RESEARCH-ARTICLE

"Chaotic, Exciting, Impactful": Stories of Material-led Designers in Interdisciplinary Collaboration

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"Chaotic, Exciting, Impactful": Stories of Material-led Designers in Interdisciplinary Collaboration

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Abstract

This paper explores the dynamics of interdisciplinary collaboration between designers, scientists, and engineers through ten stories as told from the perspective of material-led designers. These stories focus on material-led designers working in contexts like biodesign and smart textiles, where novel materials, fabrication methods, and technology often intersect, requiring cross-disciplinary collaboration. By including perspectives from designers within and adjacent to HCI, the study broadens the understanding of interdisciplinary teamwork that combines scientific, technical, and craft-based expertise. Our analysis highlights how designers navigate challenges like differing terminologies, epistemic hierarchies, and conflicting priorities. We discuss strategies such as material prototypes, attitudes of inquiry and openness, switching lexicons, and the value of interdisciplinary contexts. This research underscores designers as "translators" who mediate epistemological tensions, use tangible artifacts to communicate, and articulate possible applications. This research contributes ten stories as narrative resources for understanding strategies and fostering interdisciplinary spaces within HCI.

CCS Concepts

• **Human-centered computing → Empirical studies in interaction design**.

Keywords

material-led design, design research, materials, interdisciplinary collaboration, stories, design stories, narrative inquiry

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1 Introduction

In a recent piece published on their Substack, Elise Elsacker, a biodesigner with decade-long experience in bio research labs, reported still feeling like the "odd duck" among their scientific peers, constantly needing to prove themselves in experimental contexts to make up for their lack of official scientific training [23]. Elsacker also explains that their process as a designer relies on "prototyping, failure, and iteration," approaches that do not fit within the strict protocols of scientific experimentation. Yet, they argue it is precisely this trial-and-error approach that is best suited to working with living materials, which do not have linear or sequential growth patterns. Elsacker writes:

> "What makes the designer's role so crucial here is the recognition that living materials demand more than just scientific rigor–they require an empathetic framework that respects the autonomy and adaptability of the organism. ...Scientists may map an organism's genetic blueprint or perfect the growth medium, but designers excel at weaving these insights into holistic systems and envisioning real-world applications that resonate with human values and practical needs."

This tension between scientific rigor and the iterative, creative process of design is a feature of interdisciplinary collaboration. Designers, particularly those working in material-led design, often find themselves navigating between scientific, technical, and craft-based knowledge. In Human-Computer Interaction (HCI), this is especially apparent, as designers collaborate with anthropologists, artists, scientists, engineers, and others to propose new interaction techniques, build systems, and create artifacts. Recent trends in HCI have highlighted sustainability and innovation through interdisciplinary collaborations, particularly with biologists, chemists, and material scientists. This has resulted in innovative biomaterials that offer novel methods for fabrication and interaction, such as bioclay for 3D printing [8], bioplastics [38], biofibers [42], dissolving wearables for interactive textiles [43], sensing fibers [47], mycelium-based biocomposites for off-the-shelf electronics [29], and grown materials for interative devices [7, 46, 60], to name just a few. While these collaborations yield exciting possibilities, they also come with challenges, particularly around epistemological differences, disciplinary cultures, and divergent goals [1] These differences affect not only methodologies but also assumptions about what constitutes meaningful and valuable knowledge. For example, scientists may resist design contributions that prioritize aesthetics or user experience over scientific rigor. Engineers might dismiss design ideas that appear impractical or that challenge established technical standards. These tensions complicate collaboration, but also create opportunities for growth and negotiation.

Existing research on interdisciplinary design in HCI has provided valuable insights into formal collaboration contexts, such as residencies and workshops [22, 35]. However, there remains a need for a deeper understanding of how designers collaborate in more unstructured, informal contexts, especially when working with material innovation and novel fabrication methods. This paper seeks to address that gap by exploring the stories of material-led designers working within and adjacent to HCI. It approaches interdisciplinary collaboration explicitly from the perspective of designers, foregrounding their experiences, interpretative strategies, and material practices in navigating these complex settings.

Our research makes three contributions: (1) ten stories of material-led designers (including the first two authors) based on retrospective narrations of their lived experience of interdisciplinary collaborations. We retold their stories and present them as narrative resources to shed light on the dynamics of collaboration designers shared and the contexts in which these dynamics unraveled; (2) the analysis of these narratives from which we identified key epistemological tensions and strategies employed by designers to navigate divergent disciplinary languages and priorities; and (3) a reflection on the role of material-led designers as "translators" who mediate between disciplines and use material artifacts as means of communication and inquiry. In doing so, this study contributes a nuanced understanding of interdisciplinary design practices, focusing on how material-led designers contribute to and navigate the complexities of collaboration.

Additionally, this paper reflects on the role of design in these interdisciplinary spaces, highlighting how designers provide important interpretative skills to technical projects, conducting translation between disciplines and between research environments and artifacts that live beyond the lab. While this might seem obvious to designers, our study shows that these translational abilities were often unknown to the scientists and engineers working with the designers we spoke to.

2 Related Work

2.1 Stories and Storytelling in Design and HCI Research

Stories have long served as a methodological and epistemological foundation in design and HCI research, enabling the exploration and dissemination of situated, experiential knowledge. They unpack less reported yet common experiences in design, such as failure [34], painful memories [21] or regret [3]. Similarly, through storytelling, researchers and designers have communicated reflections [2], design processes [20], and speculative futures [11, 31]. Common storytelling techniques in HCI and design research include personas [36, 50], scenarios [14, 66], design fictions [4, 10], epics [9, 18], memoirs [21], and other speculative approaches [57, 62], which help explore design possibilities. Many of these approaches contribute to relate experiences that are otherwise messy, unbound, and open to transformation [19, 54].

Like prior work in HCI and design research that emphasizes storytelling as a method to share stories that are embodied and subject to memory, the stories designers shared with us are retrospective reflections [5] in which memory makes some aspects of an experience more distinct than others. This idea of retrospective reflection has been used in first-person retrospective methods for various purposes, such as teaching audiences how to listen to data [65] rethinking failure in design research [34], or reflecting on the complex temporalities of design events [48]. In our study, the stories we share are intimate retellings of the day-to-day realities of working within interdisciplinary spaces like biodesign and smart textiles, where novel fabrication methods and material innovation play central roles. These stories were grounded in lived experiences and immediate realities, and shed light on the mechanics and dynamics of collaboration, enriching our understanding of how interdisciplinary design unfolds in practice. They document the strategies designers use to contribute and communicate within these contexts, emphasizing their engagement with tangible materials and artifacts. By capturing these situated experiences, we use narrative inquiry as an orienting framework to interpret the data and draw insights, which we discuss further in Section 3.1.

2.2 Material-led Design in Biodesign and Smart Textiles

In this study, we refer to material-led design as design practices that foreground a hands-on approach, which in some instances mean materials informing the design process; the development of new materials or fabrication techniques; how users experience materials or actively engage in the making of tangible objects or prototypes. In this context, biodesign, smart textiles, biofabrication and digital fabrication are good illustrations of material-led design, where designers explore new materials, develop novel types of fabrication methods or interactions with materials, and build artifacts and systems.

Biodesign and smart textiles are growing areas of interest within HCI where designers often collaborate with experts from fields such as biology, chemistry, materials science, or engineering. These collaborations often focus on developing innovative materials and technologies, such as biobased materials for 3D printing [6, 52], biofibers and ecothreads for smart textile applications [42, 67], polymers for shape-changing or interactive fabrics [24, 25, 64], and technologies to enable fiber fabrication processes [42]. These efforts simultaneously address the challenges posed by material innovation, fabrication workflows, and design processes [33].

In biodesign, for instance, designers frequently engage with living or biobased materials that introduce unique challenges due to

[1]Epistemology concerns how knowledge is defined, acquired, and validated. As such, it varies across disciplines.

their inherent variability and sensitivity to environmental conditions [61]. Prior research in HCI highlights the iterative, exploratory approaches required to integrate biological materials into design, as well as the negotiation of scientific constraints and functional, aesthetic, and cultural goals [37]. Similarly, smart textiles research involves embedding interactive properties—such as conductivity, color, and shape change—into fibers and fabrics. This requires balancing technical performance with tactile qualities like texture and weight while addressing issues like sustainability and production scalability [16, 30].

While prior research on biodesign and smart textiles has explored technical innovations and application-specific challenges, less attention has been paid to the nuanced, real-world dynamics of interdisciplinary collaboration, particularly in less structured, informal settings. While formal collaboration contexts, such as residencies and workshops, have offered valuable insights [22, 59], there remains a need to better understand how designers collaborate in unstructured or informal contexts, emphasizing the role of material agency and the negotiation of shared vocabularies as they work through challenges of material innovation and fabrication methods. By focusing on stories of material-led designers working within or adjacent to HCI, we aimed to broaden the insights gained in our study.

2.3 Interdisciplinarity in Design and HCI

HCI has historically been a highly interdisciplinary field, with its roots spanning computer science, cognitive science, engineering, and design. Similarly, design has long operated at the intersection of multiple disciplines, addressing "wicked problems" [51] and fostering collaboration across disciplines. Frameworks like participatory design and research-through-design (RtD) emphasize stakeholder engagement and iterative, artifact-driven inquiry, respectively [56, 62]. These frameworks are amenable to interdisciplinary work because they foster collaborative approaches that allow for diverse perspectives to inform the design process, creating a shared space for negotiation and mutual learning among stakeholders from different fields of expertise.

While interdisciplinary collaboration often foregrounds the frictions between divergent epistemologies, prior work has also shown that science and design share commonalities in how knowledge is constructed through practice. Gaver articulates this difference through the lens of accountability: scientific knowledge is judged by the question "how do you know what you say is true?" and depends on epistemic validity, whereas design is evaluated through aesthetic accountability, understood as the coherence of formal, functional, and cultural concerns within an artifact (the basic question being "does it work?") [28]. In this framing, design knowledge proceeds through situated experimentation, "productive indiscipline," and a tolerance for ambiguity. Despite these differences, both fields involve making: they rely on material engagements, interpretive practices, and situated judgments that shape what counts as knowledge. This view is highlighted by Latour and Woolgar's study of the processes that make up scientific life [41]. Their work argues that scientific facts are constructed through local practices and material inscriptions. As such, scientific activity "comprises the construction and sustenance of fictional accounts which are sometimes transformed into stabilised objects" [41, p. 235]. In this sense, we argue, scientific knowledge production begins to resemble design–not only in its dependence on materials and situated judgment, but in its reliance on performances of credibility and shared understanding. Together, these perspectives suggest that interdisciplinary collaborations between designers and scientists are not so much about bridging distinct epistemologies, but about navigating overlapping practices of (and approaches to) making. By recognizing the constructedness of knowledge in all disciplines–in labs and in studios–we open space to appreciate how designers contribute not only through translation or aesthetics, but as epistemic agents whose practices are grounded in the same entangled processes of iteration, interpretation, and fabrication that shape scientific work.

Despite this, challenges persist, such as the "translation work" needed to reconcile differing terminologies, methodologies, and priorities across disciplines [12, 17, 63]. Growing fields like biodesign and smart textiles compound these challenges, requiring the integration of science, technology, and craft expertise. For example, biodesign demands collaboration between designers and biologists to develop sustainable materials [44], while smart textiles combine engineering, material science, crafts, and design to create interactive textiles [49]. For instance, Lazaro et al. developed gelatin fibers collaborating with chemists in an Advanced Textiles department (ITA in RWTH Aachen) [42], and Guridi et al. developed cellulose-based optical textile sensors collaborating with a biomaterial and a microelectronics researchers at the VTT's photonics laboratory [32]. These examples show how cross-disciplinary collaboration is essential to come up with innovative approaches to biodesign and smart textiles in HCI, as it brings together diverse expertise to bridge the gap between material innovation and functional application. However, despite these successful outcomes of collaborations, much remains to be understood about the dynamics of such teamwork, particularly in informal or less structured environments where the process is less defined, and the integration of knowledge from different fields can be more fluid and iterative.

3 Methodological Approach

3.1 Origins and Evolution of the Research

This research project emerged from personal reflections and dialogues between the first two authors (Gabrielle and Eldy) about our own experiences of interdisciplinary collaboration in HCI projects. These initial discussions shaped the study's direction and prompted us to explore similar dynamics across a broader community of material-led designers. Rather than positioning ourselves as detached researchers, we recognized the value of our own experiences as entry points into understanding the complex dynamics of interdisciplinary collaboration.

Our study evolved from these personal narratives to include the perspectives of other designers, creating a more comprehensive understanding of collaborative practices in material-led design. By incorporating our own experiences alongside those of other designers, we adopted a first-person research approach [27], which acknowledges the value of researchers' lived experiences while seeking to extend insights beyond the individual.

3.2 Narrative Inquiry as Methodological Framework

Through analysis of our initial conversations and subsequent interviews, narrative inquiry emerged as the most suitable framework for understanding the dynamics of collaboration [17]. Narrative inquiry values lived experiences and co-constructed meaning through storytelling, aligning with our objective of exploring not only the practicalities of collaboration but also the temporalities, motivations, challenges, and contexts of designers' experiences.

Our (first two authors) narrative approach unfolded across three tiers: it began with our own lived experiences as designers (first-person, "my experience"), which we put in dialogue through discussions and by interviewing each other (second-person, "your experience"), and ultimately expanded to the voices of other designers through additional interviews (third-person, "her/his/their story"). This progression from introspection to dialogue to collective conversation was intuitive to us and allowed us to situate individual experiences within a broader community of practice:

(1) **First-person narratives:** Our own reflections as co-authors on our collaborative practices;
(2) **Second-person narratives:** First two authors interviewing each other and writing each other's narratives to put our experiences in dialogue;
(3) **Third-person narratives:** Interview with external designers about their experience.

Rather than blending these perspectives into a singular voice, each step built upon the previous one, layering insights to form a textured tapestry of voices that collectively reflect the complexities of interdisciplinary collaboration in design. This approach enabled us to create a conversation space where our experiences could be both subject matter (with other designers) and analytical lens (for their own stories). This approach best captured the relational and dialogical nature of the study, allowing us to have conversations with material-led designers as fellow practitioners rather than assuming the stance of researchers vis-à-vis their "subjects." As material-led designers ourselves, this study was framed through the orientation of our own practice. Following Ahmed's understanding of orientation as a way of inhabiting and making sense of the world [1], we approached the study from a particular understanding and practice of materials, and saw that this sensibility shaped the way we received and interpreted the stories shared with us. While our stories and those of our participants emerge from specific domains such as biodesign and smart materials, we believe that the material-led design perspective can be of use to other designers navigating interdisciplinary contexts, as we understand design to always be dealing with the particulars of specific artifacts, services, or events [45]–and as such, with questions of "matter" in the broadest sense.

3.3 Participant Recruitment and Selection

A total of 10 participants were included in the study, consisting of eight external designers and the first two authors. External participants were selected to represent diverse experiences in interdisciplinary design collaboration, particularly in developing new materials or fabrication techniques common in fields like biodesign and smart textiles. These areas were chosen for their intersection with HCI research and their inherently interdisciplinary nature. The recruitment happened via email, and the selection process aimed to include diverse perspectives across career stages (e.g., graduate students, postdoctoral researchers, instructors, and practitioners). We contacted nine designers in total, who agreed to participate, though only eight could schedule an interview within the study's time frame.

3.4 Data Collection

All interviews were conducted virtually via Zoom. Gabrielle developed a semi-structured interview guide, which was piloted with Eldy. This initial "proto-interview" between the first two authors served two crucial purposes: it led to slight refinements in our interview questions to better capture insights into collaboration dynamics, and it provided us with first-hand experience of the narrative-sharing process we would later facilitate with participants.

The semi-structured format, which included a core set of questions for all participants along with flexibility to explore their experiences and perspectives, was consistently used throughout the study. Each interview lasted up to 60 minutes and was divided into three parts: an introduction and background, a storytelling segment focused on collaboration experiences, and a final reflection on the shared stories.

Regarding the researcher-participant dynamic, Gabrielle conducted the interviews, as she had limited prior knowledge of most participants' work, while Eldy, who had more experience with the participants' work, took notes and occasionally asked follow-up questions. Our own experiences were disclosed early on to participants to situate the conversations within a shared community of practice.

3.5 From Interviews to Narratives: Analysis and Story Construction

This study received Institutional Review Board (IRB) approval, ensuring compliance with ethical guidelines for participant recruitment, data collection, and management. All participants provided informed consent prior to the interviews, including permission for audio and video recording. Participants were assured of their right to withdraw at any time and the anonymity of their responses if desired. Two out of the ten participants (Alex and Lihua) requested to remain anonymous; as such, their name in this paper are pseudonyms, and identifying details have been altered or omitted to protect their privacy.

We employed open coding to analyze the transcripts, followed by reflexive thematic analysis [13, 15]. From this analysis, we conceptualized the following themes: material evidence; how science or scientists are perceived; strategies of shared vocabulary; the value of design or design contribution; contexts and dynamics of collaboration; access to resources and introduction to practices; and learnings.

After the analysis, we rewrote participants' collaboration stories for conciseness and to highlight key moments in the narratives. This editorial process transformed interview data into focused narratives that maintained authenticity while foregrounding pivotal moments in interdisciplinary collaboration. While participants were not directly involved in crafting their final narratives, this approach

	Title	Background	Affiliation
Eldy	PhD student	architecture, biodesign, HCI	University of Colorado Boulder
Irmandy	PhD graduated	electrical engineering, HCI	MIT Media Lab
Malu	Educator	surface and textile design, biodesign	Moholy-Nagy University of Art and Design
Sofia	PhD student	product design, biodesign, HCI	Aalto University
Alex	Postdoc	architecture, biodesign	Anonymous University
Lihua	PhD student	interactive design, electrical engineering, HCI	Anonymous University
Fiona	Postdoc	mechanical engineering, biodesign, HCI	University of New Mexico
Sam	Educator	critical studies, product design, biodesign	Amsterdam University of Applied Sciences
Alejandra	MFA in Design	fashion design, biodesign	University of California Davis
Gabrielle	PhD student	design research, digital fabrication, HCI	University of Washington

Table 1: Designers overview with title, background, and affiliation

allowed us to present their experiences with consistency and clarity while preserving their voices and perspectives. We also sent the final version of the narrative to the participants for their review and approval. To maintain methodological consistency across all narratives, the first two authors interviewed one another, wrote each other's narratives, and divided the analysis of external participants' narratives (four each).

Together, these varied perspectives contributed to a well-rounded understanding of collaboration dynamics in interdisciplinary design, situating their experiences within a broader context of design practices.

4 Interdisciplinary Collaboration Stories

In this section, we present the ten stories of the study.

4.1 Transactional Collaboration

4.1.1 Eldy's story. Eldy, a PhD candidate at the ATLAS Institute, University of Colorado Boulder, whose research focuses on biodesign and smart textiles, proactively reached out to a lab in Germany that worked with bio-based materials. Eldy was drawn to the lab's expertise in advanced textiles and their fiber production equipment, as she sought to transition from DIY methods (using syringes) to make gelatin fibers, to more advanced machinery that could make these fibers at scale. Eldy had been experimenting with gelatin to create dissolvable yarns that can be blended with conductive fibers for smart textile applications. Her goal was to develop dissolvable bio-based yarns that could integrate with conductive fibers for smart textile applications. Eldy made contact via email, framing the collaboration around mutual interests in smart textiles and sustainability. She traveled to the lab in Germany for a 2-month residency. However, while the German lab appeared intrigued by the novelty of hosting a design researcher from the US, there was a lack of clarity in defining mutual expectations for the collaboration. The German team approached materials with a more engineering-driven mindset, focused on exacting specifications and applications. Eldy's design-oriented perspective prioritized iterative experimentation and material-driven discovery, creating initial communication gaps. Eldy also required hands-on training to understand the equipment and the chemistry behind gelatin fiber wet spinning, which the lab hadn't anticipated would demand as much of their time and resources. Additionally, the lab's approach to sustainability, defined as working with *bio*materials that were not necessarily readily biodegradable, contrasted with Eldy's vision of eco-friendly, dissolvable fibers. Eldy observed that in design, applications often come out of experimentation and material exploration and are not always specified from the get-go. The tension between these perspectives became a focal point, with Eldy adapting to align with the lab's way of working while still pursuing her material-centered approach. As a result, misaligned expectations emerged as a major obstacle. Eldy reflected that, "At the beginning, they didn't grasp a hundred percent what the collaboration was gonna be about." The lack of mutual understanding stemmed partly from differing vocabularies and priorities. This gap was partially bridged through material prototypes and hands-on demonstrations. Eldy recounts showing them the material samples she had brought with her and that moment being "a key point for them to see that it's possible" and "to move forward and plan out" with them how to use their equipment and run the experiments she needed to do.

Given the short timeframe of the collaboration (2 months), Eldy eventually adjusted to their way of working, asking mostly technical questions to make things work. She resigned to the more, in her word, transactional nature of the collaboration. Through the process, Eldy learned useful technical skills and knowledge, such as viscosity testing and fiber spinning parameters, which enriched her project. She applied this knowledge to build a smaller, custom fiber-spinning machine back in her home lab in the US. But while Eldy gained valuable expertise, she recognized the collaboration was more one-sided, with the German team receiving less clear, direct benefit. During our conversation, Eldy noted the importance of clarifying expectations and leveraging tangible prototypes to bridge disciplinary divides in future collaborations.

4.1.2 Analysis. Eldy's story of collaboration reveals key themes about navigating interdisciplinary work, particularly between engineering-driven approaches and design inquiry. In particular, these themes highlight the challenges of managing expectations and of developing a common vocabulary. For instance, Eldy's background in design emphasized iterative experimentation with materials, which contrasted sharply with the engineering team's precise, applications-oriented methods. Throughout the experience, Eldy relied on adaptability to navigate the complexities of the collaboration and remained perseverant despite things not going as planned. "There were days where it seemed like it was going nowhere... I just kept having failed experiments." Success eventually came through towards the end of her short stay at the lab, including crucial advice from a postdoc that enabled Eldy to refine the spinning process. Flexibility also proved vital, as Eldy adjusted expectations and methods to better integrate into the engineering-driven environment. The short timeframe of the collaboration however forced her into a more transactional mode, with the exchange being more technical and one-sided than she would have hoped.

4.2 Entering the Collaborators' World

4.2.1 Irmandy's story. Irmandy tells a story that centers on his interdisciplinary collaborations, particularly his work on two interactive textile artifacts: a fabric keyboard and a carpet that controls sounds for dance performance. Irmandy's story shows the importance of letting collaborators express their expertise, while simultaneously entering their "world" to further the project. Irmandy, an electrical engineer by training, pursued a PhD at the MIT Media Lab to merge his technical background with a passion for textiles, design, and interactive art. He became involved in projects that bridged engineering and creative practices, focusing on making textiles interactive and expressive. Early on in our conversation, Irmandy described his work as "solving a problem." For his fabric keyboard project, his collaborators included performing artists, such as keyboardists, dancers, and sound artists, whose needs and feedback shaped the direction of his work. The fabric keyboard aimed to create a portable, tactile musical instrument that responded to the constraints of professional keyboardists. The other project, the "magic carpet," sought to give dancers agency over music, reversing the conventional dynamic where movement follows sound. Through ongoing conversations with artists, Irmandy gathered insights that informed his designs, which were rooted in both material experimentation and technical feasibility. He worked with dancers and keyboardists, who brought deep domain expertise in performance, while Irmandy contributed technical knowledge. When asked what were the most important aspects of interdisciplinary collaborations, Irmandy replied "understanding each other and each other's limits, and also expertise. What [my collaborators] are capable of." This capability-focused approach to collaboration meant that Irmandy worked hard to enter "their world" and being able to "work in their language." For instance, he learned about music software sound artists used to understand how they mapped notes. "I mean, that's not really my job in the end. That's their job. But I also need to know how it works ... so that they can map whatever they want [using my system]" Irmandy explained. He also extensively tested his magic carpet himself, initially because the pandemic meant he could not test it with dancers. But this lead him to better understand the tactile and auditory feedback in an embodied sense. This hands-on engagement not only helped him adapt the design to meet the dancers' needs but also enriched his understanding of how tactile feedback could shape performance. He noticed that this personal engagement helped him build a personal vocabulary that later improved communication with the dancers.

4.2.2 Analysis. Irmandy's account of interdisciplinary collaboration reveals his role as a kind of "director," navigating complex and distributed creative processes while holding the vision of the project and enabling his collaborators to share their expertise. Understanding the constraints (time, resources, knowledge) of his collaborators, as well as their expertise was key in developing the artifacts of the fabric keyboard and the magic carpet. "They [the artists] have limited time, so you need to prepare well, so that when they come you can solve other types of problems" explained Irmandy. Part of that preparation came from being flexible, or rather on having the flexibility to "put yourself in the shoes of the performer or the musician [his collaborators]." Preparedness therefore came through learning more about the collaborators, and taking the time to understand their world: their language, their needs and concerns. His approach to interdisciplinary collaboration emphasized good communication and the recognition of each collaborator's expertise –something that is not a given in every project, as the following story shows.

4.3 Proving Oneself

4.3.1 Malu's story. Malu's story reveals a subtle but recurring tension about establishing the value of her contributions in the face of deeply ingrained perceptions about the authority and expertise of scientists.

Malu's journey as a designer began in surface design and textiles but later shifted to circular biomaterials, particularly algae, which became a key theme in her work. After completing a Master's in biodesign at Central St. Martins in London, and working as a freelance biodesigner, she now works at the Innovation Center of Moholy-Nagy University of Art and Design in Budapest (MOME). During our conversation, Malu reflected on the social perception of scientists as inherently more knowledgeable and authoritative, which creates an implicit, or even internalized, power imbalance in collaborative settings: "[There's] this idea that the people that have the data, or the hardware [have the knowledge]... I always had this idea that people who are working on scientific topics are smart; they know things. They are the inventors." One story illustrates this tension vividly: a scientist who initially worked for a few hours (Malu estimates four hours) on Malu's algae-focused design project later expressed frustration when the project gained media attention, feeling that their contribution had not been sufficiently acknowledged. The scientist helped Malu in a few experiments, but did not get involved beyond that. Their anger indicates the difficult position of Malu in the project: at once leading the conceptual and creative aspects of the project and her perceived need to justify her contribution in interdisciplinary collaborations. Malu often found herself in the position of "ask[ing] [scientists] for help", when what she was seeking was more of a collaborative exchange. This dynamic reinforced her sense of being the "no-so-clever one," despite leading the material and conceptual explorations of the project. The impression of navigating epistemological hierarchies that privilege technical expertise over design's experiential and narrative contributions can lead to tensions on both sides. This experience led Malu to question the boundaries of collaboration and the criteria for attributing credit, especially when design contributions often involve reimagining existing knowledge rather than creating new data. It was a stark reminder that the role of design can be undervalued or misunderstood, even as it generates excitement and interest in a niche topic. The challenge of not having her contributions fully acknowledged highlighted the difficulty of "proving oneself" in a space where technical expertise is seen as making more tangible contributions.

4.3.2 Analysis. Malu's story reveals a nuanced struggle to assert her contributions in collaborative settings while navigating the implicit hierarchies of interdisciplinary work. Despite leading the material and conceptual explorations of projects, she often felt the one-sidedness of the collaboration dynamics with scientists. "My own experience has been that scientists enter these [interdisciplinary] spaces with more skepticism. ... They feel more like they're doing you a favor" explains Malu. Reflecting on what she learned from these collaborations, Malu emphasized the importance for designers not to devalue their own capabilities and contributions, highlighting that it would have changed everything if the collaboration had been seen as beneficial for the scientists as well, which they did not fully acknowledge until the project garnered media and public attention. The challenge in establishing the value of design contributions might partially come from the fact that these interdisciplinary environments between arts, design, and science are uncommon in Malu's experience: "there isn't much funding for this type of collaboration. It almost does not exist, and you have to really squeeze the design in there, as you know."This scarcity of opportunities, coupled with the confusion as to designers' role, shows the ongoing challenge for designers of asserting their value in these spaces.

4.4 Being in the Middle

4.4.1 Sofia's story. Sofia's story of collaboration finds her in the midst of an interdisciplinary nexus, balancing diverse expectations across engineering, material science, and design. Her narrative highlights the unique challenges and opportunities of being a "middle woman," navigating the intricate interplay of methods, goals, and epistemologies from different disciplines. Sofia's story highlights the intellectual value of being "in between" disciplines, where she navigates the complex interplay of engineering, material science, and design. Her role as an epistemological translator is key—organizing workshops, clarifying terminology, and fostering shared understanding to align diverse goals and methods across disciplines.

Trained as a designer, Sofia's early work in Fab Lab Santiago, in Chile, alongside architects, engineers, and textile specialists sparked her interest in interdisciplinary smart textiles. Now Pursuing her PhD at Aalto University, she collaborates across departments including chemical engineering, electrical engineering, and machine learning, supported by four advisors with varying priorities. Her work on sustainable smart textiles often requires her to build vocabulary across disciplines while translating design's exploratory approaches to each scientific colleagues.

One illustrative story of collaboration underscores Sofia's role as facilitator. During her first official experience as a designer on an interdisciplinary project, she joined a team of material scientists and a physicist who were developing optical fibers. During that project, Sofia encountered significant misunderstandings over terminology: "They were using the words fibers, but then would use yarn, and I was using, I don't know, threads. They're similar words that did not mean the same for any of us." To bridge these gaps, Sofia organized a hands-on ideation workshop, using cards to map material properties and applications. This exercise not only clarified misconceptions, but also develop a shared understanding and vocabulary for the project. This effort not only resolved communication issues but also helped align the team's goals, and acted as an introduction for the scientific collaborators to design methodology (ideation workshop).

While this story is an example of successful facilitation, Sofia grapples with the emotional and intellectual labor of navigating conflicting expectations, and juggling various disciplinary priorities: "I feel like I'm always pushing it more than them. ... It often feels like it's only me, the one who wants this to happen. ... And that's very tiring. I'm not sure how to improve it. It's an emotional charge too." Sofia shared learning from an older mentor how to "make a point" and navigate tricky moments when her contributions are not fully understood or acknowledged. While it might not alleviate the kind of emotional labor described by Sofia, it shows that designers feel the need to find ways to continually communicate the value of their work.

4.4.2 Analysis. Sofia's narrative reveals that creating contexts to develop a shared vocabulary is an effective tactic for creating common understanding and navigating the challenges of interdisciplinary collaboration. In our conversation, Sofia described her role as the designer within her team: " I've been proposing new roads, new [directions]. I question a little bit more, I imagine a bit more. And then I bring [the research] to real life. And they [the scientists and engineers she works with] are always telling me: it's nice because you bring the stuff out. We can have [the samples] in exhibitions. People can touch them, we can use them. It's like important to have that step." The "very concrete" contribution of "the materials and creations" were crucial in manifesting not only the labor of the designer, but the labor of the scientists as well –to bring the research "to real life." Sofia's story also underscores the emotional and intellectual labor this concretizing work involves, highlighting the strains of having to constantly justify and explain the contributions of design.

4.5 The Interdisciplinary "Bubble"

4.5.1 Alex's story. Alex, a postdoctoral researcher at a university in Europe, works in an inherently interdisciplinary environment where collaboration between designers, bioscientists, and architects is routine. Her journey also exemplifies how interdisciplinarity was built into her work early on. Alex started as a student in architecture, with a focus on sustainability. During her Master's program, she encountered the emerging field of biodesign, working with living systems like bacteria and fungi, which sparked her interest. This passion led to a PhD exploring a specialized process with bacteria and, subsequently, to her current work, which integrates biology, hardware, and software to manipulate living materials during growth and explore novel materials.

Alex's research group exemplifies interdisciplinary collaboration, consisting of bioscientists, designers, and architects who work side by side in a shared space. "We work very closely together," explains

Alex. "We share the same lab, we collaborate on projects and we're quite aligned under that theme." This collaborative environment fosters mutual learning, as designers adopt scientific rigor while bioscientists develop visual and conceptual communication skills. "We're probably the only lab that has a photography suite with cameras and lights and things, because [the research] is not just being right on the science. It's also about how we communicate it. " In Alex's view, the inclusion of a photography suite complements scientific rigor with effective storytelling. This dual setup ensures that the research isn't confined to technical accuracy but is also communicated in visually compelling ways that resonate with diverse audiences. This approach aligns with her lab's broader objective of fostering interdisciplinary work and making complex research understandable and have more impact.

This environment enables all sorts of productive explorations and novel research directions, even when they appear like failures at first. Alex recalls a time when she and a scientist were growing cellulose, and the scientist initially dismissed a sheet as a failure. But Alex noticed intriguing patterns in the material and, after further discussion, discovered that temperature had influenced its formation. "This is something we can work with," she thought, and they proceeded to explore how temperature control could be used to manipulate pattern formation in the material. "It wouldn't have come up if we weren't collaborating together," Alex reflects.

Alex's story highlights the importance of interdisciplinary environments, scarce enough that they feel like a "bubble," in Alex's words. In this rare environment, ideas flow freely, and the group embraces a culture of experimentation, whether it leads to failure, success, or sparks entirely new directions for grants or papers. While such seamless collaboration is extraordinary in its openness and creativity, it also underscores how uncommon this level of interdisciplinary synergy is, making Alex's lab an exception rather than the norm.

4.5.2 Analysis. Alex's interdisciplinary environment, where designers and scientists collaborate side by side in shared labs, enables her to bypass traditional hierarchies of expertise. No longer needing to convince or prove herself –unlike some of the previous stories– she can focus on helping set up research agendas and exploring novel directions. This setup fosters mutual learning, as designers adopt scientific rigor while bioscientists develop visual communication skills or remain open to new interpretations of success in the lab. By embracing "failures" as opportunities for exploration, Alex's team has discovered new avenues for investigation, such as controlling temperature conditions to create unique patterns in living materials. Collaborative environments like this are empowering to designers, but are also, in Alex's own words, "bubbles": rare settings where interdisciplinarity is fostered from the get go, with ample time and space to develop shared vocabularies.

4.6 Balancing Creativity and Technical Expertise

4.6.1 Lihua's story. Lihua is a PhD student at an American university who shared how her journey as a designer led her to recognize the importance of technical expertise in supporting her creative work. Thus, after graduating she transitioned to a role as an electrical engineer in a product design company. "I noticed that I need to get more skills in the electronic side to support all the work I want to create" she explained. There, Lihua emphasized the dual development of looks-like and works-like prototypes in the early stages of the design process, where the looks-like prototype focuses on visual design (shape, texture, and ergonomics) and is created using tools like 3D printing, or laser cutting. The works-like prototype, on the other hand, involves functional testing and is built using breadboarding, often leveraging open-source hardware like Arduino for ease of programming. One example that illustrates this balance is when Lihua worked on a project with an all-female team to design a wearable device to relieve menstrual pain. She described how the team collaborated to create a small, disc-shaped device, saying: "We had several rounds of iteration, and we were able to produce this very small disc-shaped device which comes with a skin-safe adhesive that can be replaced and to be directly applied onto the skin." On the technical side, Lihua explained that the device included features for controlling different vibration patterns. To refine both its functionality and usability, the team tested and experienced how the device felt on their bodies. This example illustrates how looks-like and works-like prototypes complement one another in refining both the form and function of a product. Lihua described her current work as sitting between design and engineering, explaining how her lab fosters diverse interdisciplinary collaboration. "For one student, their project might be more technical... versus one that would be more design-focused. For me, I'm kind of sitting between" she explained. Her technical foundation enables her to more effectively realize open-ended and exploratory projects, where outcomes are not solely about solving problems but about exploring possibilities: "I feel that the engineering and the tech is really enable the creation of the ideas I have." One clear example of this is her current work with textile fabrication, where she uses weaving as a primary method. While the process is manual and slower compared to more rapid prototyping techniques like 3D printing, Lihua values the time it gives her to "work with the material" and build a deeper connection with it. This slower pace allows her to explore the material's properties and experiment with different outcomes, rather than focusing solely on achieving a quick, defined solution. For instance, she gives herself "more room for different sizing and shifting the outcome" during the fabrication process, embracing the natural fluidity of materials. This flexibility allows her to find new possibilities in design and push the boundaries of what she can create –but only because she spent time investing in developing her technical skills.

4.6.2 Analysis: Lihua's collaboration stories highlight how her position between design and engineering offers her the freedom to explore open-ended outcomes and currently, engage more deeply with materials. She doesn't frame this space as a conflict but rather as a fertile ground for experimentation. In her current work with textiles, for example, she finds the slower, manual process of weaving to be a space rich with exploration and material interaction. This pace allows her to experiment with material properties, shift outcomes, and uncover new possibilities in design. Her technical expertise supports this approach, enabling a more thoughtful, material-led process. Lihua also made a distinction between design as "problem-framing" and engineering as "problem-solving" which adds depth to her current iterative, material-led research approach.

This framing also highlights adaptability in addressing technical constraints. Furthermore, her stories show how her lab environment enables this balance between creativity and technical outcomes. For instance, she shared that when facing technical challenges, she benefits from a range of perspectives offered by her peers, who might suggest either technical solutions or creative pivots. "Some people would provide really technical suggestions... and some might give me suggestions on how to pivot the design approach to compensate the technical difficulty." These experiences highlight her ability to collaborate and integrate others' perspectives into her work.

4.7 Materials as Middle Ground

4.7.1 Fiona's story. Fiona, a postdoctoral researcher in the department of Computer Science at the University of New Mexico, transitioned from studying mechanical engineering to focusing on biodesign during her PhD, carrying forward her interest in materials. Reflecting on her journey, she shares: "Materials are really interesting because they connect everyone and everything together; they're always going to be interdisciplinary; everyone uses them in different ways." This became evident during her collaboration with a ceramics artist, whose focus for a clay-based 3D printing biomaterial was aesthetics, while Fiona's was sustainability. Tension arose when the artist suggested adding sand to Fiona's current recipe to improve strength, as it wasn't good enough to support the desired aesthetic designs with 3D printing. Fiona rejected this idea, explaining, "sand isn't bio-based... it wouldn't align with my definition of a biomaterial." Later, Fiona realized the critique pushed her to rethink her approach: "At first, I was crushed. But it made me think outside of my own constraints, beyond the narrow scope of my research. It made me realize that I wanted to create a material that could be used in practice." As they discussed possible material compositions, Fiona mentioned her past experience with calcium carbonate, a bio-based mineral that can be found in eggshells. Fiona recalls, "It was really interesting because I was drawing on my past knowledge of biomaterials, while the artist was looking at concrete and the ingredients needed for strong materials. Calcium carbonate happened to be like one of those cool, overlapping moments where we were like, 'Oh, this could actually work."' This realization led them to use eggshells as a local, sustainable source of calcium carbonate, providing a solution that met both their functional and sustainability goals. Through this process, Fiona found a way to create a biomaterial recipe that bridged the technical and creative, showing how their shared understanding of materials allowed the collaboration to move forward productively.

4.7.2 Analysis. Materials play a crucial role in developing a common language across disciplines by serving as a shared reference point. In Fiona's collaboration with the ceramics artist, their differing focuses were reconciled through discussions centered on material properties. The artist's need for a stronger material to support aesthetic design led to the recognition of calcium carbonate, which, when sourced from eggshells, met Fiona's sustainability goals. This "overlapping moment" allowed them to bridge technical and creative concerns, illustrating how materials facilitate productive dialogue and enable diverse perspectives to converge in a common solution.

4.8 Adapting Language to Create a Shared Understanding

4.8.1 Sam's story. Sam is an educator and researcher at the Amsterdam University of Applied Sciences, with a background in product design and critical studies. Her work in biomaterials and critical making integrates chemistry into design education and industry, highlighting her interdisciplinary approach. A key aspect of Sam's work is adapting language and methods to bridge gaps across different fields. For instance, Sam invited two chemistry teachers into her lab to show them how she incorporates biomaterials, like agar, into design projects, to teach design students about biomaterials. One teacher was hesitant about how to engage with design students who lacked a chemistry background, while the other was more open to experimenting and learning through trial and error. This collaboration succeeded, requiring Sam to constantly "scan" different vocabularies–navigating between the language of product design, textiles, chemistry, and engineering. "It's constantly about scanning different indexes," Sam said, reflecting on how challenging it is to translate students' creative design questions into the technical language needed for chemists to respond effectively. Sam's approach to this challenge involves helping students refine their questions before reaching out to experts, making the inquiry more specific and clear. She recognizes that building a mutual understanding and vocabulary with scientists is a gradual process. "You're building a safe space to creatively discuss things," Sam noted, emphasizing the importance of patience and trust in interdisciplinary work.

4.8.2 Analysis. Sam's story highlights key challenges and strategies in interdisciplinary collaboration, such as how effective communication is crucial for bridging disciplinary gaps. By helping design students refine their questions and fostering a shared vocabulary, Sam navigates the tension between designerly and scientific perspectives. By ensuring there is space for open dialogue, Sam navigates the tensions between different epistemic contributions, emphasizing patience and mutual understanding as keys to successful collaboration.

4.9 Everybody Needs to Have a Voice

4.9.1 Alejandra's story. Alejandra graduated with an MFA in Design from University of California Davis, where she led the interdisciplinary project Mycotextile Futures, bringing together designers, biologists, engineers, and even veterinary scientists to explore mycelium as a binder in textile composites. As the project coordinator, Alejandra was responsible for "keeping the entire project in her mind", which posed a challenge as each collaborator entered the project with their own interests and ideas. Despite these varied perspectives, Alejandra's belief in collaborative leadership, where everyone has a voice and something to contribute, guided the process. She understood that while the project required clear boundaries, it also needed room for flexibility. "You need to have a container of what you want and what you don't want, but leave room for things to evolve," she says. A challenge in balancing team input with project objectives arose, but Alejandra navigated this by listening to everyone's ideas and assessing their alignment with the project's goals. "If you invite others to participate and just want to follow the plan, it kind of becomes a dead project," she says. While not every attempt led to a successful prototype, these "dead ends" were still valuable, providing new insights and fostering the shared context of the team. Initially focused on combining biofabrication and bioremediation, the project shifted toward lab testing, prototype creation, and contributions to a materials library. Alejandra viewed these changes as part of the exploratory process, not as failures. Alejandra emphasized the importance of ensuring that everyone involved had something to contribute and something to gain from the project. "What are you getting from the project, and what are you bringing?" she asks. She encouraged her collaborators to define their roles and participation, whether that meant being involved in decision-making or focusing on specific tasks.

4.9.2 Analysis. Alejandra's approach to collaboration effectively bridges disciplinary gaps by emphasizing the value of every team member's unique expertise. The metaphor of the container is apt here: as the project coordinator of Mycotextiles Futures, Alejandra recognized the importance of holding space for ensuring that all voices were heard and that everyone had something to both contribute and gain. Alejandra's strategy of maintaining clear boundaries while allowing for flexibility created an environment where ideas could evolve. She encouraged collaborators to define their roles, ensuring involvement aligned with their interests and expertise. By fostering this mutual exchange, Alejandra not only guided the project but also cultivated a shared sense of ownership and growth.

4.10 Aligned Collaboration

4.10.1 Gabrielle's story. Gabrielle is a Ph.D. student in the department of Human Centered Design & Engineering at the University of Washington, with a background in comparative literature, and a research focus on design methods and digital fabrication research. Her collaborations illustrate how context and shared enthusiasm can foster organic, interdisciplinary teamwork. Her collaboration with a software engineer, started when he approached her with an idea to use Observable–a JavaScript-based computational notebook–to interact with a CNC machine. Despite not having a background in programming, Gabrielle was able to contribute valuable insights based on her hands-on experience with the CNC milling machine. The collaboration was fluid because both Gabrielle and Andy [name changed for submission] were equally excited about the project, and their different expertise allowed them to quickly implement their shared ideas. "It was so fun to be able to work with someone and be like, let's make this... and immediately have ideas... on how we can start implementing it," she says. On another project, in the context of an art class, Gabrielle collaborated with an electrical engineer on a biosensitive poetry composition device. She led the project by coming up with the concept of the device, and created elements of the device like a breathing sensor, managing aspects of physical computing. However, some parts of the project, such as calibrating the sensors to filter out noise, required her collaborator's advanced technical expertise. Gabrielle noted that attempting to tackle these specialized tasks herself would probably have involved a steep learning curve that would have significantly slowed their progress. She recognized the need to delegate these responsibilities to her collaborator to ensure efficiency and precision in the work. This experience shows the importance of division of labor and trust in a teammate's specialized skills, especially under time constraints. For Gabrielle, the key to these successful collaborations lies not only in the complementary skills of the participants but also in the context in which the collaboration occurs. She highlights how important it is to be in an interdisciplinary environment from the outset –a lab, a class–, as this primes everyone to be open to new ideas. "The context is so important. These people were also primed by being in a context where interdisciplinary collaboration was sort of, if not happening de facto, strongly encouraged," Gabrielle reflects. In contrast, she notes that in more traditional research labs, where people are often entrenched in their specific domains, interdisciplinary collaborations can require more effort to initiate.

4.10.2 Analysis. Gabrielle's stories of collaboration show that success often hinges on the excitement and openness of the participants, but more importantly, the context in which they come together. She reflected that it might take longer to convince others to step outside their usual boundaries, and this can slow down the process in a collaborative project. "In my experience, I've never had to do any convincing. The people were already on board, and it made it extremely like not just pleasurable, but also a lot smoother," she shared. Gabrielle wishes that more opportunities existed for these kinds of collaborations, where people with different expertise and ideas can meet and explore possibilities together, especially to make complex artifacts. These interdisciplinary environments are not just beneficial but essential for fostering creative breakthroughs that are enjoyable and rewarding for everyone involved. Gabrielle sees her collaborations as inherently fun and rewarding. "When people [from different disciplines] meet, it's like they can just make really cool things, and it's fun for everyone," she says.

5 Discussion

The ten stories in this paper shows how material-led designers not only navigate interdisciplinary environments but actively reconfigure them–through their roles, the artifacts they make, and the meanings they cultivate. Across these narratives, we encounter multiple visions of design: design as problem-framing (Lihua), as relational space building (Alejandra), as interpretation (Sofia), as translation (Sam), and as proposition (Gabrielle). As approaches to design shifts, so do the role of the designer: from apprentice to facilitator (as in the story of Sofia), from translator to project lead (as in the stories of Alex and Malu), revealing not a fixed role but a flexible, adaptive posture shaped by context, collaborators, and materials. These situated stories offer resources for rethinking the designer's position in interdisciplinary collaboration.

Our analysis surfaces a multiplicity of roles and approaches, and as such contributes to a broader recognition of how designers define their contributions through the work of design itself. In some cases, like Alex's, the structure of the lab supported an empowered position from the outset; in others, such as Malu's or Eldy's, the designer had to assert their value against prevailing assumptions of scientific or technical authority. The stories thus reclaim the value of interdisciplinary practice not only as a context in which design work unfolds, but also as a site of epistemic negotiation—and articulation—on the role of design. Gaver's account of different forms of accountability in design and science [28] highlights that these negotiations are not about justifying the role of design (or science) but about understanding the particular functions that different approaches bring to the table. The rest of this section articulates what some of these approaches are, based on the stories that were shared with us. draws on these insights to articulate three interconnected claims about interdisciplinarity, communication through materials, and the interpretative nature of design.

5.1 Framing Design as an Interpretative Discipline

In a 1995 essay, Klaus Krippendorf shares his concerns that design discourse is "easily discountable," especially in the context of interdisciplinary collaboration with 'harder' disciplines [40]. Krippendorf's argument is that the discourse of design is not grounded in a textual canon, like most sciences, but in material artifacts, which cannot be articulated the same way text is. This lack of discursive grounding, at least in the traditional sense, tends to deligitimize the contribution of design, which is expressed not in text but in things. Krippendorf therefore calls for a "science *for* design" (our emphasis), which would address the "problematic of articulating artifacts in a language that includes their stakeholders," i.e. in a way that makes explicit the meaning (or value) of (designed) artifacts to the users. In other words Krippendorf highlights the need to develops means to make explicit the value of *material contributions*, perhaps especially in the contexts of interdisciplinary collaboration and research, where both the legacies of text and science form the grounds of epistemic authority. The designers we spoke to walk a fine line between technical research and meaningful artifacts and applications. They develop something akin to what Lucy Suchman calls a *configuration,* "a device for studying technologies with particular attention to the imaginaries and materialities that they join together" [58].

What is highlighted here, in Krippendorf's and Suchman's observations, but also in the designers' stories, is that the tension between these two poles–text and things, materialities and imaginaries, matter and meaning–is the fine line designers have to walk. The designers whose stories we shared in this paper also work to join together materials and imaginaries. But whereas materials are often understood as stable realities defined by their properties (a view of materials which is being increasingly challenged in design and HCI [26]), imaginaries are situated and relational phenomena that require interpretation. Material-led designers who build artifacts and systems, develop new materials, or conceive novel interactions or fabrication processes, are aware that the "meaning" of what they build is a dynamic, evolving property of the relations between humans and human-made things [54, 55]. For this reason, we consider material-led design as an interpretative epistemology, that is a way of knowing the world which centers the act of interpretation as the locus of meaning. Specifically, design approaches support *material* interpretation and below we highlight the differing challenges and distinctive situations of the participants and how they navigated them.

From their narratives, this interpretative nature of design is evident in the way materials acted as bridges across disciplinary divides. Materials served as shared reference points for fostering dialogue, as illustrated in Fiona's collaboration with a ceramicist artist. By reconciling sustainability goals with aesthetic priorities, their discussions about calcium carbonate highlighted how material properties create "overlapping moments" where diverse perspectives converge. Similarly, Alex's recognition of the aesthetic potential of an experimental "failure" led to new research directions. Without the ability to step out of the rigid experimental protocols, this opportunity for material innovation would not have occurred. Gabrielle emphasized the importance of open and enthusiastic collaboration contexts, where participants willingly step outside their usual boundaries to explore possibilities. Her experiences show that creating these spaces can enable collaborative breakthroughs that are not only productive but also enjoyable. Interdisciplinary collaborations can be joyful, especially if all parties involved remain curious and open to other methods and approaches. Malu described how the relationship with the scientists she worked with turned a corner after she presented material samples and the project gained media attention: "It was really interesting to see how, in the long run, their perception change once you have something appealing to show." Malu could use her skills of material and conceptual translation to bring something to the table that brought a "sparkle" to the scientists' eyes. Sofia's work of bringing research to real life through tangible prototypes similarly helped bridge disciplinary gaps and validate the role of design within scientific contexts. Their stories highlight the emotional and intellectual labor involved in fostering mutual understanding. Collaboration also relies heavily on shared vocabularies and the negotiation of roles. For instance Irmandy's role as a "director" required understanding collaborators' constraints and expertise, preparing carefully and developing an appreciation for their unique needs. This contrasts with Eldy's more transactional collaboration, where a short timeframe limited deeper exchanges and required her to quickly adapt to engineering-driven expectations. These narratives reveal the potential for material-led design to provide critically informed, relationally expansive perspectives on new materials and their applications. However the challenges in fostering interdisciplinary understanding persists, as evidenced by Sam's efforts to refine communication and bridge epistemic divides, and by Alejandra's deliberate "container" approach to ensure every team member's expertise was valued. Alex's experience in a lab designed to facilitate interdisciplinary collaboration further illustrates the importance of context: her ability to bypass traditional hierarchies and foster mutual learning stemmed from an environment that explicitly supported epistemological diversity. These stories also suggest an invitation for researchers to nurture more opportunities for such collaborative spaces, both in HCI and beyond. While HCI has historically contributed to making technological systems more accessible and meaningful, this bridging work requires deliberate (even institutional) support, time, and recognition of interpretative traditions as integral to innovation. By supporting epistemological tensions and creating environments where interpretative and technical traditions coexist, HCI can expand the range of interests and concerns addressed by emerging technologies.

As Koskinen et al. note, "collaboration has a long, though largely unwritten history in design" [39, p. 31]–perhaps because design work is not only inherently collaborative, but also plural in form, as these stories demonstrate. Interdisciplinary collaboration, in particular, requires what Poggenpohl describes as "a fluid situation in which improvisation and critical reframing are welcome" [53,

p. 142]. One clear lesson from this project is that there is no fixed script for working across disciplines. The designers we spoke with adapted to the specific constraints of their contexts by developing novel, often improvised strategies of communication. What unites these approaches, however, is their grounding in material practice—whether through prototypes, demonstrations, or shared engagement with making. In this way, materials become more than communicative tools: they are the very terrain on which mutual understanding is built.

5.2 How Materials Acted As Vectors of Shared Vocabularies

Several designers shared stories of having to "convince" their scientific collaborators of the relevance of their contribution. In this context, *material evidence* became crucial to communicate ideas, research directions, possible applications, and even argue the value of design contribution. The ability for designers to present physical prototypes and material proofs-of-concept to their collaborators proved crucial for enabling dialogue and getting scientists and engineers curious and enthusiastic, as was the case with Eldy, Lihua, Fiona, and Malu. For instance, it was when Eldy presented the gelatin-based fibers she made with her DIY equipment that her collaborators in the chemistry lab better understood her project and the possible applications. Similarly, Fiona used the bioplastics she developed to show to the various stakeholders within her department to gain insights and perspectives on how these materials could be used. Lihua created looks-like and works-like prototypes to communicate with collaborators and tackle challenges like integrating vibration mechanisms into wearable devices. These examples illustrate how materials and artifacts were used as focal points in collaborative processes, aiding communication and iteration across disciplines. Malu's material and conceptual explorations with algae organisms gained media attention that made her scientific collaborators more interested in the outcomes of the research than they had previously. Alex built custom vessels and bioreactors for her project, enabling new possibilities of interaction and visibility with the organisms her team works with.

In all of these examples, materials were not only the object of study but also the means through which designers were able to convey their vision and project. Designers want to make things and "reconnect the dots" and threads of research to assemble them into accessible artifacts or systems, to quote Malu. Alex explains that scientists often need the kind of translation work designers bring –between disciplines, and between research and the public. Without these abilities of transforming material research into artifacts and meaningful interactions, scientific and engineering research often "stays in the lab," according to Sofia. The ability to communicate both materially and conceptually requires technical and interpretative skills, as well as a spirit of inquiry and openness. Materials acted not only as evidence in the research and design process, but also as vectors of more expansive conceptual registers.

Designers, scientists and engineers have to find ways to understand each other to collaborate effectively. Part of that communication happened through material samples (prototypes, swatches, artifacts), which then acted as kinds of material evidences or arguments. But materials also acted in more subtle ways as vectors of richer vocabularies. That is, the very act of trying to understand other perspectives about materials often led to renewed understanding of the materials themselves, both in terms of their properties and possibilities. This process of acquiring more expansive lexicons about materials often took the form of preparation strategies, as in the case of Sofia reading papers from the labs she was collaborating with, seeking to familiarize herself not only with the research but the way her collaborators described materials and their processes. Another expression of this acquisition of shared vocabularies was a constant learning process, such as Irmandy learning music software to better understand the needs of musicians. Music, after all, was the material his collaborators manipulated in their work, and understanding how it could be modulated was a key aspect of his collaboration strategy. Yet another example is when Alex emphasized the importance of acquiring foundational knowledge to be able to work effectively with biologists: "The designers and architects in the group all have PhDs ... in this cross-disciplinary field or practice. So we all have kind of a basic understanding of what is possible." The understanding of material properties and biological processes not only helps the designers and architects in Alex's lab understand their scientific colleagues, but also understand the possibilities of what they can even design or propose as projects to their group. Similarly, Alejandra's emphasized the importance of understanding material science and engineering vocabulary when researching binders for composite materials. She described how she learned about concepts like bioplastics and binders used in the aerospace industry, which helped her bridge the gap between her design background and the technical expertise of scientists.

These instances also show that the process of acquiring these expanded material registers leads designers to perform a kind of constant translation work, or in the words of Sam, "scan through various indexes" to communicate with their collaborators. This process of translation demands an ability to listen and remain adaptable to new ideas, terminologies, practices, and even values. While this is not unique to material-led research in design practices, materials served as vectors of these kinds of conceptual expansions and understandings. Eldy's story, for instance, illustrates how different disciplines cultivate different vocabularies–her definition of biomaterial versus her collaborators–which can cause misunderstandings and set research trajectories on parallel tracks. Understanding what the scientists meant by biomaterials confronted Eldy to another way of conceiving of, and working with, materials. Sofia organized a workshop to address this situation, which helped not only clarify vocabulary for all the collaborators but also introduce scientists to design approaches like ideation and brainstorming workshops. The variations in a seemingly simple term like "fibers" proved to be a shaky ground on which to build a healthy collaboration between practitioners of different disciplines. The materials here provided the opportunity to reach a common ground and build stronger foundations for the collaboration. Finally, Fiona noted a significant learning curve in understanding 3D printing terminology when working with the artist in residence in her lab. The artist brought expertise in ceramics and aesthetic considerations, which at first Fiona was not familiar with, having been trained as a material scientist. Ultimately however, it allowed Fiona to expand her material vocabulary, and to consider materials through the lens of this newly acquired lexicon.

Taking seriously the role materials played in these encounters shifts how we understand both the process and the role of materials in interdisciplinary work. Materials do not operate within fixed timelines but introduce their own rhythms, pauses, and dissonances. These unfolding dynamics of both design and scientific research echo what Oogjes and Desjardins call Other-time and Temporal dissonance: moments that often collide with the linear expectations in scientific collaboration. In our study, designers repeatedly encountered such dissonances: Eldy's need to produce quickly in a constrained engineering context clashed with her desire to explore material nuance; Irmandy's careful orchestration of collaboration was itself a negotiation between diverse and asynchronous temporal demands; Alex's and her colleague's "failed" experiment. Attuning to these tensions reveals that design knowledge does not only emerge through communication about materials, but also through the *temporalities* that materials insist upon. Attending to how materials unfold across time *and* disciplinary vocabulary might give clues as to how collaboration dynamics cluster and manifest in and through materials.

If materials provided a common ground between designers, engineers and scientists, there remained the question of what kind of contribution designers were bringing to these interdisciplinary projects. In order to address this question, we turn to a discussion of the particular blend of technical and interpretative skills material-led designers combined in order to make rich contributions and lead the teams to new research directions.

6 Conclusion

At the end of each of our conversations, we (first two authors) would ask designers for three words they thought best captured their experiences of interdisciplinary collaborations. Designers shared words like: magic, understanding and flexibility (Irmandy); generative, hopeful and foundational (Fiona); curiosity, openness, making (Sam); or inspiring, richer, challenging (Sofia). We see now that these words capture many of the themes discussed in this paper: the need for flexibility and adaptability, the depth and breadth of working across disciplines and epistemologies, the tensions that arise when practitioners do so. In the end, we decided to keep Alex's words for the title of this paper, as we felt they most illustrated the mixture of possibilities and challenges inherent to interdisciplinary collaborations between designers, engineers and scientists. These collaborations are often *chaotic*, as they deal with varying terminologies, priorities, methods and sometimes even values. They are also *exciting*, bringing their fair share of challenges, learnings and growth, if collaborators remain open and curious. Finally, they are *impactful*. The designers we spoke with were almost unanimous on this: despite the challenges, interdisciplinary collaborations brought a depth and richness to the work that would not have been possible otherwise. This paper has offered a narrative-based account of interdisciplinary collaboration, centered on the lived experiences of material-led designers. Through ten stories, we identified the epistemic tensions, communicative strategies, and evolving roles that characterize such collaborations. Our analysis highlights materials as focal points for interdisciplinary dialogue and enable the development of shared vocabularies to work across epistemic approaches. Through this work, we contribute to a richer understanding of the role of design in interdisciplinary spaces: through translation, attunement, imagination, and material practice. We encourage designers to trust the epistemic value of their practice, not just as facilitators or communicators, but as thinkers and makers who offer indispensable ways of knowing. By recognizing and standing up for the unique contributions design brings, designers can help reshape the terms of interdisciplinary engagement itself.

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