Exploring the Diminishing Allure of Paper and Low-Fidelity Prototyping Among Designers in the Software Industry: Impacts of Hybrid Work, Digital Tools, and Corporate Culture

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ABSTRACT

In a rapidly evolving UX/UI design landscape marked by technological advancements and shifts toward hybrid work, understanding the implications of these changes on software prototyping practices is crucial. This study investigates the influence of evolving work practices, tool advancements, and designers' attitudes on prototyping practices and design processes in the contemporary software industry. Based on in-depth interviews with 10 practitioners and educators, we explore the factors contributing to the preference for digital-first prototypes and the diminishing appeal of low-fidelity prototyping methods. Our findings reveal how digital prototypes outshine physical counterparts in hybrid work, the role of all-in-one digital tools in centralizing designers' workflows and encouraging high-fidelity prototyping, corporate preferences for visually appealing prototypes, and the impact of designers' educational backgrounds, generational differences, and professional maturity. This research offers valuable insights to inform decision-making and strategies for design practitioners, educators, and organizations in adapting to current and future prototyping practices.

CCS CONCEPTS

• **Human-centered computing** → **Interface design prototyping**; **Empirical studies in HCI**.

KEYWORDS

paper prototyping, lo-fi prototyping, digital prototyping tools, hybrid and remote work, design practices, industry, expert interviews

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1 INTRODUCTION

Prototyping serves as a pivotal phase in the software design process, with a crucial role in transforming abstract ideas into interactive products. These renditions serve as a blueprint for the final output, allowing stakeholders to envision, explore, and test the design's functionality and feasibility [47]. In UX/UI design, prototypes enable understanding, critiquing, communication, and validation of design assumptions, thus aiding in refining the design before development [18, 23] and eventually fostering design innovation [45]. Given this integral role, the nature and methods of prototyping in design are subject to continual adjustments and improvements. As we find ourselves in a time of rapid technological advances and shifting work models, it is timely and essential to revisit prototyping practices in the industry. Recent academic discourses about prototyping are predominantly about immersive technologies [24, 25, 34] or hardware products [32, 33]. However, unlike prototyping in those domains, where physical and low-fidelity prototyping is more prevalent due to the spatial and tangible nature of these products as well as the relatively nascent stage of digital tools, software prototyping faces unique opportunities for investigation.

The spectrum of prototyping tools has evolved tremendously, from traditional paper prototyping to sophisticated digital platforms [15]. Paper prototyping, a form of low-fidelity (lo-fi) prototyping, is lauded for its simplicity, cost-effectiveness, and its potential to stimulate creativity and collaboration [49]. Despite these merits, the advent and evolution of digital prototyping tools like Figma, Sketch, and Adobe XD have been game-changing. These tools offer high-fidelity (hi-fi) prototyping capabilities, which produce detailed and interactive prototypes that closely mimic the final product. However, amidst this digital revolution, the relevance and efficacy of paper prototyping comes into question. While some research found limitations of paper prototyping in demonstrating interactivity and complexity [27], others advocate for it, citing the benefits of tangible interaction and the immediacy of sketching [4, 6].

A key consideration closely related to the paper versus digital debate is the varying fidelity of prototypes. Lo-fi prototypes, like sketches, wireframes, and mock-ups, have been celebrated for their simplicity and speed. They enable designers to externalize design ideas at a low cost and allow user study participants to focus on core functionality and the design concept. High-fidelity prototypes, on the other hand, have typically been employed for detailed design evaluations, marketing, and user testing prior to deployment. However, with the advent of advanced digital prototyping tools, a reevaluation of the comparative advantages of prototypes in different fidelities is underway. This ongoing debate about the

preference between lo-fi and hi-fi prototypes forms an integral part of the broader discourse on evolving prototyping practices [41, 43, 53, 54].

Apart from evolving work practices and digital tool adoption, factors like collaboration modes, corporate culture, agile processes, and designer career progression significantly shape prototyping practices. In the wake of the COVID-19 pandemic, we have seen a shift from traditional office-based work to hybrid and remote work models [48]; such models demand more flexible, accessible, and efficient collaboration and practices digital prototyping tools seem well-equipped to provide [37]. Some firms, particularly those with a culture valuing fast-paced development, may show a preference for high-fidelity and digital prototyping [45]. Agile methodologies, with their focus on rapid iterations and swift feedback, are further promoting the use of digital tools that accommodate these needs effectively [44]. Furthermore, as designers mature in their careers, they tend to rely more on their intuition and knowledge, often bypassing formal methods [35, 36]. These various factors underscore the need to investigate how design practices and technologies are impacting the utilization and perception of various prototyping methods in the contemporary industry.

In the software design landscape, how do evolving work practices, technology advancements, and changing attitudes of designers influence prototyping practices and design processes within the contemporary industry? As work environments diversify into hybrid models, there emerges a pivotal query regarding the influence of these new collaborative spaces and the advancements in digital prototyping tools on prevailing industry practices. Additionally, in the context of rapid technological progression, this research aims to explore perspectives and considerations regarding the relevance and preference between low-fidelity (lo-fi) and high-fidelity (hi-fi) prototypes in modern design processes. As designers navigate these changes, this research seeks to understand how they perceive and integrate traditional methods, such as paper prototyping, and lo-fi practices within contemporary design strategies. This research seeks to unearth the nuanced perspectives on these changes, highlighting the interplay between emerging work models, technological progress, and the evolving ethos of design practitioners as experienced and described by them.

In pursuit of these inquiries, we conducted in-depth interviews with a diverse mix of ten experts, encompassing both UX/UI design practitioners and educators. The findings reveal that various factors, such as hybrid work environments, the rise of all-in-one digital tools, corporate preferences, and generational and educational differences, appear to influence designers' prototyping preferences and practices. Our analysis highlights the ways these interwoven components conduces to the designers' preference for digital-first prototypes and a diminishing appeal of low-fidelity methods, the impact of professional maturity on designers' adoption of intuitive and experience-based practices, and the ways in which educational and generational differences affect prototyping choices.

Our research contributes valuable insights into the prototyping practices of the participants, providing a snapshot of their experiences in the contemporary software industry. These contributions include:

- Uncovering the nuanced impacts of hybrid work environments, digital tools, and designers' prototyping preferences, enabling a deeper understanding of the factors shaping industry practices.
- Identifying the influence of professional maturity, educational, and generational differences on designers' adoption of different prototyping methods, providing insights into the evolving design practices within diverse professional and educational contexts.
- Highlighting the potential tension between traditional lo-fi prototyping and the industry's expectations for visually appealing, high-fidelity outputs, shedding light on the challenges faced by designers in aligning their practices with stakeholder expectations.

The implications of these contributions lie in guiding design practitioners, educators, and organizations towards informed decisions and strategies in adapting to the current state and potential future developments in prototyping practices.

2 BACKGROUND AND RELATED WORK

2.1 Defining and Characterizing Prototypes

Despite their critical role in the design process, there is a noticeable lack of definition and standardization in characterizing prototypes. To ensure consistency, we will draw upon previous studies to formalize a local, operational framework for conceptualizing prototypes, which will be referenced throughout this paper.

A prototype is an early representation of a product, system, or service that enables designers and developers to explore, evaluate, and iterate their ideas [28]. Prototypes play a critical role in the human-computer interaction (HCI) domain, as they facilitate communication and collaboration among stakeholders, support usability testing, and guide decision-making throughout the design process [18]. Prototypes can range from simple sketches or wireframes to more complex interactive systems, and their primary purpose is to help designers identify potential challenges and opportunities in their design before committing significant resources to the project [43]. When we describe "prototypes" in this paper, we are broadly referring to *any early representation of a software feature or application, such as sketches, wireframes, mock-ups, and interactive prototypes*. The breadth of this definition serves for the explorative nature of our research objective.

Our framework conceptualises prototypes through three components, namely fidelity, medium, and dimension. In our framework, we define fidelity and the spectrum of fidelity as the degree to which a prototype resembles the final product or system in terms of its appearance, functionality, and interactivity. We adopted Engelberg and Seffah's definition from [15] as it provides a clear distinction between low-fidelity, mid-fidelity, and high-fidelity prototypes, allowing us to investigate the factors that influence designers' preferences for different levels of fidelity (Table 1). The medium component (Table 2) of our framework is borrowed from the "material" manifestation dimension of Lim et al.'s prototype anatomy. Lastly, the dimensions component (Table 3) is a combination of McCurdy et al.'s mixed prototype characteristics and Lim et al.'s filtering dimensions, with the functional breadth, functional depth, and data characteristics abstracted into a single functionality dimension.

Table 1: Fidelity Component of Our Prototyping Definition Framework

Fidelity	Definition
Low-fidelity	Prototypes consisting of rough analog or digital freehand sketches for the purpose of conceptualization.
Mid-fidelity	Prototypes providing detailed context for navigation, functionality, content, and layout for the purpose of conducting design evaluations, but are in schematic or wireframe form.
High-fidelity	Prototypes offering realistic simulations for the purpose of user testing or marketing prior to deployment.

Table 2: Medium Component of Our Prototyping Definition Framework

Medium	Definition	Examples
Physical	Any physical media that is manipulated (draw, fold, cut, stitch, etc.) in order to create an interactive prototype.	Paper prototype
Sketch	Any media on which design concepts can be drawn. A sketch medium differs from a physical medium in that a sketch can be either analog or digital and that it is purely a drawing only.	Paper, iPad, whiteboard
Digital	Any digital prototyping software.	Figma, Framer

Table 3: Dimension Component of Our Prototyping Definition Framework

Dimension	Definition
Appearance	Visual refinement of a design, with rough, hand-drawn sketches on the low-end and pixel-accurate mock-ups on the high-end. Appearance elements include but are not limited to colour, size, shape, and the arrangement of elements on the interface.
Functionality	What can the prototype do and how much can the prototype do? Prototypes low in functionality have the barebone interface elements needed for the intended purpose, whereas prototypes high in functionality will be close to a working, fully-implemented version of the software.
Interactivity	The ways in which users can interact with the prototype. Prototypes low in interactivity will require significant human intervention to indicate input-output behaviour whereas prototypes high in interactivity will be responsive to user inputs and display outputs automatically.

Our framework is predominantly based on the three prior studies above, as these turned out to be the most relevant to interpreting the interview data and presenting and discussing the findings in our study. Furthermore, we ensure that our definition and characterization are consistent with the perspectives provided by other researchers in the field of HCI, including the discourses by Rettig [41], Rudd et al, [43], as well as the empirical studies [46, 52, 54] and seminal work by Snyder [49]. However, admittedly, it is one of many potential approaches to characterizing various prototyping strategies. Despite the potential to enrich the discussion by considering alternate perspectives, such as different design processes, media types, and mixed-fidelities [2, 9], these considerations exceed the present study's scope and are reserved for future exploration. Furthermore, while hybrid prototyping methods, like those combining paper prototyping and AR [34], and rapid physical prototyping, like low-fidelity wireframe fabrication [32], offer valuable insights, our focus is on software prototyping practices, not on immersive technologies or physical products.

2.2 Traditional Prototyping Methods in HCI and UX Design

The field of HCI and UX design has long utilized various prototyping methods. One traditional form is lo-fi prototyping, which includes paper prototypes, sketching, storyboarding, and Wizard of Oz techniques [47]. In this approach, paper prototypes act as a "variation of usability testing," where users interact with a paper version of an interface manipulated by a person "playing computer" [49]. This method was favored due to its cost-effectiveness, simplicity, and ease of iteration, allowing designers to quickly assess user needs and preferences [41, 49, 52]. However, these practices were mainly documented in decades-old studies.

Recent literature also covers lo-fi prototyping in various contexts. Predominant works focus on rapid prototyping in virtual and augmented reality domains [16, 21, 34] and physical product development [8]. Other studies investigate the use of lo-fi prototyping for bridging knowledge gaps between corporate stakeholders [14, 22], teaching HCI concepts in design education [31], and engaging users in the design process in a participatory manner [11]. However, an in-depth, qualitative description of how recent changes in the software industry, such as hybrid work and new tools, influence designers' prototyping preferences and design processes remains an open question. The most relevant is Suleri et al's experimental study [50], which found that pattern- and library-based prototyping approaches significantly reduce designers' workloads compared to traditional methods. Our work expands this observation in an in-the-wild context by having participants elaborate on how the rise of reusable design libraries diminishes the speed appeal of lo-fi methods.

2.3 Comparative Analysis of Low-Fidelity and High-Fidelity Prototypes

The debate concerning the use of low-fidelity versus high-fidelity prototypes has been a topic of great interest in HCI and UI/UX design [43]. Low-fidelity prototypes are often paper-based or other simplified versions of the product, whereas high-fidelity prototypes are more interactive and closely resemble the final product [43]. Supporters of low-fidelity prototyping argue that these prototypes can be created quickly and inexpensively, facilitating early and frequent user testing [52]. They emphasize that these prototypes are particularly useful in eliciting big-picture feedback about usability issues and overarching design concepts [41]. On the other hand, proponents of high-fidelity prototyping believe that the close resemblance to the final product makes these prototypes more effective in gathering user feedback about specific interactions and visual design elements [27]. High-fidelity prototypes are also said to be better suited for conveying the look-and-feel of the product, which can be critical in gaining stakeholder buy-in and user acceptance.

Despite the debates, empirical studies that compare the effectiveness of low- and high-fidelity prototypes generally have not found significant differences between the two [12, 46, 53, 54]. Yet, these studies have noted nuanced differences. For example, high-fidelity prototypes can sometimes lead to more detailed feedback, but they may also cause users to focus more on details and less on high-level concepts [54]. Meanwhile, low-fidelity prototypes are found to be effective for capturing general feedback on overall design and usability [46].

Building upon previous research, our work delves into the impact of prototype fidelity within the context of contemporary agile development methodologies characterized by rapid and frequent iterations. While earlier studies primarily focused on usability issue identification, we explore how varying fidelity levels influence the entire designer's practices. By doing so, we broaden the lens to provide a more comprehensive understanding of prototype fidelity's role in user-centered design. This nuanced perspective illuminates the ways in which prototype fidelity choices can affect design work and the speed of design iterations.

2.4 Exploring the Current Use of Paper and Lo-Fi Prototyping: Perspectives from the Industry and Remote Work Settings

Existing reports on paper and lo-fi prototyping practices in the current industry settings are primarily limited to non-peer-reviewed articles and anecdotal accounts from design practitioners. Recognizing the limitation of these sources, we cautiously explore the perspectives that suggest a preference for digital-first prototypes and remote work arrangements, which might have affected the use of paper and lo-fi prototyping in some cases.

The onset of the COVID-19 pandemic and the resultant remote work conditions have highlighted the practicality of digital methods over physical ones. The UX Tools survey noted a sharp decline in the use of paper or whiteboards for exploration, from 86% in 2019 to 33% in 2020 [38, 39]. The same UX Tools surveys also indicate a rise in the use of digital tools for design activities, documenting that 95% of respondents in 2021 used digital tools for design activities [40], compared to a 2007 survey where more than 70% reported using pen and paper [5]. However, it's important to recognize these figures as indicative of a specific period marked by exceptional circumstances rather than a definitive industry-wide shift. Furthermore, digital prototyping tools, as noted in practitioner insights in [42], seem to offer advantages like design system integration, potentially speeding up the creation of high-fidelity prototypes. Yet, these observations primarily stem from individual experiences and should be considered as such, rather than as evidence of a broad industry trend. While previous research has discussed the benefits of digital tools in design collaboration [19, 51], the focus of these studies has primarily been on their features rather than their impact on design practice choices.

Despite the increasing interest in digital prototypes, some designers still find value in lo-fi prototyping for early-stage testing and brainstorming novel solutions, as it can help focus on core functionality and interaction flows [17]. Moreover, some design educators maintain a similar preference for lo-fi and paper prototyping. In the SIGCHI Education Project which gathered perspectives on priorities for HCI teaching and training courses, "paper/low-fidelity prototyping" was rated across all survey respondents as "important" or "very important" in both 2011 and 2014 [6]. A recent prototyping masterclass proposal by Leshed [26] includes paper prototyping as a core exercise because it helps students "filter out most appearance elements and focus on filtering in functionality and interaction flow."

Our research aims to provide a nuanced view of the prototyping practices in the current software design landscape. Our in-depth interviews with practitioners and educators go beyond anecdotal evidence by involving methodical questioning to extract nuanced, rich, and reflective insights on the interplay between individuals, organizations, and circumstances in design prototyping.

3 METHODS

To address our research question, we conducted interviews with UX/UI experts from both industry and academia, and subsequently performed a thematic analysis of the data. Our method largely follows Braun and Clark's thematic analysis approach [3]. However, we also incorporated a pragmatic and utilitarian approach to adapt it to an incremental and iterative data collection and analysis process as detailed below.

3.1 Participants

In our study, we aimed to explore the relationship between prototyping in UX/UI design practice and education by including both practitioners and educators. To ensure the diversity of the participants and the expediency of recruitment, we employed a combination of purposive and snowball sampling approaches. We diversified the initial contact pool based on specific criteria of age, career stage, and experience, and encouraged the recruited participants to recommend others who would further diversify the entire pool, describing the ideal characteristics of second-degree recruitments. We initiated the recruitment process by (1) sending emails to the researchers' first-degree connections, encouraging them to "snowball" or recommend other participants, and simultaneously (2) posting a public LinkedIn update that attracted responses from both first-degree and second-degree connections. Out of the 10 participants, 6 were

recruited through email, with 3 being first-degree connections and 3 being second-degree connections recommended by one first-degree connection who didn't end up participating. Meanwhile, 4 participants were recruited from LinkedIn, with 2 being first-degree connections and 2 being second-degree connections.

To ensure a baseline understanding of industry prototyping methods, we recruited participants who:

- were at least 20 years of age;
- had worked on at least 2 projects involving the creation of lo-fi prototypes, mock-ups, or wireframes; and
- had at least 1 year of experience as a professional UX/UI designer or HCI educator.

Of our ten participants (9 women, 1 man), four were early-career designers with 1 to 4 years of experience and some only started working during the COVID-19 pandemic, two were senior-level designers with 6 to 8 years of experience, three were principal-level or director-level design managers with 10 to 21 years of experience, and one was an undergraduate HCI educator who had been teaching the subject for 10 years. One of the senior-level designers currently works as a product manager, but their job still encompasses UX/UI design responsibilities. Also, one of the principal-level design managers also concurrently teaches human-centred design at the graduate level. Together, the participants have worked across many different companies with varying degrees of design maturity, including: agencies, start-ups, small, and medium-sized enterprises, and large corporations. They come from a diverse educational background including computer science, HCI, health science, architecture, psychology, and fine arts. All participants currently work in North America (Canada, USA), but one of the participants (Surya) had previously worked in India for 5 years. As such, considering differences in the software industry across different geographic regions, the findings in our paper may be localized to designers working in North America for North American companies. All participants have developed prototypes for desktop and mobile software experiences.

3.2 Data collection and analysis

3.2.1 Data collection. Data collection for this study was conducted through a combination of questionnaires and semi-structured interviews. Participants first completed a short questionnaire covering demographic information (presented in Table 4). After completing the questionnaire, participants were contacted by a member of the research team to schedule an interview. These interviews were conducted remotely via Zoom between October 26th and December 3rd, 2022 and lasted approximately one hour. Participants were compensated $40 for their time.

The interview was divided into three segments. In the first segment, we asked questions to probe into the participant's background based on their questionnaire responses, such as how they ended up in UX/UI design, at which companies they had previously worked, and what responsibilities their jobs entailed. In the second segment, we explored how the participants learned about design, with a focus on how their academic background shaped how they do lo-fi prototyping. In the third segment, we explored how lo-fi prototyping fits into their current design practices, and how their processes have changed over time and in different working environments. We also asked participants about their companies' policies on remote work and the likelihood of hybrid work arrangements persisting into the future to ensure that our sample was not biased, due to our remotely conducted interviews, towards designers who were only working from home. The allocation of time between the three segments was not uniform, since participants were free to elaborate on certain thoughts and took part in shaping the dialogue. For participants who were educators, the second segment of the interviews were slightly modified to explore how they taught lo-fi prototyping methods, and the third segment too to focus on their opinions about the relevance of methods taught in coursework versus methods used in practice.

With the participants' consent, the interviews were recorded with Zoom and transcribed using the platform's live transcription feature. These transcripts were then manually revised to correct grammar and remove some trivial pauses and filler words. We did member checking with each participant at a later date to verify that our interpretation of their words aligned with their intent.

3.2.2 Analysis. We analyzed the interviews using inductive thematic analysis [3], which was done concurrently with the data collection process in batches of 3, 3, and 4 participants. Initial inductive codes were generated by reading through interview transcripts while rewatching interview recordings. Throughout our analysis, the research team had weekly discussions to start drawing connections between our codes to form higher level categories using axial coding. The initial codes were recorded in a spreadsheet along with the corresponding interview excerpts, and then migrated to Miro, a digital collaborative whiteboard, to help facilitate the axial coding process. For example, some of our initial codes such as "competitive analysis to replicate designs" and "copy and paste from old projects" were merged into the higher level category "replicate design patterns to solve similar problems." In total, we had 319 open codes. Codes were discarded if they were either irrelevant to the scope of our study or they were not supported with strong evidence—some of these codes are addressed in our discussion. The codes that were not discarded were grouped into 6 categories, which were further developed into 2 themes. We concluded our data collection and analysis once we reached thematic saturation.

4 FINDINGS

Upon analyzing the interview data from our study, we unearthed participant narratives that illuminate the factors contributing to designers' preference for digital-first prototypes and the diminishing appeal of low-fidelity prototyping methods in the current context of the software industry. These include the impact of hybrid work environments, the role of all-in-one digital tools, corporate preferences, and the influence of educational and generational differences on designers' prototyping choices. Additionally, we explore the ways in which professional maturity conduces to the adoption of intuitive and experience-based practices.

Table 4: Self-reported participant demographics. We recruited 10 participants with diverse backgrounds in UX/UI design and HCI education. Their experience ranged from early-career designers to senior-level managers and included an educator.

ID	Pseudonym	Age	Gender	Education	Field of Study (Grad Year)	Design Experience	Job Title	Work Arrangement
P1	Caroline	20-29	Woman	Bachelors	Computer Science and Biology (2020)	2 years	Product Designer	Remote
P2	Bernard	40-49	Woman	PhD	Artificial Intelligence (2012)	10 years	Associate Professor	In-person
P3	Celeste	20-29	Woman	Bachelors	Health Science (2020)	3 years	Interaction Designer	Remote
P4	Surya	30-39	Man	Masters	Game and Interactive Media Design (2022)	6 years	Product Manager	Hybrid
P5	Janelle	20-29	Woman	Bachelors	Computer Science (in progress)	1 year	UX/UI Design Intern	Remote
P6	Xiang	30-39	Woman	Masters	Architecture (2012)	10 years	Design Manager	Hybrid
P7	Lucinda	40-49	Woman	Masters	Interaction Design (2001)	21 years	Principal Design Manager & Assistant Professor	Remote
P8	Jolene	40-40	Woman	Bachelors	Fine Arts (2002)	15 years	VP of Design	Hybrid
P9	Nadia	20-29	Woman	Bachelors	Cognitive Systems - Psychology (2020)	4 years	Product Designer	Remote
P10	Penelope	30-39	Woman	Masters	Human Computer Interaction (2014)	8 years	Senior Designer	Remote

4.1 How digital prototypes can outshine physical counterparts in hybrid work environments: integration into digital design workflow, ease of sharing, and asynchronous collaboration

Our participants reported prototyping with physical media has become less prevalent in their workflow, owing to the better adaptation of digital tools for remote work. Remote and hybrid work is becoming rapidly normalized [1] and most of the designers we interviewed, who were either working fully remotely or in a hybrid work arrangement, confirmed that their companies have strong incentives to continue supporting this flexibility.

In a hybrid work environment, digital prototypes can promote inclusivity because they are accessible by everyone, regardless of where people are working. Jolene recalls a hybrid discovery session in which both sketch (analog whiteboard) and digital (Miro) media were simultaneously used, causing feelings of exclusion for the remote designers because "people in the room [...] would just engage in their own conversation, and then sometimes they will forget about the remote team, and sometimes they start writing things on the [analog] whiteboard." Prior to the COVID-19 pandemic when most designers were working in-person, it was common to "sketch on paper [...] and go over the flow" (Jolene) at the office. Although designers still have the option of taking and sending pictures of sketches on paper, digital prototypes can be easier to share via video conferencing and digital prototyping tools, allowing designers to collaborate effectively regardless of their whereabouts.

Even if work arrangements eventually transition back to in-person, some designers would prefer to avoid physical prototypes because they don't integrate seamlessly into their design workflows, which are largely digital. For Surya, digital prototypes eliminate the once "tedious" process of translating physical sketches into digital assets later on. Even when working in-person, Caroline and Surya have developed the habit to start early-stage prototyping directly in a digital medium such as FigJam or Figma and "share [their] laptop screen" with the people around them.

Also, our designers asserted that digital tools are well-suited to *asynchronous* tasks, which is a core characteristic of hybrid work since designers now have the flexibility to choose their productive hours. Lucinda, Surya, and Jolene explained how laborious asynchronous collaboration used to be in the past—using a cloud storage service such as Google Drive to share designs, and then providing context and soliciting feedback via email. Now, designers have dedicated tools for this. For example, designers can do asynchronous design walkthroughs of their digital prototypes using software such as Loom, or through a simple screen recording (Lucinda).

More specifically, designers can use digital prototyping tools such as Figma to directly annotate a design, tag someone for feedback, or start a thread of asynchronous comments. These asynchronous features reduce the barriers experienced with sketch and physical prototypes, such as difficulty sharing designs and documenting feedback. As Caroline noted, "with Figma being such a powerful tool, and having the comments being so well-organized, I think it's easy to keep track of feedback [directly in the digital prototyping tool]." Furthermore, asynchronous features of digital prototyping tools expedite the design review process, reducing the

frequency of synchronous meetings with stakeholders. Jolene observed that, "after [the] pandemic, we just do the design review over Zoom, and if there are small changes [needed], we'll just work on the changes [in the design file] and tag the client on Figma, and then they'll just leave comments for review, so definitely the review cycle is more frequent than pre-pandemic."

When it comes to choosing a prototyping medium for evaluation purposes, our designers had differing opinions. On one hand, Jolene preferred digital prototyping tools, citing the advent of online tools such as UserZoom, User Interviews, and Lookback, which allow designers to share prototypes and conduct both moderated and unmoderated usability tests online. On the other hand, Nadia noted two caveats about online user testing - that it may be challenging to isolate product usability issues from accessibility or technical issues related to the remote nature of the interview, and participants recruited by these online platforms may be monetarily incentivized and provide low-quality feedback.

Overall, this section highlights how digital prototypes, with their ease of sharing and integration into digital workflows, enhance collaboration in remote and hybrid work settings. In the following section, we delve into the emergence and benefits of versatile digital prototyping platforms, highlighting Figma as a notable example.

4.2 The role of all-in-one digital tools in centralizing designers' workflows and encouraging high-fidelity prototyping

All the designers we interviewed reported using Figma as their primary prototyping tool. Most of them switched to Figma around the onset of the COVID-19 pandemic. The designers' narratives suggest that, for some, the shift to Figma from other prototyping tools is largely due to its comprehensive features, which streamline the design process by consolidating various tools and media into one versatile application. This simplification reduces the complexity and number of tools designers need to use. A once tedious process that was handled by multiple tools across multiple forms of media has been collapsed into a single general-purpose prototyping application.

> *"[Design used to be] a very tedious process for me—first designing on paper, then copying that into Sketch [to design] a digital version, then copying that design into InVision [to prototype interactivity]. [...] but now it has become very easy for me because [that design process has transitioned entirely to Figma]." (Surya)*

This sentiment is echoed by Jolene, who additionally notes the use of plug-ins to perform non-native functionality as an alternative to subscribing to a separate platform altogether. Jolene's team was "using 7 or 8 tools" before they switched to Figma about two years ago. This multiplicity of tools included Sketch for initial designs, Overflow for screen flow, and InVision for interactive prototyping. The introduction of Figma, with its plug-in capabilities for drawing screen flow and built-in interactive prototyping features, has allowed designers like Jolene to consolidate these disparate steps. "But for Figma, they also have the capability to, you know, use a plug-in to draw some screen flow, and also [interactive] prototyping features are built within, so we've managed to streamline the steps a little bit better," she adds. This integration of multiple functionalities into a single platform like Figma represents a perceived increase in efficiency and convenience, potentially reducing the need for multiple subscriptions and platforms.

In this way, Figma has become a multifunctional tool used to brainstorm, wireframe, mock-up, build interactions, and hand-off designs, despite the existence of more specialized tools and traditional analog sketching methods. Prior to the pandemic, most of our designers began their brainstorming process on a sketch medium, such as "brainstorming ideas on a whiteboard" (Penelope) or sketching on paper. Now, many designers are using digital whiteboarding alternatives, such as Figma's product offering, FigJam (Caroline, Celeste, Lucinda). For wireframing, even though several designers recall at one point using or having heard of Balsamiq, none of them (Celeste, Surya, Xiang, Jolene) currently use it in their prototyping process. Rather than using a dedicated wireframing tool, designers prefer to use Figma. Also, a non-trivial number of designers (Caroline, Celeste, Surya, Janelle) indicated that they often build digital wireframes in Figma from scratch using basic shapes, despite acknowledging how "inefficient" it is given the existence of wireframe templates. This behaviour of moving shapes around on a digital canvas in Figma suggests that digital prototyping tools can, to some degree, replicate the analog sketching experience for designers. For some designers, Figma has become a versatile tool of choice, akin to a Swiss Army Knife, even when other tools are available.

Among the designers we interviewed, the ability to brainstorm, wireframe, and build high-fidelity prototypes across all dimensions (appearance, functionality, interactivity) with the same platform has often reduced the reliance on physical and sketch media in their design process. Some designers, such as Celeste, Surya, Xiang, and Jolene, expressed a shift away from paper prototyping and sketching due to the accessibility and functionality of tools like Figma. Surya recalls building paper prototypes early on in his career and how he used to always "[sketch] first on a piece of paper," but the easier access to tools such as Figma has made his process digital-first. Relevantly, when Adobe Illustrator was the de facto standard amongst designers in industry, Xiang reflected that she did a lot more paper sketching since Adobe Illustrator was not purpose-built for UX/UI and she could not use it to quickly build out wireframes.

Although there is a trend toward fully digital workflows with some designers completely bypassing sketching (Celeste, Surya, Xiang, Jolene), other designers still stand by sketching, albeit with an iPad, for the purpose of exploration (Caroline, Janelle, Nadia, Penelope). Lucinda, who manages many designers, observes that designers "who tend to sketch first come from more of a visual design background." Even though these designers still subscribe to the sketch medium as part of their prototyping process and "can't imagine designing without sketching," Janelle acknowledges that spending so much time in a single digital tool, namely Figma, may be subconsciously pushing designers toward a digital-first prototyping approach:

> *"I feel like...being able to [sketch helps you stop and think], because it's a different tool,...or maybe because it's a different medium..., you stop yourself and you think more. We all have these little pockets of workspaces.*

> *So my table is for working. My bedroom is for sleeping. Same thing for Figma—it is for creating prototypes and for wireframing, things like that. And when you get into Figma and that's the first thing you think, sometimes I forget to realize, oh, I need to slow down and not jump into this headfirst. And so, almost in a way, using a different medium stops you because it's a different space that's facilitating that." (Janelle)*

Moreover, some designers have noted that the rise of reusable design components diminishes the speed appeal of lo-fi prototypes as a whole, not just paper prototypes. Having ready-to-use components at their disposal incentivizes designers to increasingly shift toward starting with prototypes that are higher in fidelity on the appearance dimension. Nadia does not make any visually low-fidelity prototypes because her company has "such an established design library." This sentiment is echoed by Caroline, who mentions that a lot of her work is about making incremental feature improvements rather than designing from first principles, so there are a lot of existing UI components from previous projects, templates, and design libraries that can be reused:

> *"[...] I enjoy breaking a problem down and going from bare bones, but yeah, I would say that when we have so many components and templates at our disposal it means that I'm kinda skipping steps and jumping straight to even medium fidelity sometimes without even sketching first because I have the UI components right there." (Caroline)*

Likewise, Xiang extends this idea further by describing how digital prototyping tools serve as "design library and design system [that] allow people to do things faster" by reusing tried-and-true design patterns. Even for agencies that don't have their own in-house design system, there is the option of using third-party design systems. Jolene works at an agency and discusses using templates from a design system to expedite timelines and cut costs.

> *"I could see the trend from now on, at least for our company we'll be using more templates for client projects so that we can expedite our development timeline, and also lower the cost for our client." (Jolene)*

To summarize, as Figma's functional scope continues to broaden, it has become, for some designers, a digital "pocket" for brainstorming, wireframing, creating mock-ups, and building interactions. For the convenience of having their entire design workflow centralized in one digital "workspace," our designers noted a shift toward more digital-centric workflows, appreciating the convenience of a centralized digital workspace, which for them, sometimes means less reliance on physical mediums and often even lo-fi prototyping. Also, the ease of access to design systems and reusable components of the integrated digital tools encouraged higher fidelity prototyping.

4.3 Corporate preferences for visually appealing prototypes over traditional lo-fi approaches

In the interviews conducted, designers describe a dissonance of expectations between themselves and stakeholders in contemporary corporate environments. The interviews suggest a perceived tension between traditional design processes, typically starting with low-fidelity or "lo-fi" prototyping, and industry expectations for immediately polished, high-fidelity designs. This tension may arise from an emphasis on *visual primacy*—a preference for visually refined designs over the developmental and explorative stages of design in some cases.

It's not that lo-fi prototyping lacks value; rather, this tension stems from stakeholders who may not be deeply familiar with design processes, hence the shift towards prototypes that are higher in fidelity along the appearance dimension. Both Celeste and Surya speak to this, acknowledging that designs should be "visually appealing," otherwise internal stakeholders and clients either won't be "impressed" or will fail to "understand" what they are looking at.

Stakeholder unfamiliarity with design processes emerged as a contributing factor to the shift away from lo-fi prototyping for some designers. Such unfamiliarity can manifest in at least three types of challenges designers face with using lo-fi prototyping.

First, there's the issue of value perception. Some designers observe that many clients, despite not being deeply engrossed in design processes themselves, have formed expectations based on prior experiences or corporate standards. Lucinda expresses her frustration with clients who, being unaware of the foundational work that goes into a design, expect polished results immediately:

> *"...a lot of our clients, they're not designers, so every time you're talking to them they're expecting to see something polished and done. And so there's this tension between their expectation and the process that is going to get you to that quality design. And so you can do all the explaining until you're blue in the face, [but if your clients are] not sophisticated or mature when it comes to design, you do have to kind of scaffold it in such a way so that they're not going to freak out basically and say, 'what on earth is this garbage you're showing me, you're fired'—and I have definitely been in situations where clients did not understand that we were doing [a] raw [prototype] to just kind of test." (Lucinda)*

Secondly, Nadia elucidates the communication challenges posed by lo-fi prototypes. While designers might find sketches as clear representations of their ideas, stakeholders could view them as abstract entities—"a bunch of squares" on a screen that demand further clarity.

Lastly, Celeste sheds light on the difficulties encountered when seeking feedback from non-designers on lo-fi designs. The fundamental objective of such prototypes—to provide an initial conceptual design—often gets overshadowed by subjective perceptions of aesthetics. This perspective barrier prevents non-designers from providing useful feedback on functionality because they are too fixated on visual appearance.

> *"I think, also a lot of times non-designers don't know how to critique lo-fi work, because they'll be like, 'it doesn't look that good.' But it's not meant to look that good, you know. I think a lot of times people think in terms of like, 'oh, it looks good like that makes sense to me,' or like 'I've seen that before.' But if [the prototype is too] lo-fi, they can't refer to any of those familiar*

> *things, and so I think sometimes it's harder for them to gauge if it's what they wanted, you know." (Celeste)*

An important contextual backdrop amplifying this pattern is the prevalent results-centric culture in the industry. Surya comments on how working in a corporate environment altered his priorities as a designer to focus on "what you are delivering rather than how you deliver" because stakeholders only care about the outcome. This "bias towards action" is echoed by Nadia, who notes that the nature of working in a fast-paced environment with "agile" practices is about shipping and iterating fast, often opting for quick approaches that get features out the door first, like A/B testing over usability testing. Our findings suggest that in some corporate contexts encountered by our participants, there is a tendency to prioritize tangible outcomes, possibly overlooking the intrinsic value of the design journey.

According to our participants, this inclination towards high-fidelity designs can also extends beyond client interactions in their respective environments. Within some design teams, particularly in agile and fast-paced environments, there can be an impatience for quick refinement and a tendency to bypass the explorative stage of lo-fi work. Celeste encapsulates the sentiment, revealing the delicate balance between the need for exploration in the design process and the pressure to quickly settle on a refined direction:

> *"We were working in a start-up so it was very fast paced. No one was interested in what I had to do lo-fi, everyone was just like, okay, well, just show it to me in a more finished version, so I can give critique on it. [...] there's that task of needing to translate why what you're doing in your design sprint is important, and almost a need to justify each day that you take up in a design sprint, and it's harder to do it with lo-fi work because people are getting antsy and being like, 'oh, okay, well, we just need to settle on a direction and just move forward with it, so that we can have something a little more refined.'" (Celeste)*

4.4 How educational and generational differences of designers can impact their prototyping choices

When asked about what nurtured them into becoming the designers they are today and how it influenced the way they prototype, our participants cited educational and generational backgrounds as influential factors that shape their perception of the value of traditional design methods. In this section, we explore how differences in designers' backgrounds can impact their choices of prototyping media and their receptiveness to learning new skills and tools.

Regarding educational background, students with technical, non-art backgrounds may find it challenging to appreciate the value of traditional design methods, such as paper prototyping. As Lucinda, an experienced designer and educator, notes, "People who don't come from a design background tend to gravitate to tools that present a higher fidelity look and feel to their wireframes," highlighting the discomfort these individuals experience with more abstract, low-fidelity methods like sketching. This sentiment is echoed by Bernard, another HCI educator, who observed a split in student attitudes towards content in HCI curricula, noting that some view low-fidelity prototyping as "arts and crafts" and not suitable for computer science students.

Generational differences can also affect designers' prototyping choices. Lucinda mentioned that generational gaps at Metro Software, a company with both "lifers" and young, junior employees, may lead to varying levels of comfort and familiarity with digital tools, such as Figma and FigJam. She observed that younger designers often prefer using digital tools like FigJam for real-time collaboration, while older designers might "refuse to use the tool" due to their unfamiliarity or resistance to adopting new practices.

To address the diverse educational and generational backgrounds of designers, HCI educators can strive to establish explicit links between course modules and real-world case studies, highlighting the practical value of the methods and tools being taught. Bernard found success in this approach by interviewing industry practitioners and discussing their design challenges and processes in the context of the course material, stating that he tried to "align it to something that we taught in that module." By demonstrating the applicability of various prototyping methods, educators can help bridge the gaps between designers' backgrounds and foster a shared understanding of the value of different prototyping approaches.

In summary, educational and generational differences can impact designers' prototyping choices. While educational backgrounds shape initial preferences and comfort levels with various prototyping methods, generational influences bring a dynamic shift towards digital tools. However, a focus on teaching in-demand skills and emphasizing the practical value of different methods can help bridge these gaps.

4.5 The influence of professional maturity on designers' adoption of intuitive and experience-based practices

In the early phases of their careers, designers we interviewed often reported adhering strictly to the formalized methods they've been taught, following them with a meticulous rigor. Nadia's experience serves as a telling example, highlighting how she leaned heavily on paper prototyping during her initial internships since that is what she had "learned to be useful" through her formal education at a design bootcamp. However, the experiences of the designers interviewed suggest a possible transition as they navigate through the challenges of the industry. Some designers may shift from this stringent adherence to formal methods towards more pragmatic, experience-driven approaches. The real-world demands of the industry, coupled with the need for speed and higher fidelity outputs, often necessitate this change. Lucinda's perspective encapsulates this evolution, stating how designers frequently find themselves compromising, "bending to stakeholder" needs.

One of the most evident manifestations of this shift is observed in prototyping methods. Initially, low-fidelity prototypes, like paper prototypes, are revered for their utility in exploring and validating initial concepts. However, as designers grapple with industry needs that rarely require ground-up solutions, the reliance on such low-fidelity prototypes can diminish. Some of our interviewees mentioned a preference for "mid-fi" prototypes that, while richer in appearance, lean heavily on established design patterns and systems:

> *"In practice it's pretty difficult to find an opportunity to use lo-fi just because there's so much context already for the work that we do. There's rarely a situation where we're trying to build something from scratch." (Nadia)*

Indeed, our interviewees reported that with ample industry exposure, they developed a sort of "product sense"—an innate understanding of how to solve design problems based on patterns and strategies they've seen or employed before. This intuition serves as a proxy for the initial explorative phase, often making low-fidelity prototyping seem redundant. Nadia's illustrates product sense as a knack that "comes with experience over time"—with a strong grasp on fundamental design concepts and enough repetition, designers "develop a sense for how to approach solving a problem." Jolene's experience further reinforces this point, hinting at how experience in the design realm can sometimes preempt the need for traditional explorative methodologies:

> *"I don't know if it sounds egoistic to say this but it's just because I've been working in this industry for quite a while... So there's not a lot of point for me to just start with lo-fi [prototypes] again [for exploring the solution space], so I just start with mid-fi right away." (Jolene)*

In essence, the experiences of our interviewees suggest an ongoing evolution in their approaches. While the foundation is laid by formal methods and rigorous processes, the real-world intricacies of the industry, combined with accrued experience, guide designers towards a more adaptable, intuitive, and often pragmatic approach to problem-solving.

5 DISCUSSION

We discuss the implications of our findings within the context of remote and hybrid work environments, technological advancements, and the evolving landscape of digital-first design tools. We delve into how these trends can influence collaboration, the creative process, and the bridge between HCI education and practical UX/UI design skills, while also considering the broader ramifications for prototyping practices in both digital and physical product design.

5.1 Implications of digital-first prototyping on the design of prototyping tools

Our interviews suggest a tendency among our participants to start the prototyping process directly in a digital medium using Figma. This preference for digital-first prototypes appeared to be influenced by: (1) the increase in remote and hybrid work arrangements, and (2) technological advancements resulting in some intrinsic advantages that digital prototypes have over their physical counterparts. As digital-first prototyping becomes more common, more considerations will need to be put toward designing digital prototyping tools that optimize for remote collaboration and preserve the ability of physical prototypes to focus designers' attention on functionality rather than visual appearance.

5.1.1 Digital prototypes in hybrid work environments. The preference for digital over physical prototyping media among our interviewees aligns with the wider discourse on remote work, where digital tools have played a crucial role in fostering better collaboration, communication, and efficiency, removing geographical barriers and enabling asynchronous collaboration [37]. To this end, the design of future prototyping tools should continue to improve the experience of sharing prototypes and providing feedback both in real-time and asynchronously with remotely located design and non-design stakeholders.

However, given our limited sample size of 10 designers and the recency of pandemic-related work-from-home requirements (our interviews were conducted 8 months after employers in BC, where most of our participants resided, were no longer required to allow remote working arrangements), we cannot make a definitive statement on the future of work arrangements in the software industry [7]. Furthermore, since all our participants are currently based in North America, the status of our findings around remote work might be localized to the geographic scope of our participants. Notably, though, our study found that design workflows and habits developed as a result of remote and hybrid work could persist into the future because they appear to be agnostic of work arrangements. This is highlighted by our findings in Section 4.1, where designers indicated that their teams would brainstorm, design, and share work directly on their laptops, even when they were meeting with each other in-person. A re-evaluation of the prototyping landscape after more time has passed will allow us to take a more definitive stance on the long-term outlook of hybrid work arrangements in the software industry for designers, and the corresponding role of digital-first prototypes.

5.1.2 Digital prototypes can be cheap, simple to use, and conducive to rapid iteration, but might lack in exploratory potential needed for early-stage prototypes. Past research indicates that paper prototyping is an effective method for early-stage prototyping because of cost effectiveness, simplicity, and ease of iteration [41, 49, 52]. Based on our participants' perspectives, improvements in digital prototyping tools like Figma seem to have reduced some of the advantages that paper prototyping once offered.

From a cost perspective, Figma has a freemium model so that designers can pay for only as much functionality as they need. The no-code interface allows designers to build visually high-fidelity prototypes with sophisticated interactions without requiring any development effort. From a simplicity perspective, designers noted in Section 4.2 that Figma has reduced the number of tools they need, so there are now fewer tools to learn how to use. They also describe how digital prototyping tools have made it easier for designers to build out initial prototypes digitally since they can leverage ready-to-use components and templates from design libraries. From an ease of iteration perspective, digital prototyping tools allow designers to easily copy and paste over work from a previous iteration of a feature and build on top of it.

One key benefit of paper prototyping, however, still stands. It is outlined by Janelle in Section 4.2—working in a physical medium allows designers to slow down and focus more on function over visual appearance. Nadia mentions in Section 4.5 that in industry, building from first principles is not very common because there is usually a lot of context surrounding the work being done. Rather than starting from scratch, designers are usually tasked with making iterative improvements to existing features that already have well-established design patterns to follow. However, in cases where designers do need to build from first principles, such as in the case

of building a new app or completely redesigning a feature, going back to traditional prototyping methods with physical media may be helpful because they force designers to slow down and "filter out...appearance elements and focus on filtering in functionality and interaction flow" [26]. In these scenarios, physical prototyping methods might be more conducive to the creative exploration traditionally fostered in the early design stages [4, 28]. One tool, Balsamiq, sought to foster this experimental ethos in a digital medium, but as pointed out by designers in our study, it is not commonly used among them, with these designers opting for Figma instead. Some designers noted they sometimes create digital lo-fi prototypes or "wireframes" by moving around basic shapes in Figma despite it being "inefficient"—future work can explore enhancements to Figma via plug-ins that will allow designers to better replicate the analog sketching and paper prototyping experience in a digital medium to help facilitate creative exploration, while still keeping the sketches digital so it doesn't take designers out of their digital design workflow.

5.2 Bridging the gap between HCI education and UX/UI design skills

Research by Gray found that the ability of designers to understand fundamental design principles was far more important to companies than knowledge about how to use specific software to produce prototypes [17]. This notion that a deep understanding of design theory is more valuable than hard skills is logical - Figma is just a tool that facilitates the work designers do. That said, from our findings in Section 4.4, some participants felt unprepared going into their first UX/UI design job in industry because they felt that they didn't have a grasp of the "practical" skills needed to succeed in the role. Furthermore, the HCI educators we spoke to mentioned that in their combined 15 years of teaching, students seemed more receptive to learning design concepts when these were linked to practical skills.

Even if industry-specific tools change, the foundational principles of design remain largely consistent [36]. Hence, paper prototyping still has its time and place, such as in teaching core foundational design concepts and principles like "fit" and to "filter out…appearance elements" to focus on functionality and interaction [26, 31]. However, to strike a balance and fill the gap in HCI education with respect to incorporating more industry-relevant practices and tools, exploring different means of teaching prototyping for different scenarios may help better engage students and prepare them for the workforce. For example, it may be valuable to create design exercises that mimic scenarios a designer working in industry today would face - access to a design library with premade components, context of an existing interface to build on, and a task to make an incremental improvement to an existing feature. By using a combination of traditional paper prototyping and digital prototyping approaches, not only would HCI education provide learnings on how to facilitate the creative, exploratory process of building from first principles, but it would also equip junior designers such as those in Section 4.4 with the practical skillset needed to transition into industry UX/UI design roles.

5.3 Prototype fidelity by designer use case: Communicating with business stakeholders, exploring the design space, and conducting usability tests

Our findings in 4.3 suggests that there appears to be an inclination among some companies towards emphasizing speed and clear communication, potentially influencing designers to lean towards producing visually high-fidelity prototypes early on in order to appease business stakeholders. This seems to align with Dix and Gongora's notion that externalizations in design for the purpose of interacting with others require a "shared taxonomy" so that there is a "common point of reference" on which critique can be based [13]. In communicating with business stakeholders including internal management teams and external clients, the "shared taxonomy" is the high-fidelity visual dimension of the prototype because it resembles the final user interface that stakeholders can look at, understand, and offer critique on. Due to precedence of business needs in industry, within the context of our study, producing visually high-fidelity prototypes to help communicate with business stakeholders appears to be the most notable use case.

However, skipping over low-fidelity prototypes doesn't necessarily imply a best practice or reflect the attitudes of all designers. Some designers, such as Janelle in Section 4.2 "can't imagine designing without sketching." The sketches here are externalizations for the purpose of interacting with oneself, and do not require a common ground since the goal is to help the designer understand the design space better by communicating it to themselves [13]. When designers find the time and it makes sense for their design deliverable, it may still be preferable for them to do exploratory work by themselves with a low-fidelity prototype.

Paper prototypes were traditionally defined as tools for conducting usability tests on end users with the Wizard of Oz approach [49]. Our study, however, did not adequately capture the state of prototypes for usability tests in industry. Future studies can help fill in this gap, but based on our limited sample, there are indications of several factors that might influence the less frequent use of prototyping for usability testing in certain industry contexts than in academia. First, in Section 4.1, Nadia points out that in a remote work setting, conducting usability tests online can be challenging due to the accessibility or technical issues that may arise, in addition to dealing with low-quality feedback from monetarily-incentivized participants recruited from the popular online usability testing platforms (UserZoom, User Interviews). Second, in Section 4.3, our participants note that the corporate expectation for efficiency may lead to a preference for feedback mechanisms that allow features to ship more quickly, such as A/B testing. In comparison to A/B testing where the designer can propose two designs for developers to implement and gather telemetry on, usability testing may take longer due to the time it takes to devise a test plan, recruit participants, conduct tests, synthesize results, and iterate on designs. However, these are only inferences based on a small sample size of 10 participants as to why usability testing seems less common in industry contexts - future larger-scale studies are needed to confirm or refute these claims.

5.4 Beyond On-screen Software: Prototyping for Physical Products and 3D Interactions

The perspectives shared by our interviewees indicate a preference for digital-first prototypes within software design in their specific contexts, but the application of these findings to the realm of physical products and 3D interactions necessitates further exploration. Physical product design often necessitates physical prototyping, where the tactile experience, sense of scale, and real-world functionality are key evaluative parameters. Fabrication technologies such as 3D printing have revolutionized prototyping practices, enabling rapid manufacturing of physical artifacts [32, 33]. However, the physicality of these products introduces challenges not found in on-screen software design. These encompass material considerations, manufacturing constraints, and ergonomic factors. Simultaneously, the rise of AR/VR technologies presents new opportunities and challenges for prototyping 3D interactions. Research and development for prototyping in this space are vibrant, with digital tools offering promising capabilities such as virtual reality-based prototyping [24, 25]. As these tools mature, they could potentially bridge the perceptual gap between the digital and physical realms, opening up new frontiers in the prototyping practices of physical products and 3D interactions.

5.5 Spectrum and dimensions of fidelity

The dichotomy of lo-fi versus hi-fi prototypes in our study could be seen as an oversimplification. In reality, the fidelity of a prototype is a multi-dimensional concept [28], encompassing not only visual and interactive fidelity but also data fidelity and platform fidelity [9, 30]. For example, a prototype could have a lo-fi visual design but use real-world data, making it high in data fidelity. This spectrum of fidelity is often overlooked in practice, with designers defaulting to either lo-fi or hi-fi without considering the nuanced implications of various fidelity levels. Participants in our study indicated increasing incentives to bypass lo-fi prototypes, but it's worth questioning whether this viewpoint would persist if other dimensions of fidelity were taken into account. For example, would a prototype that is lo-fi in appearance but hi-fi in data or platform fidelity still face the same dissonance in expectations among stakeholders? Further investigation is needed to answer these questions and provide a more nuanced view of prototyping practices.

5.6 Ethical and Creative Implications

The ascendancy of reusable design components also presents ethical and creative conundrums that warrant consideration. By prioritizing speed and efficiency, we might be inadvertently curbing the originality and uniqueness that is core to the design process. This begs the question, are we sacrificing creative diversity at the altar of standardization? The advent of a ubiquitous set of design libraries could potentially homogenize design outputs, stifling innovation and differentiation in UX/UI design [4]. Furthermore, the ethical implications of using third-party templates and components, as highlighted by Jolene, could lead to potential issues around intellectual property [10]. Lastly, the emerging role of generative AI in interface prototyping [20, 29] could further intensify these dilemmas, reaffirming the need for a nuanced discourse on the evolving prototyping practices.

6 CONCLUSION

In synthesizing our findings, we explore the potential dynamics that can influence the prototyping practices of the designers within the contemporary software industry. Insights from our interviews suggest that the interplay of hybrid work environments, advancements in digital tools, and shifting attitudes and experiences of designers could be influencing their prototyping preferences and practices in various ways. Our research indicates components that can contribute to a preference for digital-first prototypes and a diminishing appeal of traditional low-fidelity methods among the participants, such as the need for seamless collaboration, communication, and efficiency in increasingly remote and hybrid work settings. Furthermore, participants in our study indicated that the advent of all-in-one digital tools, such as Figma, has helped streamline their workflows and contributed to a personal shift towards high-fidelity prototyping, spurred by corporate expectations for visually appealing prototypes and fast-paced development cycles.

These findings invite a critical examination of the design industry's trajectory, provoking a dialogue on balancing efficiency with the reflective essence of traditional design practices. The preference for visually refined designs over the design journey illuminates a potential tension between process and product, hinting at the need to reeducate stakeholders about the inherent value of design processes. Meanwhile, the increased reliance on reusable components and intuitive practices calls into question the prospect of homogenized design outputs, raising important considerations about innovation and creativity in design. As the industry continues to evolve, these findings offer a timely reflection on current practices, fostering meaningful discussions about the future of design, the essence of prototyping, and the evolving role of designers in the industry.

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A INTERVIEW QUESTIONS

A.1 Ground Rules/Ethics Protocol

(1) Please confirm that you understand and agree to this interview being recorded for research purposes.
(2) Would you like your identity to be anonymous in the final paper?
(3) Please be aware that you may pause, stop, or opt not to answer any question at any time.
(4) Do you have any questions before we start the interview?

A.2 Demographic Background and Lo-fi Prototyping Experience

(1) Could you introduce yourself a bit more?
(2) What is your educational background?
(3) What relevant courses have you taken?
(4) How many years have you been in the industry?
(5) How many years have you been in your current role?
(6) What are your job responsibilities?
(7) How would you define lo-fi prototyping?

A.3 Lo-fi Prototyping as a Pedagogical Tool

(1) Can you recall your first introduction to lo-fi prototyping and the methods you learned?
(2) What resources did you utilize to learn about lo-fi prototyping?
(3) How did you decide what you needed to learn?
(4) When did you first learn about lo-fi prototyping?
(5) What do you perceive as the purpose of lo-fi prototyping?
(6) What specific methods or tools did you learn to use?
(7) What was your initial attitude towards lo-fi prototyping methods?
(8) In your opinion, did learning about lo-fi prototyping assist you in your first design role?
(9) Do you find any advantages in learning with physical versus digital tools?
(10) How do you stay up-to-date with design trends, new tools, and new methods?

A.4 Lo-fi Prototyping Methods as a Design Method

(1) Could you describe your prototyping process in detail?
    - What are your goals? (exploration, communication, iterative development, evaluation)
    - What medium do you use? (physical, digital)
    - What dimensions do you focus on? (appearance, functionality, interactivity, data)
(2) Is there an established process you follow? If so, could you describe it? If not, why not?
(3) Have you noticed differences in the prototyping process between different companies?
(4) How is your product team structured and how does it affect your design processes?
(5) Is lo-fi prototyping an essential part of your design process?
(6) Do you think there's an industry standard for prototyping tools?
(7) Do you think there's an industry standard for lo-fi prototyping?

A.5 Impact of the Pandemic on Design Work

(1) Can you share how often you were working remotely before, during, and after the COVID pandemic?
(2) Who decides your working arrangements and what do you anticipate for the future?
(3) How did the pandemic alter your design process, specifically with respect to lo-fi prototyping?
(4) Can you discuss any challenges of collaborating in a remote or hybrid environment, specifically related to prototyping?

A.6 Closing

(1) Do you have any final questions for me?
(2) Please confirm receipt of your honorarium of C$40.
(3) Can you recommend any other designers who might be willing to participate in this study?
(4) Thank you for your participation and time.