atmosphere and an inviting ambience.

Click on tags below to update your prompt above

Dimensions	Tags	Add Tag	Delete Tag
Aesthetic	Minimalist, Neutral, Clean Lines, Textured Fabrics, Bold Color Gradients, Soft Curves, Sculptural Forms	+	-
Sustainability	Eco-friendly, Durable, Biodegradable Materials, Upcycled Materials, Recycled Components	+	-
Functionality	Ergonomic, Lightweight, Sturdy, Scratch-resistant, Modular Design, Adaptable Design, Space-saving, Integrated Storage	+	-
Comfort	Ergonomic lumbar support, Cushioned seat with memory foam, Padded armrests, Reclining backrest, Breathable Materials, Temperature-regulating Fabric	+	-
Color	Bright primary colors, Earthy neutrals, Monochromatic patterns, Pastel shades	+	-
Mood	Calming Atmosphere, Inviting Ambience, Playful Vibe, Artistic Flair	+	-
Versatility	Adjustable height dining chair for different tables, Convertible dining chair with storage, Folding dining chair for compact spaces, Multi-purpose Use, Interchangeable Components	+	-

+ Add New Dimensions

Image Gallery



Your goal now is to explore different design concepts for a chair to satisfy your client's needs. You h Generating image... ite prompts that will generate images of chairs. Click the 🕒 icon to see more dimensions on an image. Use the ❤ heart icon to add images to your favorites. In the next stage, you will pick one chair for your client from your **favorites folder**. You can only advance to the Next step after 15 minutes. (Design Requirements | 📁 Image done)

🕒 13:19 Next

Write prompts to generate product designs

This design features a neutral aesthetic with clean lines, a minimalist Scandinavian approach, durable elements, and ergonomic, lightweight functionality, all accentuated by a soft lavender color.



Click on tags below to update your prompt above

Dimensions Tags

Add Tag Delete

Minimalist Neutral Clean Lines Minimalist Scandinavian



Mid-Century Modern Velvet Industrial Metal



Eco-friendly Durable Organic cotton upholstery



Bamboo seat and backrest Upcycled metal accents and components



Ergonomic Lightweight Sturdy Scratch-resistant



Soft Lavender Mustard Yellow Terracotta



+ Add New Dimensions

Image Gallery

3



Research Questions

- How does dimensional scaffolding affect text prompts?
- How does it influence generated designs?
- How do users engage with dimensional scaffolding?

Baseline Interface

Write prompts to generate product designs

A dining chair that is cozy, modern and wooden



Image Gallery

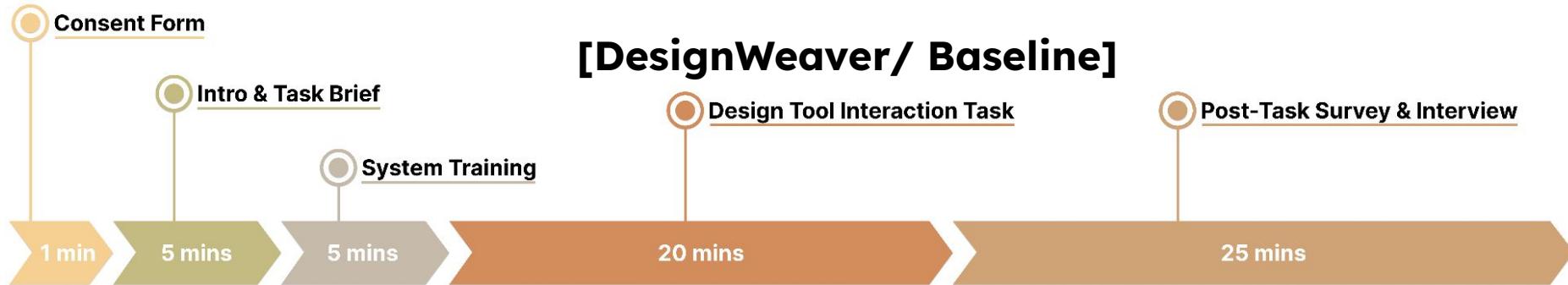
2



13

Methods

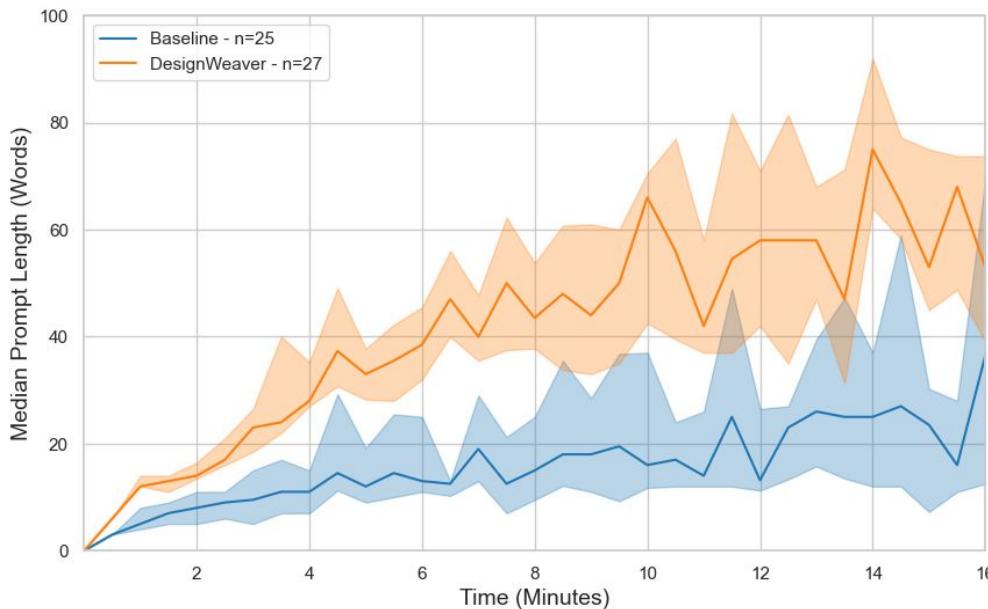
Details of this Between-subjects Study (N=52)



Measurements

- Prompts Length
- Design Terms Used
- Generated Images
- Expert Ratings
- Survey Response
- Interview Notes

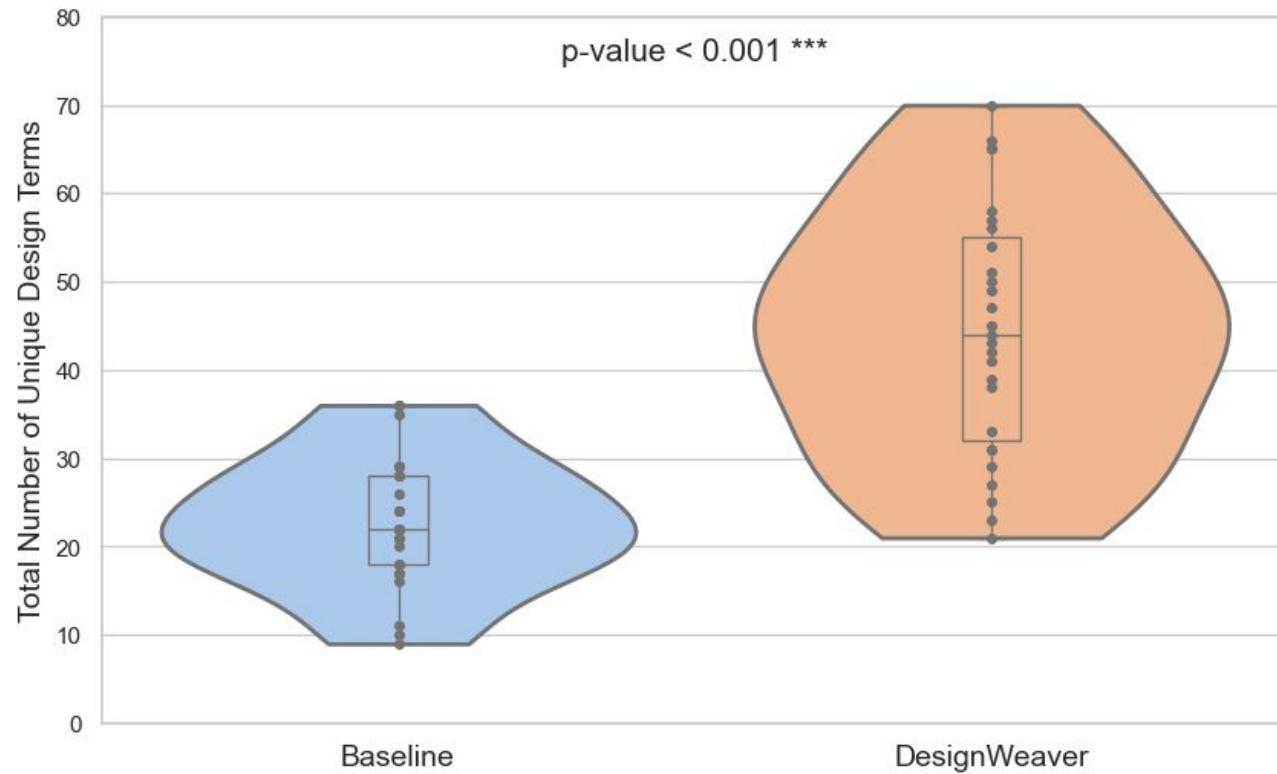
RQ1: DesignWeaver Prompts are More Detailed



Baseline Participants: A dining chair that is beige in color, made out of wood and leather, with a unique leg design, a wide sitting space, an ergonomic design, a curved and tall back, and a minimalistic aesthetic. It is described as comfortable. (*P18 - 10th prompt*)

DesignWeaver Participants: The design features a neutral vibe, bold accents, and contemporary elements. It includes unique, eye-catching details and emphasizes eco-friendly and durable elements such as sustainable materials, renewable resources, and energy-efficient production. Ergonomics, lightweight construction, sturdy build, and scratch-resistant surfaces further enhance its functionality. Wood adds natural warmth, and the curved back with dynamic posture support improves comfort. Playful geometry adds to the modern aesthetic. (*P7 - 7th prompt*)

RQ1: DW Prompts Also Have More Design Terms

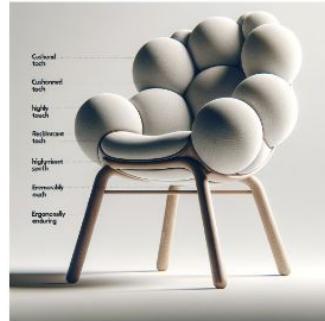


RQ2 - Top 3 Chairs in Novelty by Experts

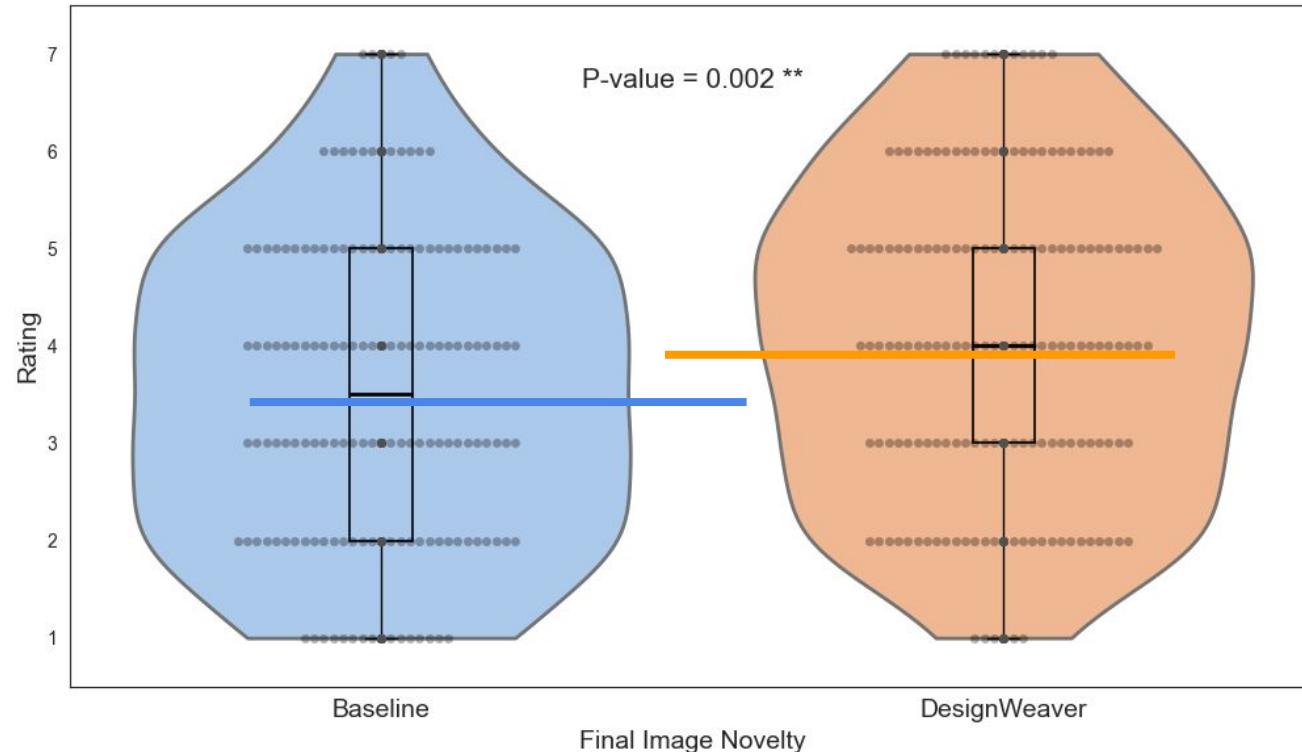
Baseline:



DesignWeaver (visually more novel):



RQ2 - DesignWeaver Designs are More Novel

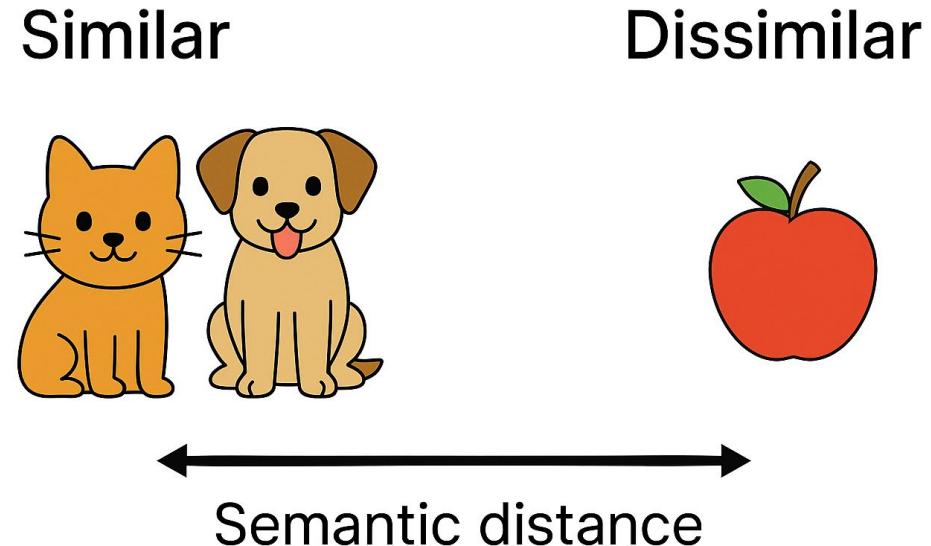


Expert Rating on Novelty

RQ2: Measuring Design Diversity

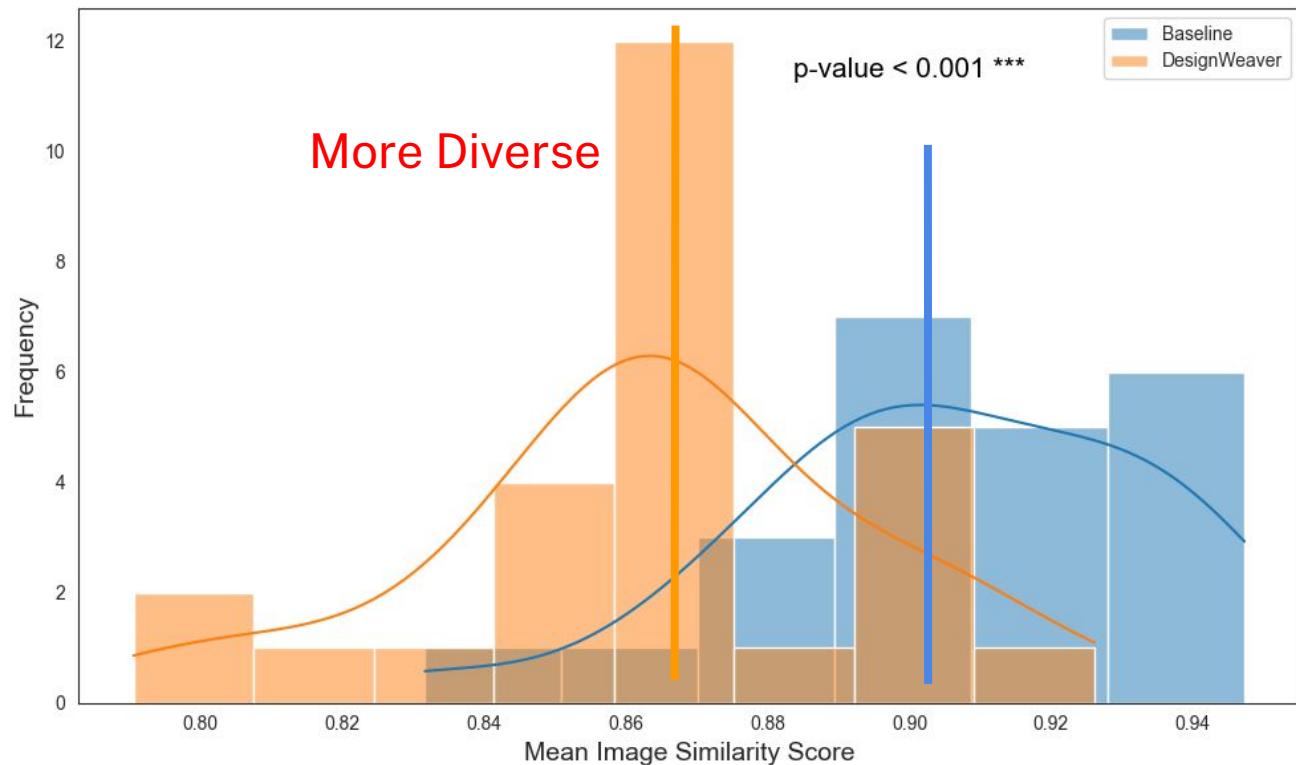
What is CLIP Model?

- Links images and text by meaning for **conceptual comparison** beyond pixel



(Made with GPT 4o)

RQ2: DesignWeaver Designs are More Diverse



CLIP-based Similarity comparison

RQ3 - User Perception

Challenges

Tag Management

“At the end, it was kind of already having too many tags, and it was kind of just showing me like a little off to what I needed.”

Misalignment

“I wanted the colors not to be just tan and white, but they were only giving me tan and white. I didn't know how specific I could be ...”

Support

Discoverability

“There were lots of different dimensions that I wouldn't typically think about for chairs. So that was like new information.”

Flexibility

“I was able to change the chair and select different [options] that fit the design... and go back if I wanted to add or change tags.”

Key Findings & Interpretations

 Dimensional Scaffolding Boosts Prompt Richness

 Targeted Edits Drive Image Diversity

 Bidirectional Loop Enhances Adoption & Control

Our Thoughts

**"Technology evolves fast,
but human needs don't."**

Future



Next Steps

- Extend scaffolding to architecture, fashion, ...
- Explore impact on expert designers



Future Vision

- Real-time, adaptive visual-textual interaction

DesignWeaver: Dimensional Scaffolding for Text-to-Image Product Design



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Structurally surfacing design dimensions helps novices better articulate, explore, and refine ideas



Project Page:
<https://dylantao.github.io/projects/designweaver>