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Ideating Under Constraints With UIDEC in UI/UX Design

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Mémoire présenté en vue de l'obtention du diplôme de *Maîtrise ès sciences appliquées*
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POLYTECHNIQUE MONTRÉAL
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Ce mémoire intitulé :

Ideating Under Constraints With UIDEC in UI/UX Design

présenté par **Atefeh SHOKRIZADEH**
en vue de l'obtention du diplôme de *Maîtrise ès sciences appliquées*
a été dûment accepté par le jury d'examen constitué de :

Zohreh SHARAFI, présidente
Jinghui CHENG, membre et directeur de recherche
Karyn MOFFAT, membre externe

DEDICATION

To those who inspire creativity;
and to my family and friends,
whose support made this journey possible.

ACKNOWLEDGEMENTS

I would like to express my heartfelt gratitude to my advisor, Prof. Jinghui Cheng, whose expertise, patience, and encouragement guided me throughout this project. Special thanks to my collaborators, Bahati Tadjuidje, Shivam Kumar, and Sohan Vasant, for their dedication and contributions, which were invaluable to this research. I am also grateful to Polytechnique Montreal for providing the resources and environment that made this work possible and the participants in my study, whose insights were vital to this work.

RÉSUMÉ

Les designers UI/UX travaillent souvent dans le cadre de contraintes spécifiques, telles que les directives d'identité de marque, les normes industrielles et les standards de conception établis, qui jouent un rôle essentiel dans la formation de l'idéation et de l'exploration. Malgré cela, peu d'outils de soutien à la créativité existants abordent pleinement l'impact de ces contraintes sur les flux de travail des designers. Ce travail présente UIDEC, un outil alimenté par IA générative, conçu pour faciliter l'exploration créative dans un contexte contraint, en soutenant l'idéation conformément aux exigences du projet. Nous avons commencé par une étude formative auprès de 19 designers de divers horizons, ce qui a révélé trois profils de designers différant dans leurs attitudes face aux contraintes lors de l'idéation. Ces profils — caractérisés par différents niveaux de flexibilité et d'adhérence aux conventions de conception — ont guidé la conception des fonctionnalités d'UIDEC, avec pour objectif de rendre la créativité sous contrainte accessible et adaptable aux besoins variés des utilisateurs.

UIDEC permet aux designers de saisir des détails spécifiques du projet, tels que son objectif, son public cible, son contexte industriel et ses styles de conception. Sur la base de ces informations, l'outil génère une gamme d'idées de design conformes aux spécifications, avec un besoin minimal de saisie de commandes. L'outil propose également des fonctionnalités pour partager les conceptions générées et les contraintes avec d'autres membres de l'équipe, offrant ainsi une base pour une idéation collaborative. Pour évaluer l'efficacité d'UIDEC, nous avons mené une étude utilisateur avec 10 designers représentant les profils identifiés. Les résultats ont montré qu'UIDEC s'intégrait non seulement aux flux de travail existants des designers, mais qu'il constituait également une source d'inspiration précieuse, en particulier lors de l'initiation de nouveaux projets. Les retours ont souligné le potentiel de l'outil à rationaliser l'idéation tout en soutenant l'exploration créative sous contrainte.

Ce travail contribue à la compréhension de la manière dont les outils alimentés par IA peuvent soutenir les designers dans des environnements de conception contraints en intégrant des fonctionnalités pertinentes et en générant des idées de design adaptées. Les résultats offrent également des perspectives concrètes pour le développement futur d'outils de conception alimentés par IA, notamment dans les domaines de l'idéation sous contrainte, de la collaboration et de l'adaptabilité à diverses pratiques de conception.

ABSTRACT

UI/UX designers often strive to create novel user interfaces within specific constraints, such as brand identity guidelines, industry standards, and established design norms, which play a significant role in shaping ideation and exploration. Despite this, few existing creativity-support tools fully address the impact of these constraints on designers' workflows. This work presents UIDEC, a generative AI-powered tool designed to aid creative exploration within specified constraints, facilitating ideation in line with project requirements. We began by conducting a formative study with 19 designers from various backgrounds, which revealed three designer personas that differ in their attitudes towards constraints during ideation. These personas – characterized by varying levels of flexibility and adherence to design conventions – guided the design of UIDEC's features, with the goal of making constraint-based creativity both accessible and adaptable to diverse needs.

UIDEC enables designers to input project details, including purpose, target audience, industry context, and design styles. With this input, it generates a range of design ideas that adhere to these specifications, with minimal need for prompt writing. The tool also offers features for sharing generated designs and constraints with other team members, providing a foundation for collaborative ideation. To evaluate the effectiveness of UIDEC, we conducted a user study with 10 designers representing the identified personas. The results showed that UIDEC was not only compatible with designers' existing workflows but also served as a useful source of inspiration, particularly when designers were beginning new projects and seeking initial direction. Feedback highlighted the tool's potential to streamline ideation while supporting creative exploration within constraints.

This work contributes to understanding how AI-powered tools can support designers in constrained design environments by integrating relevant features and generating tailored design ideas. The findings also offer actionable insights for future AI-powered design tools, specifically in areas of constraint-based ideation, collaboration, and adaptability across varying design practices.

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UI	User Interface
UX	User Experience
AI	Artificial Intelligence
LLM	Large Language Model
UIDEC	UI Design Exploration under Constraints

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CHAPTER 1 INTRODUCTION

UI/UX designers take on daily challenges in creating effective and usable design work. On one hand, they strive to cultivate innovative designs that set their product apart in the fiercely competitive landscape of software applications and services. On the other hand, their designs are often constrained by specific requirements, clients' preferences, and business considerations of the target product [1]. Thus, UI/UX designers frequently find themselves engaged in a delicate dance in which they seek to unleash their creativity under imposed constraints.

Drawing inspiration from existing *image-based design examples* (e.g., screenshots, UI mock-ups, and layouts) plays an essential role in this creative process [2]. This practice not only ensures that important design conventions are followed, but it also reinforces crucial creativity mechanisms when transforming, combining, and adapting elements from previous design ideas [3, 4]. Successful design innovations often originate from such an analogy-based inspiration mechanism enabled by design examples. There are currently many online platforms that facilitate the sharing and searching of image-based UI design examples for inspiration (e.g., dribbble.com, behance.net, and siteinspire.com). Several research studies also proposed methods aimed at recommending or generating design examples (e.g., [5,6]). Previous studies established that constraints can inspire creative thinking [7]. However, the current tools and approaches fail to incorporate the UI/UX design requirements and restrictions during the process of retrieval, recommendation, and generation of design examples, therefore, cannot effectively address the common "creativity-under-constraint" challenge faced by designers.

In this work, we targeted this challenge and specifically investigated how creativity-support tools can facilitate design ideation under constraints. To this end, we first conducted a formative interview study with experienced designers to understand how they worked with constraints in practice. The results revealed that the most common constraints included user characteristics, industry standards, design systems, technical feasibility, brand identity, and business needs. Moreover, designers perceived the impact of these constraints on creativity differently, considering them as either limitations or ideation materials and guidelines. Based on the study findings, we created three user personas and five design considerations, which informed the development of UIDEC, which stands for **UI D**esign **E**xploration under **C**onstraints. UIDEC allows UI/UX designers to specify their constraints and generate design examples accordingly, with minimal need for prompt writing. Designers can further use UIDEC to iterate on generated designs and collect mood boards of their favorite ideas. Subsequently, we conducted a summative user study with 10 UI/UX designers representing our three personas to evaluate the tool. The study participants found that ideating with UIDEC minimized irrelevant design exploration and enhanced the efficiency and effectiveness of the ideation process. Participants' feedback allowed us to reflect on the design considerations we created and provide further implications for creating future tools to better streamline the UI/UX design ideation process.

This research was conducted in collaboration with Bahati Tadjuidje, Shivam Kumar, and Sohan Vasant and is based on our paper, Dancing with Chains: Ideating Under Constraints With UIDEC in UI/UX Design. Project management and primary responsibility for writing were led by me, Atefeh Shokrizadeh. In the formative study, I managed the recruitment process, conducted the interviews, and handled data analysis. I also developed personas based on the analyzed data and created the initial design concepts. Developing the design considerations and defining features for UIDEC was largely my responsibility. Similarly, in the summative study, I took charge of recruiting participants, conducting the interviews, and analyzing the results.

CHAPTER 2 LITERATURE REVIEW

Our work builds upon prior research on the tools that support design inspiration and generative AI for UI/UX design. We briefly discuss each of these areas below.

2.1 Tools for Design Inspiration

Design inspiration is like the starting point of a creative journey in UI/UX design, where exploring existing designs helps in generating novel ideas [8]. In their in-depth interview study, Herring et al. [9] explored how web, graphic, and product designers manage design examples, highlighting both the typical strategies they employ and the obstacles they face in retrieving, storing, and distributing these resources. Creativity Support Tools (CSTs) have emerged to facilitate this process, particularly aiding ideation and exploration [10]. Generally, these tools support two primary search types. The first type is text-based search [11], in which users enter keywords to find relevant visuals, which has challenges for designers as they often struggle to identify keywords that will yield their desired results [6, 9, 12–16]. The second type of search is image-based [17], where users submit or select an image to locate visually similar items. In this type of search, the input could be sketches [6, 12, 15, 18], wireframes [12], or sample designs [13, 16, 19]. However, these methods require users to have a clear vision of their intended design. To address these limitations, various approaches have been introduced to improve how designers communicate their search intentions, transcending the constraints of text and visual input. For instance, the Composing Text and Image to Image Retrieval (CTI-IR) method [16] and Stylette [20] allowed designers to combine visual inputs with natural language, thereby enhancing the relevance of retrieved images. Other tools, like BIGexplore [21], interpret user actions (such as mouse movements) in exploratory search settings to suggest images, while Kovacs et al. [22] propose a system that infers designers' preferences based on previously used styles to recommend images. Additionally, WhittleSearch [14] enables users to refine search outcomes using natural language commands when initial results fall short. Most recently, GenQuery aids design exploration using visual-based iterative design search and generation [23].

Mood boards are another CST type for visual inspiration, helping designers gather ideas. SemanticCollage, for example, supports ideation by tagging images with AI-driven semantic labels [24]. Building on this, ImageSense integrates AI-suggested images into a collaborative setting [25]. These tools demonstrate AI's potential in design inspiration but focus more on organizing and suggesting rather than generating new designs.

This body of research has advanced modalities for precisely expressing search intentions, simplified methods for articulating those intentions, and techniques to explore varied design options and organizing ideas. However, no single approach has yet addressed the need for constraint-based design exploration. UIDEC enhances this by directly integrating generative AI into the design process, allowing designers to explore existing designs and create unique UI concepts.

2.2 Generative Models for UI Creation

Advances in generative AI have introduced fresh possibilities for UI creation. Earlier models like LayoutGAN generated layouts from random input [26], while recent approaches, such as Layout Generative Network, adapt layouts based on project requirements [27]. Other methods, like GUIGAN, compose interfaces from dataset components [28]. However, these approaches don't introduce entirely new styles, limiting their inspirational impact. To counter this, GANSpiration combines StyleGAN and reference styles to generate original UI images [5].

Large language models (LLMs) have also shown promise in UI generation. LayoutNUWA, for example, reformulates layout elements into HTML, leveraging design knowledge from LLMs [29]. In this vein, UIDEC uses a multimodal LLM to generate HTML artifacts based on constraints, bridging natural language understanding with layout generation. Similarly, Graphist uses a hierarchical approach for graphic composition, aligning with UIDEC's focus on constraint-based generation [30]. These models suggest that LLMs can effectively bridge language and visual design.

Alternative approaches, like LayoutFlow [31], Spot the Error [32], and the Retrieval-Augmented Layout Transformer [33], offer unique layout generation methods. UIDEC synthesizes these approaches, balancing strict constraint adherence with creative exploration. By using multimodal LLMs, UIDEC generates editable HTML artifacts that respect specified constraints while allowing for inspired variations.

As AI tools become more integrated into design workflows, human-AI collaboration becomes essential. Studies have shown that designers can balance control with AI's creative potential [34]. For instance, DesignPrompt enables designers to interact multimodally with AI, making design exploration more expressive [35]. Additionally, the unpredictable nature of generative AI can inspire new creative paths, as shown in GenQuery [23]. UIDEC builds on these insights by balancing designer control and AI-driven inspiration.

2.3 Summary

The literature on design inspiration tools and generative AI has paved the way for enhancing ideation and creativity in UI/UX design. Design inspiration tools, such as Creativity Support Tools (CSTs), typically facilitate idea exploration through text-based or image-based search methods, helping designers organize and retrieve visual resources effectively. Advances in these tools include combining natural language with visual input to improve search relevance, integrating mood boards with AI tagging, and offering collaborative features. In the realm of generative AI, tools like LayoutGAN and GUIGAN have introduced early methods for UI layout generation, while newer models like GANSpiration and LayoutNUWA leverage generative models and large language models (LLMs) to create original UI images and HTML artifacts. These developments have helped bridge language and design, allowing for innovative design exploration and layout generation.

Despite these advancements, existing tools have limitations in supporting constraint-based design ideation, which is crucial in practical UI/UX contexts where adherence to brand, industry, or user-specific guidelines is necessary. UIDEC addresses this gap by directly integrating generative AI within a constraint-driven framework, enabling designers to specify parameters such as project purpose, industry, and style to generate relevant and diverse design options with minimal prompt writing. By providing adaptable inspiration and supporting designer control, UIDEC builds on prior research while contributing a unique approach to balance creativity with constraint adherence in design ideation.

CHAPTER 3 FORMATIVE STUDY

We conducted a formative interview study with experienced UI/UX designers to gain insights into how design constraints impact the exploration and ideation process and how AI can assist designers in generating ideas. Our goal was to explore three key research questions: (1) What types of constraints do designers face throughout the design process? (2) How do these constraints influence their ability to generate new ideas? (3) What features would they like to see in an AI-powered tool that assists design exploration?

3.1 Interview Methods

Participants were recruited through personal connections, advertisements on LinkedIn, and targeted emails to professional designers. A total of 19 UI/UX designers participated in the study, representing a diverse range of experience levels, from recent graduates to professionals with up to 15 years of experience in the field. The participants included designers working in large teams within companies, design team leaders, and freelancers.

We conducted semi-structured interviews via Zoom with each participant. Each session, lasting approximately 45 minutes, was recorded with the participant's consent; each participant was compensated with 30 CAD. The interview protocol began with questions regarding the participants' backgrounds in UI/UX design, the projects they have been involved in, and their typical design workflows. Following this, we delved into the constraints they encountered during ideation, examining how these constraints affected their creative processes. Finally, we discussed their current use of AI tools in design and explored their preferences for features in an ideal AI tool.

Data analysis began with a verbatim transcription of all recorded interviews. We conducted thematic analysis [36,37] collaboratively on the transcribed interview data. Inductive coding was initially performed. Codes were then grouped iteratively into broader themes to answer each research question.

3.2 Interview Results

3.2.1 Constraints encountered by designers.

When participants were asked about "constraints," their initial thoughts centered around resources like time and budget. However, as the conversation progressed, they began to

Table 3.1 Summary of characteristics of participants

ID	Gender	Role/Profession	Years of Experience
P1	Female	UI/UX Designer	5 years
P2	Male	Product Design Lead	10 years
P3	Male	Product Design Lead	8 years
P4	Female	UI/UX Designer	4 years
P5	Female	UX Designer	6 years
P6	Female	UX Designer	2 years
P7	Male	Product Designer	2 years
P8	Female	Graphic Designer/UX/UI Designer	10 years
P9	Male	Senior product designer	8 years
P10	Female	Interaction Design Student	2 years
P11	Male	UX Designer/University Lecturer	15 years
P12	Female	UX Junior Consultant	2 years
P13	Male	Product Designer	4 years
P14	Female	UI/UX Designer	4 years
P15	Female	UI/UX Designer	2 years
P16	Male	UI/UX Designer	2 years
P17	Male	Graphic Designer	2 years
P18	Male	UI/UX Designer	6 years
P19	Male	UI/UX Designer	2 years

discuss content-related constraints, which can be categorized as follows:

User Expectations: Naturally, designers must consider user characteristics to, for example, use familiar patterns and structures to avoid adding cognitive load. For example, P8 elaborated that it is important to "*anticipate what it is the users are going to be looking for when they come to whatever website you're doing. What would be, you know, the main categories or information that they would want to see? And from there guide them on a journey that makes sense for them.*"

Industry Norms: Designers must also adhere to norms specific to the industry that they design for. For instance, designing for the food industry differs significantly from designing for health applications. For example, P2 noted "*There are certain colors that lend themselves better to certain things... red and orange... are connected usually to food and appetite. So there are general, you know, categories.*" P12 also discussed balancing industry norms and uniqueness of the product: "*So it was mostly like trying to be part of the same market of people, like other companies. But I did use a bit of different colors to not look exactly like Netflix or Prime.*"

Design Systems: Another key factor is the design system in use. As P11 mentioned "*[The design system] is not always up to me to decide. Sometimes it already has been decided,* *and sometimes it needs to be created.*" Most companies have internal design systems that designers must follow, with limited flexibility for modifications. For example, P13 shared, "*When I'm designing, sometimes I have arguments with the design system manager. I ask him for a new component, and he tells me I had to do the design with this component, and he didn't want to add a new component to the design system.*" Sometimes, designers must consult with the development team regarding the design system and adhere to it. As P9 stated, "*That usually depends on the code base the development team is working with. So there's less friction when it comes to the design handoff.*"

Technical Feasibility: Designers also face technical constraints that require collaboration with the development team to assess the feasibility of their ideas. For instance, P5 described "*As designers, we tend to go overboard with animations and prototyping. We like everything! Right? So what happens is developers come into the picture and they give you sort of an idea of this. This is possible now; this is too much... Whatever. So that discussion is the most beautiful part of the entire process because there you have, like, a reality check on if it is possible or not or how can we best make it right.*"

Brand Identity: Designers often have to align with specific visual elements that reflect a brand's identity, such as color palettes, fonts, and styles. As P11 explained when choosing color palettes and other elements "*It's a matter of taste. And that's not always my taste. It sometimes is the taste of the marketing team or the client.*"

Business: Participants also noted that, especially in larger teams, the business strategy of the company often puts constraints on design. For example, P3 explained, "*Typically in a big company, you'll talk to product owners and managers and stakeholders to find out if it aligns with the business strategy, business values, all that stuff... in a smaller company you don't have as many mouths to feed so you get to kind of just go into it.*"

3.2.2 Effects of constraints on the design process.

Participants had varied perceptions of having constraints during the ideation process. Some viewed the constraints as limitations, while others took a more positive approach, seeing constraints as helpful guides.

Negative Effects: Several participants disliked working under constraints, feeling limited and unable to ideate freely. E.g., P8 noted, "*You want to do one thing, but then you have constraints that you need to come back to and think about them. There's a lot of back and forth between the ideation and making sure that you are following them.*" Others, like P4, felt constraints led to suboptimal designs, such as when corporate design systems restrict creativity: "*Maybe the project needs fancy design, but the design system limits us to some buttons and some styles that are defined before.*" Participants also mentioned that working with constraints sometimes prevented them from thinking outside the box to make true innovations. P6 discussed this point: "*Maybe I haven't encountered a design guideline that is really different from my ideas. But you know I always have them in mind. So it affects my way of thinking while I'm working on a design.*"

Positive Effects: Conversely, some participants, particularly those with more practical experience, saw constraints as beneficial. They felt constraints shape the ideation process, preventing distractions and speeding up ideation. By skipping decision-making on details like color palettes, they could focus on more important tasks. On this, P9 explained, "*Once you have a design system, creating new designs is quicker, letting you focus on where it's needed in that research and creation phase.*" Many also likened constraints to "*Lego pieces,*" with P3 saying they help structure designs while still allowing creativity: "*It's just a tool that helps you create your art piece.*" Constraints also aid communication with developers and stakeholders, serving as a common language, as P11 said, "*They ensure developers know what's being proposed or if they already have one.*" The design team can also use these constraints as a guiding "north star" to ease decision-making. As P15 explained, "*It's like an alignment within the team because a lot of designers focus on small details. So having those skylights helps us speak the same language when we're working together.*" Moreover, some participants considered working under constraints as an essential aspect of design, which is parallel to the creative process, as P11 mentioned, "*I think the innovation and the ideation phase comes first. And then the prototyping and the design system come second. So in my process and in the process that I see other designers use, they're separate.*"

3.2.3 Designers perception towards AI tools for design under constraints.

Given that our ultimate goal is to create an AI-powered tool to assist designers during the ideation process, we sought participants' perspectives on their current use of AI tools at this stage, the challenges they encountered, and the features they would like to see in ideal tools.

Current Usage: Participants used AI tools for ideation, layout structuring, and generating placeholder content. For example, P4 used AI for "*categorizing ideas and receiving suggestions,*" P7 employed it for structuring page layouts, and some designers turned to AI tools for inspiration on colors. For example, P10 described using an extension in a web browser "*to see what specific colors people would use.*" Similarly, many designers mentioned using AI to generate textual content, such as placeholder text. As P8 noted, "*You might use ChatGPT to get a little description that you don't want to have to write out yourself*" A few participants discussed their use of AI tools to generate interactive prototypes as a foundation for further ideation and customization, as P11 shared: "*UIzard is able to create visual, clickable prototypes from a text prompt, which saves me hours or even days of work.*"

Challenges and Desires: Designers preferred to play an active role when working with AI in shaping the concepts during ideation. For example, P5 said: "*You have to be very mindful when using AI... It can never replace real artists. That gap will always exist.*" Participants expressed that they want AI to remain a source of inspiration rather than a replacement, with P5 adding: "*Not in a way that takes away the job of a UI/UX designer, but as an ongoing inspiration.*" Designers want AI to generate diverse, relevant results while allowing them to make final decisions. However, they emphasized that the results should not be random or generic and instead tailored to project goals and needs. On this, P3 expressed: "*It would be great to consider different brands, colors, and versions.*" P10 highlighted industry-specific needs, saying: "*The medical industry should have different visuals and color tones rather than the fashion industry.*" Designers also noted the need to modify generated results, as P1 stated: "*I want to be able to edit a specific part... What we have now is too general.*"

Moreover, participants identified a lack of familiarity and learnability with current AI-powered tools. Some tools offer editing features, but they are not intuitive for designers, as P10 noted: "*Making changes in UIzard isn't as intuitive as in Figma or Adobe XD.*" Participants stressed that mastering these tools takes time and effort, as P9 suggested: "*There should be a help section or tutorial that shows the tool's full capabilities.*" Nearly all participants noted that writing prompts for LLM-based tools is challenging and requires skill. On this, P9 said: "*You have to be very specific, and it may take some refining depending on the output.*" Even after refining prompts, the desired outcome is not guaranteed, as P10 mentioned: "*The AI often doesn't understand what I want, even when I feel my prompt is complete.*" Designers unfamiliar with the tool's capabilities struggled to create effective prompts. P12 said: "*I don't know how far the tool can help, so it's hard to write the right prompt.*" Some participants suggested AI tools should improve input methods, with P5 proposing: "*It should ask questions and frame its own answers, rather than relying on one prompt like ChatGPT.*"

3.3 Personas and Design Considerations

Through our interview study, we identified three distinct designer groups based on their experience levels, each with unique perceptions of design constraints. For experienced designers, particularly those in leadership roles, constraints were valued for fostering consistency and efficiency within teams and across products. Junior designers, on the other hand, expressed frustration with constraints, perceiving them as restrictive to their creative exploration. Conversely, recently graduated design students viewed constraints positively as they provided structure and guidance to compensate for the lack of experience. To better address the needs of these groups, we developed three personas to represent each group, respectively. These personas were created by revisiting interview data and grouping codes from related participants to extract relevant insights. They were named with alliteration: Eric the experienced designer, Julia the junior designer, and Sarah the student entering the job market. We briefly introduce the personas here; their detailed information can be found in Appendix A.

1. **Eric** is a seasoned UI/UX designer with 12 years of experience, leading a team at a tech company. Eric values structured creativity and uses constraints to promote consistency and efficiency in his team's work. His challenges include balancing innovation while maintaining a cohesive design language and effectively communicating design changes with stakeholders.

2. **Julia** is a freelance UI/UX designer with four years of experience, seeking creative freedom while balancing client demands. She struggles with managing client expectations, working under tight deadlines, and ensuring technical feasibility.

3. **Sarah** is a design student preparing to enter the workforce, who is eager to learn and apply her theoretical knowledge to practical projects. Sarah faces challenges in selecting cohesive design elements and lacks access to professional resources.

After persona creation, we first conducted brainstorming sessions to come up with concrete design ideas and actions that could address the main goals and frustrations of each persona. Then we performed an affinity diagramming exercise to group these design ideas and actions into higher-level design considerations (DCs) that can inform UIDEC and other tools for design ideation under constraints. Overall, the primary focus of our tool is on **supporting UI/UX designers in creative inspiration**, rather than serving as a full-fledged prototyping solution. With this scope in mind, we consciously avoided considering aspects that aimed to support prototyping or developer handoff. Table 3.2 summarizes our design considerations, along with how each is linked to the personas to address their unique needs and challenges. We briefly describe these considerations below.

DC1: Integrating in Designers' Early-Stage Processes to Maximize Creative Exploration. Eric requires tools to integrate past work and foster team collaboration, while Julia values compatibility with external design tools for her freelance projects. Ideation tools should thus support the collaborative process and integrate seamlessly into the designer's workflow.

Table 3.2 Summary of our design ideas and actions, mapped to persona's requirements and design considerations

Design Considerations	**Persona's Requirements**	**Potential Design Ideas and Actions**
DC1. Integrating in designers' early-stage processes to maximize creative exploration.	[Eric] Facilitating collaboration with team members and stakeholders.	- Exporting the designs and constraints to share with team members and stakeholders.
	[Eric] Integrating previous work to improve consistency and continuity.	- Ability to upload previous work to guide design generation. [Not implemented]
	[Julia] Being compatible with other design tools.	- Having different formats for exporting the designs so that designers can import them into their design tools like Figma. [Not implemented]
DC2. Providing scaffolding for creative inspiration to minimize uncertainty and confusion.	[Sarah] Showing the capabilities of the tool to the users so that they know what to expect from the tool.	- Showing some generated designs and the related constraints when the tool is loaded the first time.
	[Sarah] Keeping UI/UX designers updated with the latest design trends.	- Providing suggestions on design themes consisting of fonts, colors, and component styles, based on what is trending.
	[Sarah] Reducing confusion while choosing design constraints.	- Showing hints or suggestions when selecting different constraints. (E.g., Designers mostly use these color palettes when designing health apps.) [Not implemented]
DC3. Facilitating flexibility in defining constraints.	[Eric] Providing flexibility in specifying the functionality of the design.	- Providing options for defining functionality and screen types.
	[Eric] Allowing different ways to effectively describe the desired design constraints.	- Having multiple options to choose from regarding the design constraints and providing text inputs to describe more details.
	[Julia] Making a design constraint constant during the generation process.	- Having a "Lock" option on the constraints. When locked, all the generated examples should observe that constraint.
DC4. Allowing exploration of design alternatives through iterative modifications.	[Sarah] Being able to modify different aspects of the generated results.	- Providing a dialog box to allow users to adjust options and provide inputs to change in the design.
	[Julia] Being able to show different variations of the generated design.	- Having a "Regenerate" feature, while keeping the previous versions when editing a generated design.
DC5. Facilitating the organization of ideas based on projects and preferences.	[Sarah] Being able to save their favorite designs.	- Having a "Like" feature in generated examples and saving them in folders to create personal mood boards.
	[Julia] Organizing user's different work in multiple projects to facilitate easy access.	- Having a "Canvas Collection" feature to manage projects.

DC2: Providing Scaffolding for Creative Inspiration to Minimize Uncertainty and Confusion. Sarah, as a novice designer, needs guidance when using new tools, exploring design ideas, and staying updated on industry trends. To address these needs, tools for ideation under constraints should provide guidance and support and inform designers of domain-specific common practices and patterns.

DC3: Facilitating Flexibility in Defining Constraints Eric and Julia both need flexibility when defining design constraints – Eric for satisfying diversity across projects, and Julia for adapting to diverse clients' needs. So, enhancing flexibility and freedom during constraint specification is important.

DC4: Allowing Exploration of Design Alternatives Through Iterative Modifications Sarah needed features to track her inspiration and ideation process, while Julia wanted to explore design variations for different and evolving client needs. Thus, it is critical for tools to support design exploration during the iterative process of creative design.

DC5: Facilitating the Organization of Ideas Based on Projects and Preferences Sarah needs features to help develop her design style, while Julia requires tools to manage multiple client projects. Thus, ideation tools should allow designers to organize ideas in flexible ways to support their work.

3.4 Summary

In summary, this formative study captured the perspectives of 19 UI/UX designers on the role of constraints in design ideation and the potential of AI tools to support this process. The study identified six key design constraints – user characteristics, industry norms, design systems, technical feasibility, brand identity, and business strategy – revealing designers' nuanced views on how these limitations impact creativity. Additionally, participants shared insights into their current use of AI tools, challenges they encounter, and features they desire, emphasizing the need for AI that fosters creativity without overshadowing the designer's role. The findings informed three personas – Eric, Julia, and Sarah – representing varying levels of experience and perspectives on constraints. Finally, five design considerations were distilled to guide the development of UIDEC, an AI-powered tool focused on supporting creative inspiration. The design and implementation details of UIDEC are presented in the next chapter.

CHAPTER 4 SYSTEM DESIGN AND IMPLEMENTATION

This chapter explains the process of designing and building UIDEC, an AI-driven tool to help UI/UX designers create design ideas within certain constraints. It starts by covering the initial concepts and how they were refined. Then, it walks through the development of key features and workflows, leading up to a functional prototype. It also describes how the tool's workflows allow users to generate, edit, and organize design examples. Finally, the chapter presents the system's architecture and the way prompts are constructed, showing how the tool turns user inputs into cohesive design outputs.

4.1 Design and Implementation Process

Following the creation of personas and the design considerations, the design ideation phase was initiated by generating preliminary design concepts that aligned with the identified user needs. These initial ideas were then presented and discussed in weekly team meetings to refine the concepts and ensure that the designs aligned with the project goals. Next, a site map and user flow were developed, providing a comprehensive overview of the tool's structure and user journey. A list of concrete feature design ideas and actions was then created, with each feature carefully identified and mapped to specific personas to ensure the tool would cater effectively to different user scenarios (see Table 3.2). Sketches and prototypes of each feature were then produced, reviewed, and iterated upon through team discussions. Along this process, an interactive Figma prototype was created and a working system was implemented by the developers of the team. Throughout the development phase, the tool was tested iteratively by the entire team, ensuring that it met the design objectives.

4.2 Interaction Design

UIDEC has a minimalist, intuitive interface. Upon first visiting the tool, users are presented with a curated set of examples and detailed specifications, demonstrating the platform's capabilities and guiding new users through its features [DC2]. Once logged in, the interface transforms into a fully functional workspace. Below, we introduce the interaction design of UIDEC through three workflows.

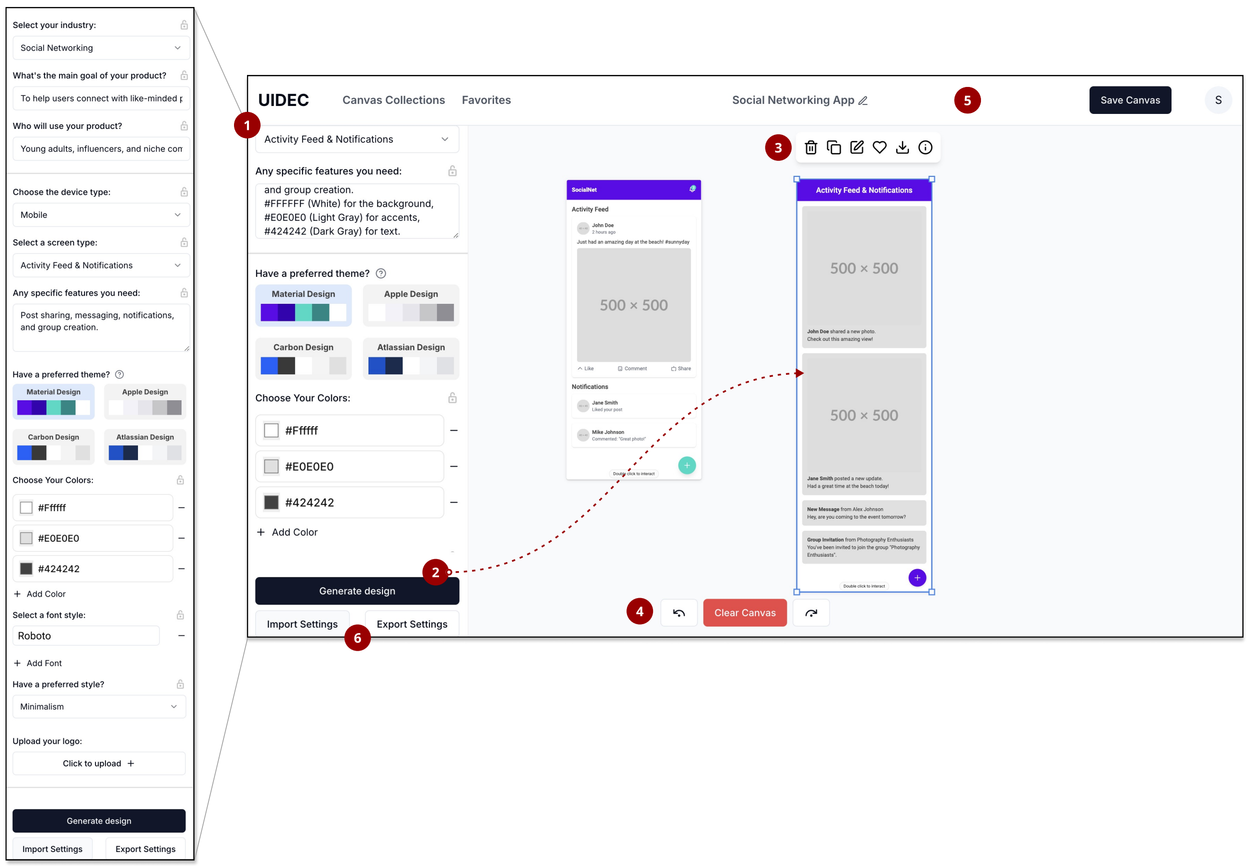

Figure 4.1 UIDEC interaction workflow 1: generating the design examples

4.2.1 Workflow 1: Generating the Design Examples

The main interface of UIDEC features a side panel, a main canvas, and a top navigation bar (see Figure 4.1). The side panel ((1) in Figure 4.1) includes various inputs corresponding to the constraints designers face in the ideation process, as described in section 3.2.1. Using these inputs, users can select the industry, specify the goal of their product, define their target users, and choose the device and screen type [DC3]. They can also describe specific features they need and select a preferred design theme [DC2]. Additionally, users can select up to five colors and three fonts, choose their preferred design style, and upload their logo. Users can lock specific constraints to ensure they remain fixed throughout the entire design idea generation process for consistency [DC3]. Once the inputs are provided, users can click the *Generate design* button, and a design ((2) in Figure 4.1) is produced on the canvas.

Upon selecting the generated design, a toolbar ((3) in Figure 4.1) appears with six buttons, respectively for removing the design, duplicating the design, editing the design, saving the design to a Favorites folder, downloading the HTML file of the design, and displaying the design specifications [DC1, DC4, DC5]. Users can also move and resize the designs freely on the canvas [DC5]. The canvas also includes three control buttons: *Undo*, *Redo*, and *Clear Canvas* (④ in Figure 4.1) [DC4]. Additionally, the UIDEC allows users to rename and save their canvas (⑤ in Figure 4.1) from the top navigation bar [DC5]. Canvas organization is further described in Section 4.2.3.

Users can generate additional designs by pressing the *Generate Design* button as many times as they wish, with each click producing a new design next to the previously generated design. The canvas automatically zooms in to display the newly generated design. Below the *Generate Design* button in the left side panel, there are two additional options: *Import Settings* (to load constraints and settings from a JSON file) and *Export Settings* (to save the current constraints and settings as a JSON file) (⑤ in Figure 4.1) [DC1].

4.2.2 Workflow 2: Editing the Design Examples

Once a design is generated, users can make edits by using the *Edit* button (① in Figure 4.2) located in the toolbar [DC4]. After clicking the *Edit* button, users must select the specific part (② in Figure 4.2) of the design they wish to modify. Upon selection, a *Modification Box* (③ in Figure 4.2) appears next to the design, offering various options such as resizing the component (smaller or larger), altering the color scheme or typography, as well as a text box allowing users to write detailed modification requests [DC4]. Once the desired changes are set, users can click the *Regenerate Design* button (④ in Figure 4.2) to generate a new version of the design with the applied modifications. Below the generated design, a navigation panel (⑤ in Figure 4.2), with left and right arrows and numbered indicators, enables users to browse through earlier versions of their edited designs [DC4].

4.2.3 Workflow 3: Organising the Design Examples

Users can save any generated design they like to a *Favorites* folder [DC5]. To do this, the user clicks the *Save* button in the design's toolbar and a *Save to Favorites* popup (① in Figure 4.3) will appear, prompting the user to select a folder and confirm by clicking the *Save* button on the popup. Users can access their saved designs by clicking on *Favorites* (② in Figure 4.3) in the top navigation bar. There, users can select the desired folder (③ in Figure 4.3) from the left side panel, and the canvas on the right will display all the designs saved in that folder. Users can also create new folders (④ in Figure 4.3) or delete existing folders (⑤ in Figure 4.3). This feature helps users build mood boards, allowing them to categorize and store design inspirations based on their specific needs [DC5].

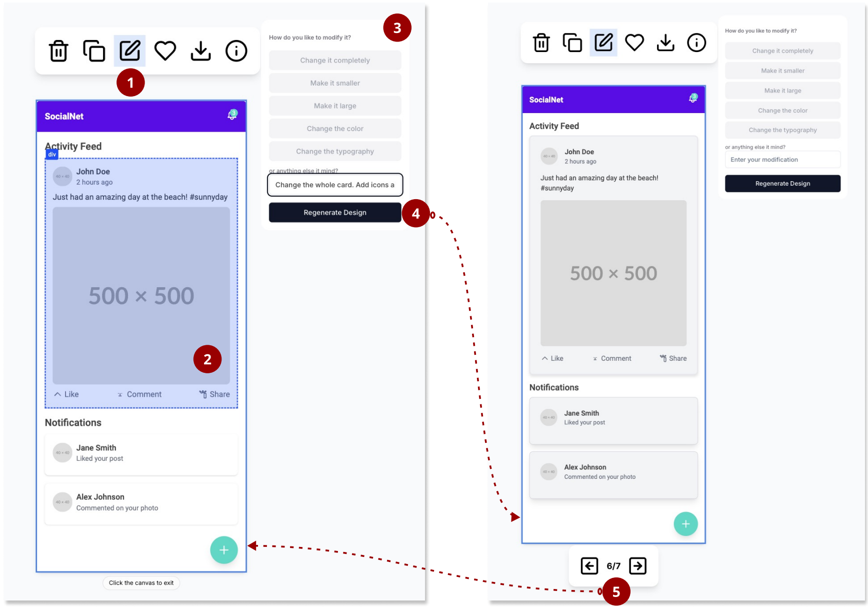

Figure 4.2 UIDEC interaction workflow 2: editing the design examples

Additionally, saved canvases (see Section 4.2.1) can be accessed via the *Canvas Collections* present in the top navigation bar (⑥ in Figure 4.3) [DC5]. The saved canvases are displayed in the left side panel. Upon selecting a canvas (⑦ in Figure 4.3), two options, *Load Canvas* and *Delete*, appear in the left panel (⑧ in Figure 4.3), while a preview of the selected canvas is displayed on the right (⑨ in Figure 4.3). By clicking *Load Canvas*, users can open the desired canvas with all the original settings and designs for further ideation.

4.3 Implementation

4.3.1 System Architecture

Our system leverages modern web technologies and a Large Language Model (LLM) to generate UI designs based on user-specified constraints. The application is built using Next.js, a React framework that provides both frontend and backend capabilities [38]. For authentication, database management, and storage, we integrate Pocketbase, an open-source backend solution [39]. The core of our design generation process relies on the OpenAI API, specifically utilizing the GPT-4o model for its advanced language understanding, multi-modal capabilities, and code generation capabilities [40].

The system follows a monolithic architecture, where frontend and backend are tightly integrated within the Next.js framework, simplifying deployment and management by using

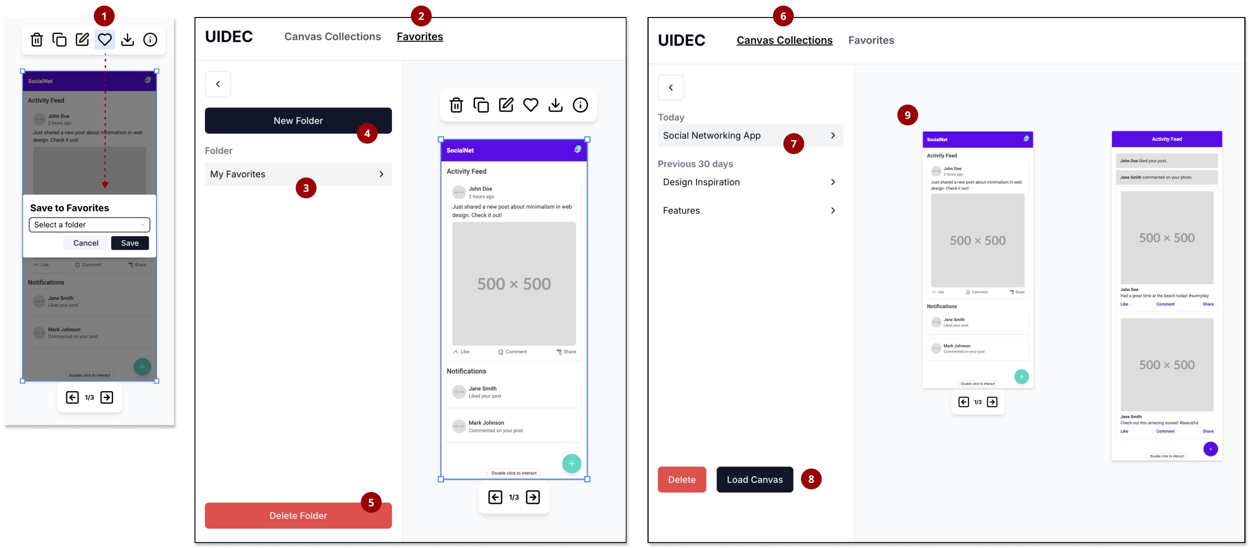

Figure 4.3 UIDEC interaction workflow 3: organizing the design examples

a single codebase that handles UI, backend logic, and database interaction. The frontend, implemented using React components, communicates with the backend through Next.js API routes. User inputs are processed in the backend, where appropriate prompts are constructed and sent to the OpenAI API to generate an HTML page that satisfies the constraints, with added variations each time the page is generated (see Section 4.3.2). The OpenAI API outputs are then parsed and the generated HTML designs are returned to the frontend for rendering on the canvas.

To ensure efficient rendering and manipulation of multiple designs simultaneously, we employ the HTML canvas API [41]. This approach allows for smooth user interaction with generated designs, enabling features such as zooming, panning, and selecting specific elements. The canvas implementation includes custom drawing and interaction functions, allowing the user to freely resize and update the generated designs.

Constraint adherence is mostly achieved through prompt construction (see Section 4.3.2). Additionally, the "Device" constraint (mobile, tablet, desktop) is reinforced by setting the size and aspect ratio of the viewport that renders the generated HTML page. However, users can resize the viewport to explore how the UI will appear and function on different screens.

4.3.2 Prompt Construction

The prompt construction process is crucial for generating UI designs that align with user specifications while providing diversity and variation. Our prompt for generating UI designs includes two main parts: the system prompt and the user prompt. The system prompt (provided in Appendix B.1) sets the context for the AI, positioning it as an experienced web designer and developer. Table 4.1 justifies the structure of the system prompt by outlining each component and its rationale.

Table 4.1 System prompt structure and justifications for its components

Prompt Component	**Justification**
Role Definition	The AI is positioned as an "exceptional web designer and developer with millennia of experience" to ensure the model takes on the role of an expert capable of creating high-quality and modern website prototypes.
Expertise Scope	By emphasizing that the AI's knowledge spans "countless design trends, technologies, and best practices," the model is encouraged to leverage its knowledge of both contemporary and historical web development techniques, ensuring that outputs are well-rounded and contextually appropriate.
Task Definition	The AI is explicitly tasked with "transforming specific requirements into visually stunning and functional websites," focusing its efforts on producing appealing and functional outputs that adhere to specific user inputs and constraints.
Understanding User Specifications	The AI is provided clear instructions to carefully analyze specifications such as industry context, colors, fonts, devices, design themes, screen types, target audience, and product purpose. This ensures that the model generates tailored designs that meet the user's precise requirements.
Interpreting Design References	When given reference UI screens, the AI is instructed to focus on layout and structure while disregarding non-relevant elements such as colors and fonts, unless specified otherwise. This helps ensure consistency in following user-defined specifications while leveraging external design references for guidance.
Prototype Creation Guidelines	Detailed prototype creation instructions—using Tailwind CSS, custom CSS/JS, Google Fonts, and placeholder images—are provided to ensure that the AI follows best practices in producing a fully responsive and interactive website prototype.
Result Presentation	The AI is instructed to deliver its response as a single HTML file with an interactive prototype, ensuring a cohesive and usable design output that can be easily reviewed and integrated by the user.

The user prompt is constructed dynamically based on user inputs. It combines the following elements:

- The *base prompt* (see Appendix B.2.1) sets the context for the AI, framing the task as a real-world design request from a product manager. It also clearly specifies the expected format of the response.
- The *user specifications prompt* (see Appendix B.2.2) includes the user's design constraints specified through the UI, such as industry, screen type, color palette, and fonts.
- A *design theme expansion* will be appended when the design theme is selected in user specifications. It includes detailed specifications for colors, typography, and component styles for the selected theme. An example of the Material Design theme is included in Appendix B.2.3.
- An *reference UI screen prompt* (see Appendix B.2.4) instructs the AI to use the provided UI screen as a structural reference while disregarding specific design elements that may conflict with the user's specifications. This prompt is added to enhance the variation and the diversity of the generated images. The details of the UI screen dataset and the selection process are described below.

Reference UI Screen. To improve layout diversity in the generated UI designs, we incorporated reference UI screens as structural guidance for design generation. A reference screen was randomly selected according to the user constraints from a dataset derived from the Mobbin platform [42]. We manually curated this dataset by collecting UI screens from Mobbin along three main constraints: industry categories, screen types, and device types; these constraints were selected to organize the dataset because they often indicate distinctive page layouts and structural styles. For each combination of possible values of the industries and screen types (as options provided to the user in UIDEC), we browsed the Mobbin platform for corresponding apps and websites and selected up to 50 unique UI screens across Mobile and Desktop device types. Through this process, we collected a dataset that comprises 14640 UI screens from iOS, Android, and web applications. For each combination of user-specified constraints, the database contains multiple images from different applications, thus offering a rich source of diverse design patterns and layouts. After the dataset was collected, we then converted all images to grayscale, aiming to reduce the impact of color on the model's interpretation of the design while preserving the essential layout and structural information. During the prompt construction process, we first query the dataset for records that match both the user-specified industry category and screen type. If matching records are found, we randomly select one image from the set of images in the matching records. If no matching records are found, no image is selected, and the final prompt will not include an image reference.

Edit Generated Designs. UIDEC also supports editing previously generated designs. After the user has selected a section they want to edit, the tool allows them to specify the edit they want or select from a list of common editing commands (see Section 4.2.2). UIDEC then constructs the edit prompt based on the editing task and content of the previous design, along with the system prompt described above; the detailed edit prompt is shown in Appendix B.2.5.

By carefully constructing the prompt with user constraints and providing relevant information and reference images, we ensure that the LLM generates HTML code for UI designs that closely align with user specifications while maintaining creative freedom in areas not explicitly constrained. This approach allows for generating unique and tailored UI designs that meet specific project requirements while leveraging the power of advanced language models and previous design examples and principles.

4.4 Constraint Adherence Evaluation

We conducted a preliminary evaluation to assess the adherence of our generated UI designs to specified constraints. For constraints like *color schemes*, *fonts*, *device types*, and *logo inclusion*, we can directly inspect the output HTML code to evaluate whether they are observed. For this purpose, we created five diverse sets of design briefs (summarized in Table 4.2), each incorporating a unique combination of constraints. For each set, our approach generated five design variations, resulting in a total of 25 generated designs. We then measured how well each design adhered to the specified objective constraints, using the following formula:

Table 4.2 Summary of design constraint sets for evaluating adherence to color schemes, fonts, device types, and logo inclusion

Set	Colors	Fonts	Device Type	Logo
1	#2C3E50 ■, #18BC9C ■, #ECF0F1 ■	Orelega One, Pacifico, Montserrat	Desktop	Provided
2	#2196F3 ■, #FFFFFF □, #FFC107 ■	Merriweather, Philosopher, Platypi	Tablet	Provided
3	#4CAF50 ■, #FFFFFF □, #FF5722 ■	Lato, Prompt, Quando	Mobile	Provided
4	#212121 ■, #FFEB3B ■, #E91E63 ■	Montserrat, Revalia, Playfair	Desktop	Provided
5	#000000 ■, #FF0000 ■, #FFFFFF □	Roboto, Rubik, Silkscreen	Mobile	Provided

$$\text{Adherence}(c) = \frac{\text{Number of correctly implemented instances of } c}{\text{Total number of instances where } c \text{ should be applied}} \times 100\% \qquad (4.1)$$

The results show strong adherence to objective constraints across all sets, with perfect adherence to color schemes, device types, and logo inclusion. Font adherence shows some variation among the five sets, ranging from perfect adherence to 40%, with an average of 74.7% across all sets.

For the other constraints like industry, screen type, theme, and style, it is challenging to provide an objective evaluation of adherence. Instead, we focused on exploring how our approach responds to changes in these constraint fields. To this end, we created four sets of design briefs. Each set focuses on varying a specific constraint while keeping others constant. Figure 4.4 shows the varying constraints, the constant constraints, and the examples of the generated designs for each set. These examples illustrated our system's ability to effectively respond to changes in various constraint fields.

4.5 Summary

This chapter provided a comprehensive look at the design and development of UIDEC. The process began with the ideation phase, where we identified core needs and challenges faced by designers working under limitations. Initial ideas were brainstormed and refined, focusing on features that would assist designers in balancing creativity with project requirements. In the feature development phase, key functionalities were outlined to align with these goals. Specifically, workflows were created for users to generate, edit, and organize design examples with ease. The generation workflow was designed to let users input specifications and receive tailored design suggestions. The editing workflow allowed users to modify elements directly, adjusting layouts, color schemes, or other features to better fit their vision. Finally, the organizing workflow provided tools for users to save, categorize, and review their ideas. The chapter also provided an in-depth look at technical aspects like the system's architecture, explaining how different components work together to support each function of UIDEC. This section outlined how data flows through the tool, from user inputs to AI-driven design outputs. Finally, the prompt construction process was discussed, which is a crucial element in translating user specifications into cohesive design outputs. This process involved creating prompts that align with user-provided constraints and project goals, helping the AI generate relevant, high-quality design suggestions. Overall, this chapter provided a comprehensive overview of UIDEC's development, from the initial ideation phase to its final implementation. After the tool was developed, a summative user study was conducted to evaluate its

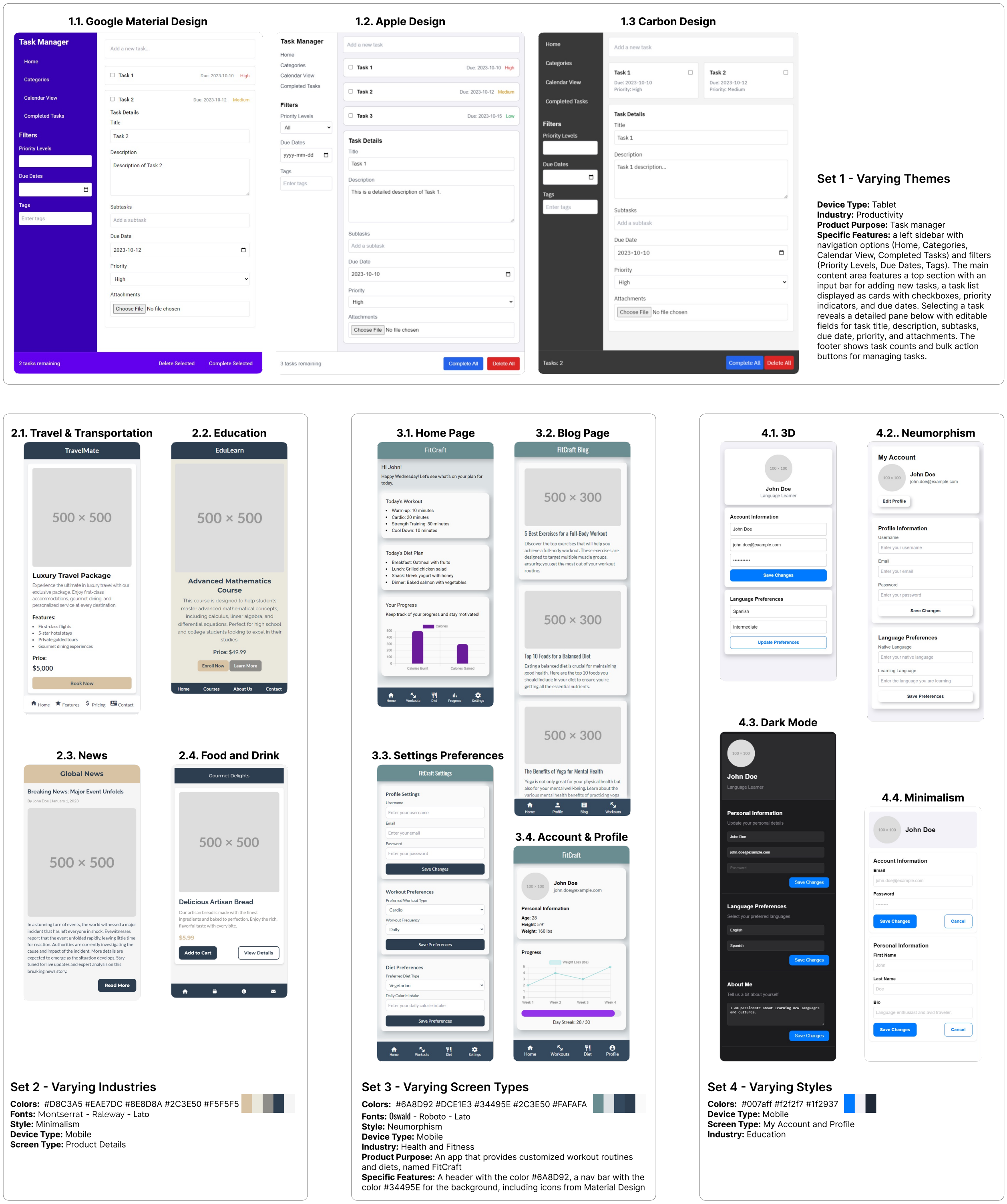

Figure 4.4 Examples of the generated designs when varying a specific constraint while keeping others constant

effectiveness in supporting UI/UX designers during the ideation process. The findings from this study are presented in the following chapter.

CHAPTER 5 SUMMATIVE STUDY

We conducted a user study to collect UI/UX designers' feedback on UIDEC and evaluate its effectiveness in addressing the challenges faced by designers during the ideation process. The study aimed to understand (1) the general usability and user satisfaction of UIDEC, (2) the potential of the tool to be integrated into the designers' ideation workflow, and (3) the designers' feedback on the generated ideas and UIDEC features.

5.1 Methods

The summative study involved a user-centered evaluation of UIDEC with ten UI/UX designers of varying expertise levels, recruited via LinkedIn and prior contacts. Sessions were conducted remotely over Microsoft Teams and lasted approximately 60 minutes. Participants completed two tasks: generating design ideas based on a provided brief and applying UIDEC to one of their own projects. They rated the generated designs on inspiration quality and adherence to constraints, and provided usability feedback. Session recordings were analyzed thematically to extract insights relevant to the study's objectives.

5.1.1 Participants

Ten UI/UX designers, representing various roles and levels of expertise, were recruited to ensure that all three personas identified in our formative study were included. The participants' characteristics are detailed in Table 5.1. Recruitment was conducted via LinkedIn, where an advertisement for the study was posted, and previous participants from our formative user study were also contacted. Notably, seven of the participants had also taken part in the formative interview study.

5.1.2 Data Collection

All user study sessions were conducted remotely via Microsoft Teams. Each session lasted approximately 60 minutes, and participants were compensated with 30 CAD for their time. Each session commenced with brief background questions related to participants' roles, design experiences, and current usage of AI-powered tools in the design process. A three-minute video explaining UIDEC's features was then shown to the participants. Subsequently, participants were provided with the tool's link and login credentials specifically created for them, after which they were asked to log into UIDEC and share their screens.

Table 5.1 Summary of characteristics of user study participants. Participant IDs marked with an asterisk (*) also participated in the formative study.

ID	Gender	Current Role	Years of experience	Related Persona
P1	Male	Design Student - Product Design Intern	1	Sarah
P2 *	Male	Product Design Lead	8	Eric
P3	Female	UI Designer / Front End Developer	1	Sarah
P4 *	Male	UI/UX Designer / University Lecturer	15	Eric
P5 *	Female	UI/UX Designer - Freelancer	4	Julia
P6 *	Male	Senior Product Designer	8	Eric
P7	Male	Junior Product Designer	2	Sarah
P8 *	Male	Digital Product Designer	4	Julia
P9 *	Female	UI/UX Designer - Freelancer	5	Julia
P10 *	Female	Design Student - Freelancer	2	Sarah

During the study, each participant was asked to complete two tasks. In the first task, participants were asked to ideate for a hypothetical application named "EcoTravel," which promotes eco-friendly travel experiences. A document was shared with the participants containing the project brief and brand style guide, which included a color palette, fonts, and a logo. Participants were required to generate ideas for a search page of the mobile version of the application and save the design examples they found inspiring. In the second task, participants were first asked to briefly describe one of their current projects. They were then asked to use UIDEC to generate new ideas for any part of the project, again saving the designs they found inspiring. The two tasks were designed so that the first task presents the same scenario to all participants to gather consistent feedback, while the second task allows participants to reflect on the usefulness of UIDEC in their real-world practice.

Following each task, participants were asked to explain their reasons for saving specific design examples generated by the tool. They were then asked to provide two ratings on a 10-point Likert scale and explain their ratings; the two ratings were: (1) the helpfulness of the generated designs as a source of inspiration, and (2) their adherence to the specified constraints. Additionally, participants were asked about any constraints they wished they could specify but found missing in UIDEC. At the end of both tasks, further questions were posed regarding their overall experience with the tool and the likelihood of its adoption in their ideation process. With the participant's consent, the entire session was recorded and transcribed via Microsoft Teams for further analysis.

5.1.3 Data Analysis

Following transcription, we conducted a thematic analysis [36, 37] to identify patterns and insights within the data. Specifically, we first systematically assigned structural codes to different segments of the transcripts, aligning these codes with the four primary research questions guiding our study. Next, an inductive coding approach was employed to identify themes and concepts that emerged from the participants' feedback. Descriptive codes were generated initially from the raw data, capturing distinct ideas, opinions, or experiences expressed by the users. The codes were then iteratively grouped into categories, which were further organized into themes. The coding and the grouping were done collaboratively through multiple rounds of discussions in the team.

5.2 Results

On average, participants rated UIDEC's helpfulness for inspiration as 6.2 out of 10 for the first task (ideating for a hypothetical application) and 7.4 for the second (ideating for the participants' own projects). Regarding adherence to specified constraints, the ratings were 8.3 for the first task and 8.9 for the second, indicating a general satisfaction with constraints adherence; in most cases, participants considered the occasional discrepancy between the constraints and the generated designs as tolerable, as P4 stated: "*I'm pretty impressed. I mean, I can forgive things like the charts not showing up.*" Below, we focus on reporting the qualitative results from the user studies.

5.2.1 General Usability and Satisfaction

Participants generally described UIDEC's design as simple and intuitive, facilitating rapid idea generation "*with very little effort,*" as noted by P4, who further elaborated: "*It's really simple, and anybody could use it. Pretty flexible as well.*" P9 expressed a similar sentiment: "*The user interface is intuitive, and it's easy to navigate through the different features.*" P8 particularly appreciated the process of specifying constraints: "*I like the flow of getting the information, like using dropdowns. This part of the process is okay for me and improves the experience.*"

Several participants also provided feedback to improve the usability of UIDEC. For example, two participants (P5 and P8) indicated that the process of exporting and importing constraints can be made more straightforward. A few also reported that the feature for editing the generated designs is a bit hidden. On this, P6 remarked: "*The only negative for me was interacting with the regeneration. I feel like that part should be more prominent since it's* *something you'd use frequently.*" Some participants suggested that the UI should be designed to resemble commonly used design tools, as P8 explained: "*I think the tool should be more like other design tools, like Figma or Framer, with features like tooltips and info icons that are familiar to designers.*"

5.2.2 Potential Usefulness and Value of UIDEC

Most participants expressed a willingness to adopt UIDEC in their design workflow, as P3 said: "*I would surely use it whenever I get a project.*" Some considered UIDEC to be more beneficial for new products than for mature and established products, as P2 explained: "*If I am starting from scratch and I have no structure and no idea, it is a lot easier to use a tool like this... But a defined product is harder to 'recut' and start from zero.*" When discussing the usefulness of UIDEC in their daily design practice, the participants mentioned various aspects that we categorized into the themes below.

First, participants believed that **fixing the hard constraints during ideation accelerates the process**. The main functionality of UIDEC to generate tailored designs based on specific constraints allowed participants to focus on ideation without encountering irrelevant examples. For example, P1 remarked: "*I can just have a constraint and not worry about what it's going to produce. I know it's going to be what I have told it.*" This customization facilitated a more efficient ideation process. As P7 explained: "*It's going to speed up my workflow... So I don't need to go to like Behance, Dribbble to search for inspiration. Here I'm getting a basic rough layout idea like hey, this is going to be my screen!*"

Moreover, participants found UIDEC **helpful in initiating design concepts**, which can be further refined to reach their final designs. They expressed interest in using the tool during the early stages of the design process. On this, P6 said: "*It's good for the ideation phase, like when you're starting off with a new idea and trying to get a sense of how it might look.*" Most participants acknowledged UIDEC's utility in layout ideation, particularly beneficial for wireframing. For example, P7 stated: "*It's giving me a fundamental layout and content structure idea, which will be helpful for my design process.*" Similarly, P5 noted: "*We can get an idea of the placement of specific elements or the way we can arrange information.*" In addition to wireframing, some participants indicated that they would take the generated ideas and implement modifications in their prototyping tools, such as Figma. As P5 mentioned: "*I will use it at the beginning of the design process to get ideas, and then I can add my own personal information and ideas and edit the whole design.*" Others preferred to make adjustments directly within UIDEC to finalize their concepts, as P3 stated: "*If any details are missing, we can add them through the tool and make it more closely match the project* *requirements.*"

Participants also discussed how **UIDEC could alter their current ideation process**. Some believed it could replace the need to explore other platforms. For example, P7 explained: "*I could design more quickly by not spending too much time looking for inspiration on platforms like Dribbble or Behance.*" Others said they would still visit those platforms for inspiration but use this tool to customize ideas. On this, P9 said: "*I would do both. When I search, I get a lot of ideas. When I use this product, I can structure all the ideas and see what works better for my product.*" Some participants viewed UIDEC as an assistant for layout ideation, while still preferring other platforms for UI element inspiration. P5 noted: "*The concepts are different. That one [platforms like Dribbble or Behance] is ready to use like already produced designs... more for UI elements.*"

Participants also emphasized UIDEC's **usefulness in both solo and collaborative settings**. For instance, P9 said she would use UIDEC "*when I want to think by myself about the whole ideas.*" On the other hand, P6, for example, saw the value of UIDEC in team collaborations and mentioned: "*It makes sense for generating a few concepts and discussing them in a collaborative environment.*" Many participants highlighted the potential of the tool in real-time collaborative design sessions. For example, P5 explained how it could fit into this process: "*I think it works well for both the initial discussions with the client to understand their needs and for getting early feedback from them. This way, we can refine our work based on their input.*" P3 proposed an alternative way of understanding the needs of the clients: "*Maybe they could give me some ideas through that... They could visualize their idea and present it to us.*" P4 shared a similar view when discussing with product stakeholders: "*I could foresee using this as a real-time tool in a meeting with a bunch of people around the table and nobody can decide what we want on this page.*"

5.2.3 Feedback on the Generated Design Ideas

Participants provided rich feedback on the generated design ideas, identifying both their strengths and potential areas for improvement. We grouped these user comments into the three themes below.

Quality of the generated design

Many participants appreciated **the high quality of the generated design, which can easily facilitate further adjustments**. They found the designs to be responsive, allowing them to view a single design in different sizes. For example, P9 observed: "*The best thing I* *see... is that if I chose this design exactly and I wanted to see it on a tablet or mobile screen, I could easily do it.*" In certain cases, the designs closely matched their final solutions. For example, after generating ideas for a dashboard in his own project, P4 commented: "*I mean this looks very close to what the final solution ended up being in terms of layout.*"

However, some participants voiced desires to see **more visual details in the generated design**. As P8 explained: "*For me, as a designer, I need more images or illustrations related to what I'm working on, like travel or transportation. If I'm searching for something like a hotel, I want to see a preview image in the results.*" Similarly, P10 felt that "*there's an amazing and surprising factor that's missing*" in the generated designs. To address these issues, participants suggested providing more detailed input options. For example, they frequently mentioned the importance of defining categories for colors and fonts, as P7 explained: "*Giving the option of customizing primary color, secondary color, and grayscale will help the user understand where to use these colors.*" P2 suggested a similar approach for fonts: "*Is this for my body? Is this for my header? It is better to know the purposes.*" Other suggestions included incorporating a negative constraint feature to specify undesired design elements, having a grid system, and input for specifying the brand name. Participants also expressed a desire for the ability to generate individual components rather than entire screens, which could prove useful for working on existing projects.

Aligning the generated design with the project

Participants were pleased to have **relevant and specialized content in the generated designs**, which minimized the need for external resources to create textual and visual content. For instance, P9, who generated ideas for a flight tracking dashboard, noted the inclusion of a Google Map, while P10, who created a video editing mobile app, was pleased to see videos integrated into the screens. P2 was also surprised by the generated title, stating: "*I never mentioned what my company name was, but you have it written over here. So you guys were able to actually read this logo name [from the uploaded file]. Really cool.*" Another notable aspect was UIDEC's ability to adjust textual content based on input. P9 tested this during the interview: "*So if I write 'kids' here [in target audience input], for example, so the copywriting would change? [Tried it and it worked.] OK, it made it simpler.*" Similarly, P2 requested UIDEC to create a French website: "*So this gave me a description of Mattie Thomley, and it gave it to me in French and it gave me French names. So that's pretty cool.*" Likewise, P8 provided a prompt in Persian to describe his desired layout, and the tool responded accordingly.

Participants also suggested potential improvements to **align the results more closely with**

the existing ideas and the designers' styles. The most frequently mentioned feature was the ability to upload images or paste a link to a website. As outlined in Table 3.2, while this feature was considered during the design phase, it was not implemented due to time constraints. Participants expressed a need for this functionality to use the uploaded design as a reference to generate related designs. For instance, P1 remarked: "*If it's possible that I can include those images, then something related to that is generated, that will ease up my task a lot.*" Similarly, P6 expressed a desire for sketch integration, stating: "*I felt like if I was able to kind of sketch something and then upload it as an image and then it can use that as a reference. So that would be cool.*" Another notable suggestion in this area included the ability to learn from designers' preferred styles and generate designs accordingly. On this, P8 explained: "*Maybe I can add more content and create a mood board. The design tool could then learn from the mood board and generate designs based on that.*" Participants also mentioned the need to incorporate their design systems and style guides, as P2 said: "*Having my corporate style guide linked either as a CSS file, a SAAS file, or a LESS file would make it really, really simple.*"

Diversity of the generated designs

Some participants were satisfied with the diversity of the generated designs, considering that **the designs enabled them to explore a wide range of ideas**. For example, P1 stated: "*The things that I like were firstly the amount of variation it provided, which can be beneficial when you're stuck or need fresh ideas.*" Similarly, P9 commented: "*The strength of the tool is that it offers a diverse range of design ideas and inspirations, which can be very useful.*"

On the other hand, some participants believed that UIDEC can **offer even more variations of the design ideas**. For instance, P3 commented: "*It gives small variations in different designs, but not like how I was thinking that it might give a completely different variation.*" P4 echoed this sentiment and suggested adding a feature to adjust the creativity level: "*I would say there's room for improvement if there was some kind of dial for creativity.*"

5.2.4 Feedback on UIDEC Features

Participants also provided feedback on specific features of UIDEC. Many participants commented on the tool's ability to **facilitate ideation from scratch**, even without clear style guides. This is achieved by features such as suggesting predefined themes based on widely used design systems. On this, P2 remarked: "*I like the fact that you have a theme already. If I'm starting from scratch and I have no idea of what my product is and I need something to be generated really, really quick. This is good.*" Participants also noted UIDEC's capability to **support iterative design exploration** by allowing regeneration of specific sections of a design. As P10 stated: "*I just want to regenerate this NAV bar. I don't want to regenerate any other section of this page. It's perfect.*" Additionally, participants appreciated the ability to view and compare different design versions after editing. As P6 noted: "*I like that you can go back in version. That's really cool.*"

User suggestions for improving UIDEC features fell into one of the following two categories. First, participants suggested improvements to **accelerate the process of design generation**. For example, they wanted to save and reuse colors and fonts as custom themes, as P10 explained: "*That way, we don't have to choose the colors every time we start any new design.*" P5 offered an alternative approach, suggesting uploading an image and using its colors and fonts. Some participants also proposed to incorporate relationships among different types of constraints. For example, P9 suggested that the tool could display themes related to the selected industry: "*For example, if I want to go with food, it shows me red palettes which are famous for the food companies.*" Another related suggestion involved generating multiple results simultaneously, with the option to create a thread of similar or related ideas. For example, P4 proposed to allow the selection of multiple screen types simultaneously and generate a sequence of related screens for the same app.

Second, participants suggested areas of improvement related to **providing annotation options on the canvas to facilitate the ideation process**. Features such as linking ideas, grouping them, and adding comments were considered useful during ideation, even in traditional paper-based processes. On this, P2 elaborated: "*Having the ability to group things into sections or add a line – small elemental things like that could help. ... I'm going to want to create clusters of different themes, pros and cons, leaving comments, and stuff like that.*" P4 shared this idea but expected more automation from an AI-powered tool: "*It would be great if there was a setting where you could automatically link these pages together.*" Participants also considered collaboration an essential part of the ideation process and expressed interest in having real-time collaboration within the same canvas, with P6 noting: "*It would be great if this was a place where you could invite people and have multiple people generating things at once.*"

5.3 Summary

The summative study chapter presents an in-depth evaluation of UIDEC's usability and potential integration into design workflows, based on feedback from ten professional and novice designers. Through task-based assessments, participants explored the tool's effectiveness in both hypothetical and personal projects, highlighting UIDEC's strengths in constraint-based ideation and early-stage design generation. The chapter reveals positive feedback regarding UIDEC's simplicity and relevance in streamlining inspiration sources, while also identifying potential enhancements, such as visual detail adjustments, expanded customization options, and alignment with industry-standard tools. Ultimately, the findings indicate UIDEC's promising utility as a creative support tool in UI/UX design, particularly for ideation and layout exploration. The following chapter will discuss these findings, examining their implications and exploring how UIDEC can evolve to address designers' needs more effectively.

CHAPTER 6 DISCUSSION

Through our exploratory interview study, we identified the design constraints UI/UX designers frequently encounter, the effect of these constraints on their creativity, and their use of AI-powered tools to support the ideation process. Based on these results, we create three distinct designer personas, each with differing views on working within constraints. From these insights, we developed five key design considerations to address the specific needs and goals of our personas, which guided the development of UIDEC, a GenAI-powered tool designed to foster creativity within constraints. UIDEC enables designers to input project details, such as purpose, target audience, industry, and design styles, and generates a range of design examples that adhere to these constraints, with minimal prompting required. In a user evaluation with designers representing the identified personas, participants found UIDEC to be compatible with their existing workflows and a valuable source of creative inspiration, particularly for initiating new projects.

Compared to existing GenAI-based design support tools (e.g., Dora[1], Galileo[2], Orb AI[3], Uizard[4], Framer[5], and Visily[6]), UIDEC incorporated several unique design features to strengthen its efficacy in supporting design ideation. First, in terms of **input methods**, existing tools mostly provided prompt-based inputs, with Uizard and Visily supporting both text prompts and image uploads. While this method offers flexibility, it often results in inconsistent outputs and is cumbersome for designers, who struggle to articulate abstract or complex ideas when creating prompts [43]. UIDEC distinguishes itself by using structured inputs, where designers select their projects' constraints, upload logos, and answer targeted questions. This approach minimizes ambiguity and ensures that generated outputs align closely with project requirements. Second, in terms of **editing the generated results**, tools focused on prototyping, such as Uizard, Framer, and Visily, emphasize robust editing features, enabling detailed adjustments for production-ready designs; this approach is similar to previous work on prototyping tools such as Rewire [44]. Conversely, inspiration-oriented tools like Dora and Galileo prioritize rapid generation, offering limited or no editing capabilities, which is similar to previous inspiration tools such as GANSpiration [5]. UIDEC occupies a unique position in this spectrum by providing targeted editing and ideation options, allowing designers to

[1] https://www.dora.run
[2] https://www.usegalileo.ai
[3] https://www.withorb.com
[4] https://uizard.io
[5] https://www.framer.com
[6] https://www.visily.ai

iteratively regenerate specific components while preserving other parts of the design. This feature bridges the idea exploration gap between pure inspiration and production. Third, **canvas workspaces** are typically associated with prototyping tools like Uizard and Framer, but not inspiration or ideation tools. UIDEC adapts this feature uniquely for ideation. Its canvas enables designers to visually organize, group, and compare multiple design ideas, promoting non-linear exploration. This spatial reasoning tool also allows designers to manage versions and relationships among ideas. This echoes the view of version control as "material interaction" [45] and extends this notion to facilitate a visual representation of the creative process.

These unique design features were made possible by our efforts in creating and integrating our design considerations (DCs). Below, we discuss our reflections and future design ideas, based on our results, related to the five DCs we identified earlier and used to guide the design of UIDEC. These DCs, along with our reflections, offer design implications for future AI-powered tools that incorporate constraints into the ideation process to enhance creativity.

6.1 Reflection on DC1: Integrating in Designers' Early-Stage Processes to Maximize Creative Exploration

Collaboration is an important aspect of designers' early-stage processes. To facilitate collaboration, we designed two exporting features: exporting the generated design to share with stakeholders and exporting the design constraints to share with team members. The user study results indicated that the participants found these features effective for streamlining their work and supporting collaboration. They also indicated the need for real-time collaborative ideation within the tool. To further support this, future tools can consider another user persona – a client or non-designer stakeholder – who would use the tool to generate ideas and provide feedback to designers. This would facilitate better communication for the designers to understand business goals, technical constraints, and the user's needs.

Related, to further facilitate the integration of UIDEC in designers' early-stage process, we considered compatibility with other design tools by offering various export formats. In the current version of UIDEC, only one export format (HTML) was implemented. In the summative user studies, participants emphasized the need for additional formats to facilitate importing into other design tools. We can also develop plugins (to, for example, Figma) that integrate UIDEC features directly within the current design tools, allowing for a smoother design ideation process.

From the formative study, we also found that designers valued consistency and continuity of their work, which affected their creative exploration process. We considered features to improve this aspect by allowing users to upload pre-existing UIs. While this feature was not implemented in the current version of UIDEC, the need for extending ideation from existing designs resurfaced in the summative user study. To streamline this process, we should consider integrating real-world UI designs or the designers' previous work within the tool, alongside the customized results, reassuring designers that the tool aligns with industry patterns and human-designed UIs. This would facilitate benchmarking and minimize the need for designers to use other platforms for research.

6.2 Reflection on DC2: Providing Scaffolding for Creative Inspiration to Minimize Uncertainty and Confusion

In the formative study, we identified a lack of knowledge among designers about the capabilities of AI-powered tools, which led to confusion and avoidance of using them. This echoes prior studies that emphasized the advantages of informing users about AI and its capabilities [46], and providing onboarding resources and activities [47]. To reduce this uncertainty, we designed the landing page to showcase design examples alongside their corresponding settings to give designers a clear understanding of what to expect when using the tool. This approach seemed effective, as participants in the summative user study found UIDEC intuitive and easy to use.

When designing UIDEC, we also considered recommendation features while specifying constraints, such as trending design or industry-specific styles, but were unable to do so due to time constraints. In the summative user study, participants highlighted the fact that the constraints are interconnected and expressed the need for further guidance when specifying constraints, which could be addressed by features like this. For example, the ideation tool could analyze the industry, product goals, or target audience and suggest UI patterns, color schemes, or layouts consistent with these boundaries, providing starting points for designers to build upon.

Additionally, we could enable designers to create and share constraint libraries that others could adopt or customize for their own projects. These libraries would contain predefined sets of constraints tailored to specific design styles (e.g., material design, minimalism) or industries (e.g., e-commerce, healthcare). By sharing these libraries within an online community integrated into the tool, and allowing for customization of constraints, designers could quickly begin new projects with a foundation aligned with best practices, while retaining the flexibility to adjust for unique needs.

6.3 Reflection on DC3: Facilitating Flexibility in Defining Constraints

Based on the formative study results, we identified that prompt writing is a challenging task for designers, particularly when using text-to-image AI tools, echoing the results of a recent study by Mahdavi Goloujeh et al. [48]. To address this, we designed a comprehensive input form that covers various aspects of design. This form includes a mixture of selectable options and guided text fields for prompt construction, aiming to minimize the need for extensive prompt writing. In creating the input form, we incorporated the constraints identified in the formative study, such as *industry norms*, *business objectives*, and *brand identity*. We partially reflected *design systems* by building themes based on some design elements from widely used design systems. For the *user characteristics* constraint, we considered using layouts from popular applications to generate designs more aligned with familiar user patterns. Additionally, for *technical feasibility,* as the designs are generated as HTML code, they are inherently feasible for implementation.

In the summative user studies, designers expressed a desire for even more detailed selections, including the ability to define specific values for primary and secondary colors, as well as for header and paragraph fonts. Interestingly, we observed diverse ideation preferences of designers when specifying the constraints. For example, we found that experienced designers often had clear design visions in their minds and used UIDEC to visualize those visions, sometimes to see how their visions work within design constraints. On the other hand, junior designers seemed to be more exploratory, relying more on UIDEC for high-level inspiration and obtaining ideas for different aspects of the design. To support designers in exploring ideas according to their preferences, we could consider providing more customizable constraint templates. Designers could create and save their own sets of constraint inputs based on their individual needs. Additionally, we could introduce a flexibility slider for each constraint, allowing designers to determine how strictly each constraint should be followed during the design generation process.

6.4 Reflection on DC4: Allowing Exploration of Design Alternatives Through Iterative Modifications

As a core feature, UIDEC allows for generating and comparing different design ideas based on the same set of constraints. We also developed a regeneration feature that allows designers to modify specific parts of the design while retaining the original version and all subsequent iterations. Participants appreciated these features, although they provided additional feedback for improvement. To further support the exploration of design alternatives, we could introduce additional features like idea threads, which allow designers to select one of the generated results and build upon it. These threads could also provide a structured way for designers to continue exploring and refining their ideas by emphasizing different design elements. For example, designers could create a thread to explore variations of a design with similar layouts, color schemes, or other critical components, allowing for a more targeted and iterative creative process.

6.5 Reflection on DC5: Facilitating the Organization of Ideas Based on Projects and Preferences

We introduced a favorite folder feature to allow designers to collect mood boards, as well as a canvas collection to organize different projects or ideation sessions. While the effectiveness of these features could not be fully evaluated in our single-session user study, a need for more control over the main canvas to better organize ideas was identified. Providing designers with the ability to group generated ideas, link related design concepts, and offer feedback on them, similar to how designers work with physical paper, could enhance their creativity.

We could also make more effective use of the mood board by learning from designers' tastes and offering further customization based on their preferences. In addition to saving favorite generated ideas in the favorite folders, we could also introduce an inspiration board where designers can upload their external inspirational resources, such as sketches or screenshots; these artifacts can be further used to guide the tool in generating color schemes and other design aspects to facilitate more targeted ideation. To better organize design ideas and make learning from designers' preferences more efficient, we could introduce a tagging option when adding designs to folders. These tags could reflect preferred design aspects, such as color schemes, layouts, or text content, or indicate the level of inspiration of a certain design.

6.6 Summary

In the Discussion chapter, we reflected on the key design considerations that guided UIDEC's development, examining how the tool supports designers' creative processes and aligns with the distinct needs identified in our formative study. Each reflection discussed UIDEC's current capabilities and limitations and proposed future design enhancements to improve collaborative ideation, inspire creativity within constraints, and increase customization and flexibility in the ideation process. These insights contribute to a broader understanding of how AI-powered tools can enhance UI/UX designers' workflows by integrating constraint-driven inspiration and supporting iterative, flexible design exploration.

CHAPTER 7 CONCLUSION

7.1 Summary of Works

In this thesis, we investigated how creativity-support tools can help UI/UX designers generate ideas under constraints such as brand identity, industry standards, and user needs. Our formative study showed that designers have varied views on constraints – some find them limiting, making it harder to explore freely, while others see them as helpful guidelines that bring structure and focus to ideation. From these insights, we developed three designer personas and five design considerations to inform tools that support ideation under constraints. Guided by these findings, we created UIDEC (UI Design Exploration under Constraints), a tool that helps designers explore ideas based on specific project needs. UIDEC allows designers to set key project details—such as audience, purpose, and style preferences—and generates design examples that align with these settings, reducing the need for complex prompt writing. It also lets designers adjust, regenerate, and organize these examples, offering flexibility to adapt ideas as they refine their vision. With the ability to save mood boards, UIDEC provides a structured source of inspiration that designers can return to as their projects develop. In our evaluation with designers representing the three personas, participants appreciated UIDEC's ability to provide relevant design examples that matched their project constraints, finding it helpful for inspiration without the distraction of unrelated ideas. They also valued UIDEC's flexibility to refine and organize ideas, making the tool a practical addition to their ideation process.

Our findings suggest that UIDEC contributes to the field of design support tools by demonstrating how constraints can act as productive guides for focused creativity. By generating customized design examples that align with specific project constraints, UIDEC reduces irrelevant exploration, streamlining the ideation process while maintaining creative flexibility. The positive feedback from designers who used UIDEC in our summative study underscores its value as a practical tool for aligning AI-powered inspiration with the real-world needs of UI/UX design. In summary, this thesis contributes to the development of creativity-support tools for UI/UX design by showing that constraints, when thoughtfully incorporated, can foster focused and effective design ideation. UIDEC serves as a practical example of how AI can enhance ideation under real-world constraints, offering insights for future tools that blend creativity and structure to meet the dynamic needs of modern design professionals.

7.2 Limitations and Future Work

While our study offers valuable insights for constraint-based ideation, several limitations highlight opportunities for future study directions and enhancement of tools like UIDEC.

In the formative user study, although we included participants with diverse roles, experience levels, and employment types (freelancers and employees), the sample size for each user group was relatively small. A larger group of participants from each category could have provided a deeper understanding of each persona's behavior and preferences, leading to a version of UIDEC even more closely aligned with user needs. In the future, we can conduct more in-depth studies tailored specifically to each persona and explore additional potential personas, such as non-designer stakeholders.

Moreover, the summative user study was conducted in a lab setting. While the study provided valuable qualitative insights, it may not fully capture how the tool performs under complex and diverse real-world conditions. The relatively small sample size and short testing duration could also limit the generalizability of the findings. Future research could include longitudinal studies or diary studies to observe how designers integrate the tool into their practice over extended periods and across various projects.

In terms of the design and functionality of the tool, one limitation is UIDEC's capacity for collaboration and integration with existing design ecosystems. Although the tool provides foundational features for sharing generated designs, its current capabilities limit real-time collaboration, which is critical in design environments where input from multiple stakeholders shapes ideation. Additionally, UIDEC's limited compatibility with established design tools restricts its flexibility in designer workflows. Future work could explore real-time collaborative ideation and provide seamless integration with platforms like Figma and Sketch. Enhancements might include adding live editing functionalities and offering multiple export formats or direct plugins to facilitate fluid transitions between UIDEC and other design platforms.

The flexibility and guidance in defining constraints is another important aspect to address in future studies. UIDEC's current constraint-setting interface provides a structured starting point but lacks dynamic guidance and adaptability to complex, interconnected constraint settings, which can limit creativity. Future iterations of UIDEC could make constraint definition more flexible and intuitive, catering to varying levels of designer expertise and preferences. Implementing guidance features such as industry- or style-specific constraint recommendations, as well as adjustable constraint adherence (e.g., through flexibility sliders), could enable a more personalized and adaptive ideation experience, enhancing creativity and control for designers. To better support diverse design needs, future work could also focus on creating and sharing libraries of predefined constraints tailored to popular design styles (e.g., minimalism) or industries (e.g., healthcare). Allowing designers to access, modify, and save these libraries would accelerate project initiation and provide a foundation of best practices.

Additionally, while UIDEC includes basic organizational features, these are insufficient for efficient long-term use, particularly in managing and evolving design concepts across multiple iterations. The development of more advanced organizational tools could help designers categorize, iterate, and retrieve ideas efficiently within the tool. Enhancements might include adding tagging options, grouping generated ideas, and improving mood boards by enabling users to import external references. These improvements could support designers in better organizing, comparing, and refining their ideas across projects, fostering a more structured ideation process.

Another area for improvement lies in the adaptability of UIDEC to pre-existing designs and user preferences. Currently, the tool does not allow designers to build upon existing design assets, which restricts its adaptability to established brand styles and user-preferred patterns. To enhance relevance and continuity in creative workflows, future developments could focus on incorporating user-uploaded assets as inputs for design generation, as well as learning from user behaviors to align generated outputs more closely with personal design tastes. Specific improvements could include the ability to import previous UI elements and the creation of adaptive mood boards that better reflect each designer's aesthetic and organizational preferences.

Finally, UIDEC's implementation has several technical limitations. For design generation, we tested and used only one LLM, GPT-4o. Using this model, UIDEC can generate each design in around 20 seconds. While this delay may be reasonable for certain use cases, it could interrupt the creative flow, particularly during rapid ideation or discussion sessions where designers expect instant feedback. Future work could focus on optimizing the backend processing pipeline and exploring other generative AI models to improve efficiency and speed up the generation process. Further, the generated designs do not include realistic images or illustrations and use placeholders instead. Since we already have key inputs such as industry, product purpose, and target audience, incorporating image-generation AI models could potentially create relevant visuals to enhance the results. This multi-agent structure would significantly improve the final appearance of the design ideas and produce more inspirational outcomes.

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APPENDIX A DESIGNER PERSONAS

The following three personas were created through the formative interview study.

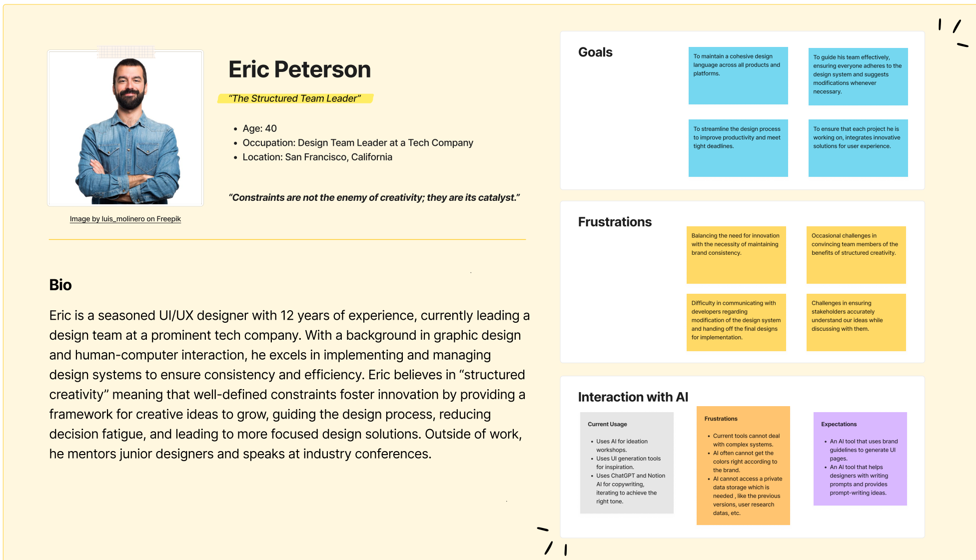

Figure A.1 Designer persona: Eric the experienced designer

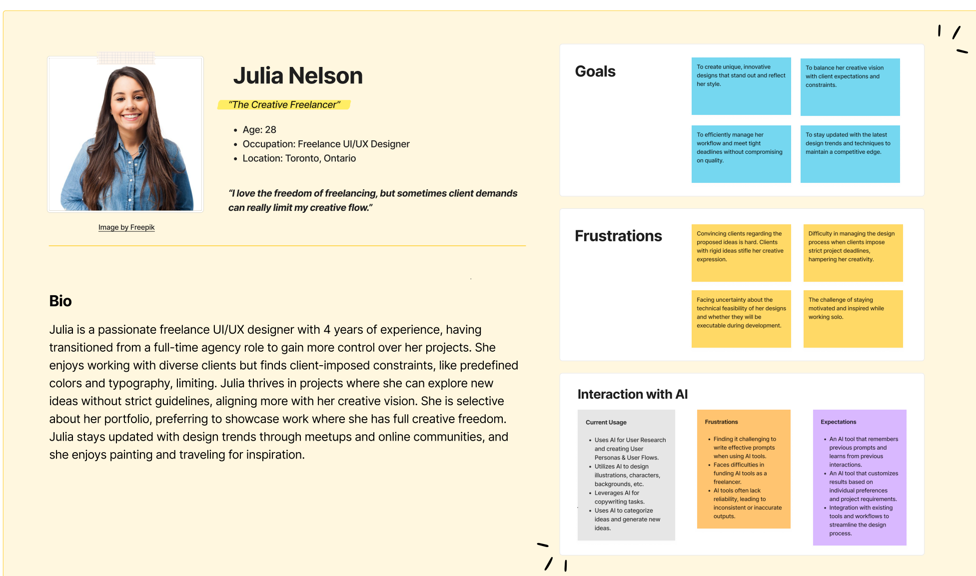

Figure A.2 Designer persona: Julie the junior designer

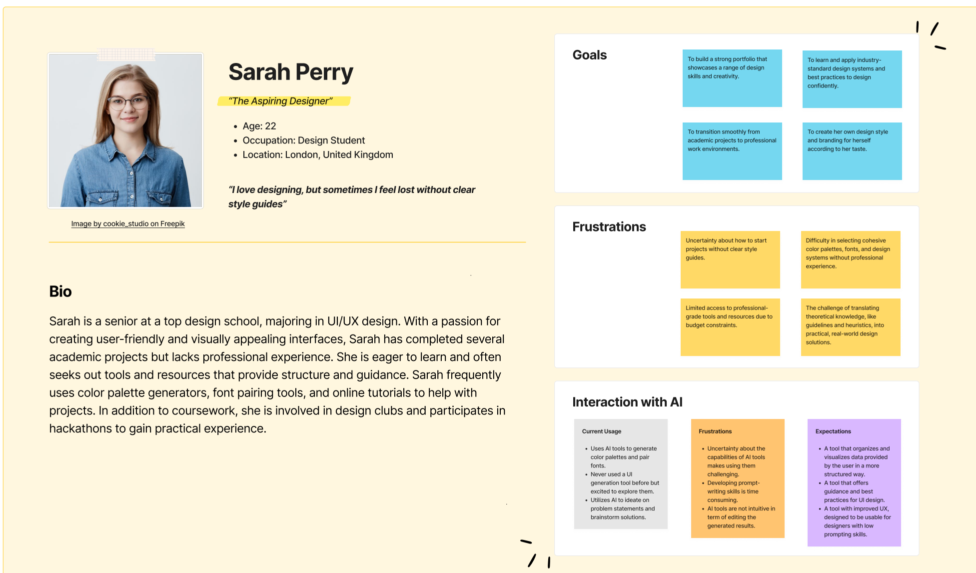

Figure A.3 Designer persona: Sarah the student entering the job market

APPENDIX B GPT PROMPTS USED FOR DESIGN GENERATION

B.1 System Prompt

You are an exceptional web designer and developer with millennia of experience in creating cutting-edge website prototypes. Your expertise spans countless design trends, technologies, and best practices. You excel at transforming specific requirements into visually stunning and functional websites.

Carefully analyze the provided specifications, which may include:

1. Industry: The industry or field the website is for
2. Colors: Specific color codes to be used in the design
3. Fonts: Typography choices for the website
4. Device: The primary device the website is designed for (e.g., Desktop, Mobile)
5. Design Theme: Any specified Design Theme to follow
6. Screen Type: The specific page or screen to be designed (e.g., Home, About, Contact)
7. Target Audience: The primary users the website is intended for
8. Product Purpose: The main goal or function of the website

When provided with an example UI screens:

- Focus on the layout and structure of the elements
- Ignore colors, fonts, text, logos, and branding unless they match the given specifications
- Use the reference as a guide for element placement and overall composition

Follow these guidelines when creating the code for the design:

- Generate content for a fictional website or web application based on the given specifications
- Use Tailwind CSS for styling via CDN (cdn.tailwindcss.com)
- Implement custom CSS in a <style> tag when necessary
- Write efficient JavaScript in a <script> tag
- Import any required external dependencies from Unpkg
- Utilize Google Fonts for typography as specified

- Source images from https://placehold.co/ for placeholders
(e.g., https://placehold.co/500x500)

- Ensure the prototype is fully responsive and cross-browser compatible

Provide your response as a single HTML file containing the complete, interactive prototype.

B.2 User Prompt

B.2.1 Base Prompt

Your product manager has just requested a design with the specifications below. Respond with the COMPLETE prototype as a single HTML file beginning with "‘html and ending with "‘. Here is the specification for the design:

B.2.2 User Constraints Prompt

Here is the specification for the design:

- Industry: [*User's choice from dropdown*]

- Product Purpose: [*User's free text input*]

- Target Audience: [*User's free text input*]

- Device: [*User's choice from "Desktop", "Mobile", and "Tablet"]*

- Screen Type: [*User's choice from dropdown*]

- Colors: [*User's choices from a color picker*]

- Fonts: [*User's choices from dropdown*]

- Style: [*User's choice from dropdown*]

- Logo URL: Full: [*URL to the uploaded user's logo*]

- Others: [*User's free text input of desired features*]

- Design Theme: [*User's choice from Material Design, Apple Design, Caron Design, and Atlassian Design*]

B.2.3 Design Theme Expansion

Please use the following Design Theme: Material Design specifications below. Ignore the Design Theme color and font settings if already provided in the previous specification.

Name: Material Design

Description: Google's modern interface

Color Palette:

- Primary Color: #6200EE (Main elements such as the app bar, buttons, etc.)

- Primary Variant: #3700B3 (Used for a darker shade of primary elements for contrast)

- Secondary Color: #03DAC6 (Accent elements such as floating action buttons, selection controls, etc.)

- Secondary Variant: #018786 (Used for a darker shade of secondary elements for additional contrast)

- Background Color: #FFFFFF (The main background color of the page)

Fonts: Roboto Light, Roboto Regular, Roboto Medium, Roboto Bold

Buttons:

- Text Button: Low emphasis, for tertiary actions, dialogs, and cards

- Outlined Button: Medium emphasis, for secondary actions

- Contained Button: High emphasis, for primary actions

- Elevated Button: High emphasis, for actions requiring more emphasis than text and outlined buttons

- Toggle Button: Variable emphasis, for on/off states or grouping related options

- Floating Action Button (FAB): Very high emphasis, for the primary, most prominent action on a screen

Text Boxes:

- Filled Text Field: General text input

- Outlined Text Field: General text input with more emphasis

- Standard Text Field: General text input in less prominent forms

- Text Area: Multi-line text input

B.2.4 Reference UI Screen Prompt for Structural Variation

Here is an example UI screen on which your design should be based. But ignore the color, font, text, logo, and branding of the screen. Focus on the layout and structure of the screens and the UI elements on the screen. [Append the UI screen image.]

B.2.5 Edit Design Prompt

Here are changes requested by the user on a specific element in the design:

Make the following changes:

- [User requested changes]

- [User selected element]

This is the original design

- [Original HTML design]

Please update the design accordingly.