The Material Practices of Collaboration

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ABSTRACT

Drawing on a three-month bookbinding apprenticeship, this paper examines how people's coordination work is tightly bound up in material practices, the union of material arrangements and social relations. Through the construction of a book, I reveal how sensitivities to delicacy, flexibility and delay emerge through detailed engagements with the book, the binders and the workshop environment. From small adjustments of the hand, to the coordination and exchange of materials and tools, the accomplishment of each task rests on how digital and age-old resources are woven into everyday collaborative practice. This approach extends how computer-supported cooperative work (CSCW) frames and mobilizes the material to recognize materials as compositional elements, surfaces and flows. It also contributes to conversations on digital materiality by emphasizing the temporality of material practice. Thus, I use the bookbinding workshop as a resource for understanding the ways materials, techniques, and relationships are continually re-bound in a digital age.

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Design, Human Factors.

INTRODUCTION

"Materiality is our physical engagement with the world, our medium for inserting ourselves into the fabric of that world, and our way of constituting and shaping culture in an embodied and external sense." [26:11] —Lynn Meskell

"In employing this term [materiality] I am not just trying to discuss materials and their processual properties [...] I am attempting to engage with the manner in which the material properties of things profoundly affect human conduct, both enabling and empowering people's lives and constraining them."[41:3]—Christopher Tilley

As material culture scholars, Meskell and Tilley illustrate the concept of materiality does not entail one set of ideas or approaches to the study of culture. Indeed a homogeneous and coherent theory of materiality may never fully surface. Yet over the last few decades, the concept of materiality has gained considerable currency in a variety of fields, including anthropology, sociology, archeology, museum studies, and even CSCW. By emphasizing the *ordering* capacity of things—the ways in which things enable and constrain action—researchers have used the concept of materiality to avoid the idealism that people interact in the world however they wish, independent of non-human actors [41].

For CSCW the lack of definitional clarity has helped sustain two analytical shortcomings. For one, materiality is taken as tantamount to physicality, a conflation that assigns material to a distinct realm of embodied or tangible interaction. As recent work has begun to address [4,7,31], treating material practice as a special case of CSCW places materiality a long way from the digital and risks overlooking important players in collaborative work. This treatment exposes the *trope of immateriality* [4] wherein digital information is denied its material form.

A second concern for CSCW is how we have elevated artifacts over the material—"the stuff things are made of" [19:1]. While we have usefully highlighted the social and functional roles of artifacts (paper, books, tools) [6,8, 12,14,15,39], we have also overlooked the constituents (the grain of paper or shine of plastic) and their continued mixing, changing, combing, and dissolving over time. As Suchman [37] and others have noted, treating artifacts as uniform actors belies their emergent and constituent nature. This view advances an *object-bias* wherein materials are attended to as fixed forms rather than as heterogeneous enactments. As we will see, this bias conceals the temporality of material with which we might effectively conceptualize collaborative practice.

Bringing together perspectives from CSCW [7,31,37], cultural anthropology [19,20,27,41], and STS [2,4,21,29], I offer material practice as an alternative analytical lens on collaborative work. In particular, I extend anthropologist Tim Ingold's notion of *circulatory flows* [19]—"the generative fluxes of the world of materials"— to suggest that materials not only enable and constrain action, they also unfold through collaborations with people, workspaces, and even each other. As I elaborate later, this perspective acknowledges "material" as part of human interactions in three ways: (i) as compositional elements; (ii) as surfaces; and

(iii) as spatial-temporal flows. Thus I weave together an understanding of material arrangements and social practices to consider how materials come to frame and constitute human action and understanding. Through this lens material is understood as *more* than the physical, encompassing the breadth of interwoven constitutive elements, and underscoring their formative and transformative nature [19,20].

The material practice perspective makes two central contributions to the CSCW literature. First it broadens our understanding of collaborative work by taking into account a heterogeneity of interactions. For example, it allows us to recognize what might appear to be individual activity as constituently collaborative, developing among materials, people, and workspaces. Second, this view advances discussions of digital materiality by emphasizing the emergent and improvisational nature of material relations. Collaborations are not fixed in time but extend over a broad range of temporal and spatial configurations. Together these contributions provide conceptual scaffolding for moving beyond the trope of immateriality and object-bias to consider what Miller calls "the large compass of materiality" [27:4].

In this paper I examine material practices through a three-month bookbinding apprenticeship. By exhibiting prolonged engagements with digital and non-digital elements, bookbinding illuminates the technical particularities of material. This approach draws on autoethnographic methods in HCI (*e.g.*,[1,16]) and Lave's recent account of apprenticeship in critical ethnographic practice: "*learning to do what we are already doing*" [22:156]. I thus use my own binding practice to understand the ways seemingly individual craft practices are actually part of collaborations with the book, the workshop and the binding trade, more broadly. Through the construction of a book, I reveal how sensitivities to delicacy, flexibility and delay emerge through detailed engagements with, and awareness of, particular qualities of the book: the grain of leather, the stiffness of cord and the evenness of glue. From small adjustments of the hand, to the coordination and exchange of materials and tools, the accomplishment of each task rests on how digital and age-old resources are woven into everyday collaborative practice. It is by taking part in multiple material interactions that I began to uncover the temporal patterning of cooperative work.

BACKGROUND

To set the stage for an analysis of material practices, I briefly examine how CSCW and craft scholars perceive the material. Specifically, I review key themes in the CSCW literature of relevance to this work—*handwork*, *paper*, and *systems design*—and basic notions of embodiment and material engagement. This review is necessarily partial, but is meant to foreground issues of long-standing interest to CSCW that motivate our theorizing of the material.

CSCW & materiality

A rich and varied literature in CSCW is already oriented toward the close examination of the material settings for collaboration. This work examines how tools, artifacts, and machinery are brought to bear in the practical accomplishment of a range of cooperative tasks, including passing and handing surgical implements [39], operating a steel plant [8], the codification of soil samples [14], the arrangement of clutter in the home [40], and the communication of knitwear design specifications [12]. Here the material refers primarily to the tools of the trade—drills, suction instruments, slabs of steel. While these studies attribute agency to people, other work has viewed humans and non-humans as symmetrical social actors, the actor-network approach [21] being perhaps the most familiar to CSCW. This work begins to push at the boundaries of what is considered material, but it rarely looks beyond the artifact to its constitutive relations.

Closely related to this work, a second theme in CSCW concerns the use of books, paper and physical documents. This includes Harper and Randall's [15] descriptions of flight strips in air-traffic control, Berg's [3] discussions of paper as a bedside technology, Mackenzie's [22] analysis of task cards in programming, and Sellen and Harper's [35] discussion of paper in office work. Here materiality is not connected to the digital or infrastructural layers of CSCW. Rather materials are enrolled circuitously: when a particular communicative breakdown arises [24], a request for information is made [35], or defects in operations emerge [3]. Thus, the material qualities of practice are considered critical only to some aspects of action and not others.

A third strand of CSCW research consists of the designer's perspective on material. Here we find Büscher's [6] extensive research on what she terms *palpable computing* helpful for considering how computing might be "available to the senses" through visibility, deconstruction, understandability, coherence, stability, user control and difference. Dix and others [11,42] have similarly attended to "physicality" by exploring the way artifacts, tools, and appliances can inform the design of more "novel digital and hybrid digital–physical artefacts" [11:1]. Although the concept of *affordance* (*e.g.,*[28]) has usefully called attention to the ways in which physical objects structure and inform practice, it has been treated with some caution in CSCW, as it sensitizes designers to the sociomaterial dimensions of artifacts as a matter of a perception rather than a matter of situated material engagement [17,39]. These explorations of "digital-physical artifacts" also maintain an ontological separation between atoms and bits, furthering the familiar trope of immateriality.

Altogether this prior work highlights the breadth of interest in material as well as some challenges for its theorizing. A growing number of CSCW scholars are working to overcome these analytical hurdles by looking beyond individual artifactual actors. Rattenbury *et al*. [31], for example, address the temporality of the material by turning to the metaphor of plastic, a concept they use to describe how mobile devices are integrated into everyday patterns of activity. Plastic time describes the temporal and spatial rhythms of "unplanned, opportunistic" interaction and how they fit into surrounding events. Their work thus makes an appeal to

concepts of materiality, which this work seeks to extend in more depth.

In another promising analysis, Chalmers and Galani offer the idea of "seamful interweaving"—the process by which perceivable differences between technological constituents become less important than "*the quality of interaction with the whole*" [7:244]. In their study of mixed reality system they found that people's understanding of the system emerged as part of interconnections between multiple media. Emphasizing the importance of heterogeneity, they suggest designers attend to the diversity of actors in different "modes" of interaction. The material practice approach advanced in this paper furthers this view by suggesting we not only design for *perceptions* of seamfulness; we should also design for *processes* of seamfulness: the ongoing capability of those seams to perform, mix and flow.

Materials in Craft and Design
Just beyond CSCW, several scholars of craft and design consider the kinds of social, emotional, and political processes at play in material interactions [10,22,30,32,33,36]. They observe structural qualities that are often not immediately "visible" and become accessible only through continued practice [18,22,33]. In a broad examination of embodied knowledge, Schön [33] develops the idea of *reflective conversation* with the materials to describe how the designer frames and imposes order on a given situation. Through a generative cycle of material interaction, the architectural studio becomes a craft-based learning environment that provides insights for educational reform. Materials are collaborators in the craft process, enabling artisans to construct, enact, and reaffirm their identities [22].

Furthering the centrality of material collaboration, McCullough embraces the possibilities of "traditional notions of practical, form-giving work" [25:19] by urging technology designers to become sensitive to the properties of their medium. In recent dispositions on craftwork in modern society, Sennett [36] and Crawford [10] similarly make the case for working more with the hands, extolling the virtues of "the spirit of craftsmanship" [36:286]. They maintain that professionals bear witness to an increasingly "rationalized" and management-driven workplace that inhibits artistic pride and accountability. However, whereas Sennett celebrates the open source movement in which he finds Linux programmers the modern embodiments of Medieval craftsmen, Crawford takes a hard stance against "cubicle life," implying that often "there isn't anything material

being produced" [10:127]. In light of modern technologies, Sennett and Crawford thus take opposing sides regarding the trope of immateriality.

The present discussion of material practice confronts these debates by building on concepts of plasticity and "seamfulness," to conceptualize how heterogeneous interactions come about. By framing material as neither static nor uniform, we begin to move beyond the analytic separation of our digital actions from their material seams. In the following section I seek to further ground this approach in ethnographic work by turning to the practice of bookbinding.

METHOD
To study a binding workshop, I organized my ethnographic inquiry through an apprenticeship. This auto-ethnographic approach follows from prior CSCW research that employs the author as research subject by constructing a reflexive autobiographical account of the author's experience. This work includes examinations of a naval tactical command and control system [1] and embodiment while horseback riding [16]. My methodology draws most closely on anthropological approaches to the study of craft skill, such as Ingold's [18] sawing of wood, Prentice's [30] employment in a garment factory, and work by Lave [22], Coy [9] and others that suggests apprenticeship gives way to valuable insights into technical and social behavior. As compared to a course, apprenticeship imparts tacit skills (physical, economic, social) "through long-term observation and experience," [9:xii]. Anthropologists have long employed embodied subjectivity as an instrument of ethnographic inquiry, "theorizing not only what work *means* to people, but also what it *does* to them" [30:55]. Through continued engagement with materials and tools, my work became a gateway for my social inclusion in the workshop and in my understanding the particularities of the binders' practice.

I visited a bookbinding workshop in the UK for an average of three days per week over three months, and attended binding classes at a second workshop in the US one day per week for an additional four months. I also conducted one-to-two hour semi-structured interviews with 13 key participants: five professional binders, five hobbyist binders, and three customers. Informed by CSCW research where the observation of a given context has been given primacy over the talk about it [39], I built up an account of my practice by taking part in and documenting ongoing bookbinding activities through co-present and video-mediated observation. Handwritten jottings, digital photos and bits of bound and

Figure 1: (left to right) Sean prints gold letters on a spine; Ellen, an assistant, & Peter examine mottled pages; the binders at work.

unbound material also served to record my interactions. In effect, I attended to not only what is seen or heard, but also to my own reflexive account of learning the practice.

In the following sections I introduce my fieldwork materials by following the trajectory of books in the bindery. There books develop from parts and pieces into encased archival objects through a series of discrete activities: folding, sawing, sewing, pressing, gluing, chopping, rounding, backing, lining, paring, staining, covering, and finishing. Performed sequentially, these activities also form the backbone of my exposition. Specifically, I work my way from the detailed use of materials and tools to their situated use in the collaborative environment of the workshop. I then show how each stage of binding has temporal and collaborative qualities, sometimes between the person, resource and tool, and sometimes with the wider setting of the workshop and those working in it. It is by examining these forms of collaboration that I open up some different ways of thinking about digital tool use and, in doing so, reflect on material practice.

FIELDWORK

On my first visit to the workshop I met Sean, the owner and operator of the bindery, and Peter, his long-time business partner.[1] While Sean is a loquacious character, Peter is more reserved and disciplined, attending to the task at hand and leaving most of the client relations to Sean. The materials around Sean seem to echo his liveliness. Book spines, tattered covers, and newly printed theses are stacked on tables and shelves, and colorful papers and cloths hang out of drawers. The bindery, divided into two rooms, enables Sean and Peter to work separately, following the long-practiced separation of *forwarding* (Peter's binding) from *finishing* (Sean's decoration).[2]

The workshop now represents a disappearing site in the book binding industry. Much like workshops of the 19th and early 20th centuries, it mostly serves local patrons and bookbinding hobbyists—enthusiasts seeking to learn more about the trade. Despite the continued presence of these visitors, the bulk of the workshop's income comes from a neighboring university where library books need constant repair and student theses require binding.

Within the last five years a few things have changed. New binding jobs have decreased due to a proliferation of online self-publishing companies (*e.g.* lulu.com or shutterfly.com), which offer cheap products in small quantities and in less time than hand binding. It is through these developments that journals, once the workshop's "bread and butter" work, became almost entirely digitally produced. In addition to new books, repair and restoration work has declined by virtue of a downturn in clientele, such as secondhand book dealers who face increasing competition by e-reader and online book markets.

Alongside these shifts, new tools have entered the workspace. A laptop connected to wireless Internet gives Sean immediate access to business inquires and customer correspondence. Word processing software enables the design and printing of labels for book spines. And a mobile phone service provides a means of coordinating jobs in between personal tasks. If one binder misses a call on his phone, the call is automatically routed to the other binder's phone, and vice versa, until the call is picked up. This pragmatic digital presence extends to the workshop's website, which describes the binders' expertise and workmanship. It also led me to the workshop.

Beginnings of a Book

To consider the dynamics of material practice, I first turn to a passage from my field notes that describes the seemingly individual activity of sawing along the edge of folded and nested pages to create the book spine (see Figure 2).

I insert my saw into the spine of the text block, angling it backward as I pull it across the sections of the spine. I stop. The saw does not want to move back up the sections. Instead, it wavers, and the sections waver with it. I readjust the saw in my hand, curving my thumb around top of the handle, aligning my body over the block. I pull down, hit the bottom of the spine, and reinsert the teeth at the top once more. I repeat: pull down, realign, pull down. Aware that I am only sawing in one direction, I try to move the saw up the groove on the block. The block begins to wobble, and I stop. "Not deep enough," Sean says, leaning down to check how far the groove has come. I reinsert the saw at the top and apply more downward force. The groove looks thick and contorted; far messier than the thin mark Sean created a few inches to the left.

As this excerpt suggests, my experience sawing into a book spine follows a coarsely defined trail, reflecting what Ingold [18] has called the *processional* quality of tool use in reference to sawing a plank of wood. As an intervention, sawing is one of the first steps in bookbinding: grooves are created along the edge of pages that will be sewn along the spine. As a collaborative process, sawing creates holes for other hands to insert a needle and thread. As a spatial-temporal process, sawing becomes a successive stage in the lifecycle of the book: catalogues produced by a company, collected by an enthusiast, and now arranged by me for rebinding.

In this respect, sawing begins to unveil a set of different relations around handwork practice of relevance to CSCW. It is easy to see this detailed engagement as individual, i.e.,

Figure 2: Sawing along edge of folded and nested pages that are held together in a wooden press.

cutting through thin layers of brittle coated paper involves two hands and a saw. Yet, as we will soon observe, sawing reveals itself as part of an intricate array of social and material activities beyond this immediate context. Sawing presents a possibility: the beginnings of a book.

Materials

Materials reveal their itinerary to the binder as part of, not separate from, the unfolding of skill. After creating saw grooves, *cords* (thick string) are inserted along those grooves and a needle and thread pass around the cords to secure the gathered pages (see Figure 3a). In the next example from my field notes, Peter demonstrates how to fray the ends of cords so that they eventually lie flat under the cover:

> *Peter frays the cords that adhere the sections of the 18th century book. As his knife moves along the cord, he is sensitive to how his thumb creates resistance with the knife, grooming the material down to a thin, flexible form. As it is worked, the crisp end thus gradually looses its shape, turning flat, malleable, and increasingly thin. "Feel the ends," he instructs, taking a moment to let me rub the material. The cord has a silky texture. As Peter continues, a small cloud of beige material builds around the knife, obscuring my view of his hands. Peter stops again to fold the end of the cord over the book's spine, pressing it flat against the bare cover board. Some fuzz has fallen to the floor and I can see the cord's remains: a fine wisp. The once tight, brittle form is now a delicate lock of thread. Peter hands me the knife: "Your turn."*

Fraying a cord is one of the first techniques I learned at the bindery because it highlights some of the ways in which materials hold the book together. On older books, cords are used to secure the pages by creating thick bands along the spine, which threads are sewn around (see Figure 3a). To ensure the book's strength and smooth look, the cord's middle must remain strong (securing the pages), while its edges must become weak (so that they lie flat and imperceptible under a cover board). As such, the cord's properties must be changed: its round shape turned flat, its brittleness made smooth and flexible, and its solid mass converted into a cloud of fuzz. Peter is attending to each of these changes by pressing his thumb between the cord and paring knife, a small hand tool used to thin leather knife (Figure 3b). He concurrently monitors the knife's movement and the cord's tactile qualities to respecify the book's look and durability.

The ability to manipulate material is therefore *not* an all-encompassing skill. A material may give the binder hints as to how it should be sawed, sewed or pressed, but it will

Figure 3: (a) Fray a cord inserted into sawn grooves. (b) paring knife: the metal blade is uniquely worn in by the binder.

challenge and surprise the binder, too. Consequently, much like Schön's [33] notion of *reflective conversation,* materials are often described as *having a say* in the binding process; and sometimes they even need convincing. "*Persuade the sections out*" was Peter's way of telling me to separate the sections of the text block while I rounded a spine. Similarly, when an assistant wanted to set letters on a spine, he asked: "*Does it want to be capital?*" Thus, though materials are inherently oriented toward performing one way or another, binders can negotiate a way forward through careful use of tools.

Yet Peter's work involves additional concerns beyond the book. He is aware of my presence, asking me to take part in actively monitoring the cord myself. He is also attending to his next job (a stack of theses that await new bindings) and the subsequent work for this book (pressing and then handing it to Sean). Fraying cords involves interweaving these seemingly discrete activities. Like the sawing that came before, it is not a solitary event; rather it is entrenched in the broader spatiotemporal arrangements in the workplace.

Before the next stage of binding, let us first briefly consider the relevance of this work to CSCW. For starters, we see how the binders engage the particularities of material. By identifying the delicate or intricate we might similarly interact with specificities of the digital. When we talk of e-readers, for example, to what extent do we invoke the metal case, the processor, the e-reader software, the digital file, or all of the above? The ambiguity of these terms and how we refer to our computational devices, suggests an ambivalence toward their digital particularities and an understanding of the digital as metaphor [12]. Designing for how materials affect our interactions means attending to the material properties of digital content: the ways digital elements mutate and degrade over time, how they get encoded and stored as well as how people fine-tune their configurations.

We also recall from the interplay between knife and leather that materials have a "say" in the process. The materials tell us they are not passively confined to the things made from them but have their own propensities for mixing, mutating, swelling, or shrinking. In this sense, materials are not imbued with agency but exhibit agency by rising above other material activity. The cloud of fuzz is no longer a cord but a part of the formation of a flexible and flat wisp. This suggests we consider how digital materials have an equal say in work practices, and how our interactions sometimes preclude listening. In the following section, we see that how tools also figure into these material assemblies sheds further light on the collaborative possibilities of human skill.

Tools

The tools of bookbinding tend to resemble common household implements: scissors, knives, rulers, hammers, and so on. They also reflect the breadth of techniques involved in binding, much like Svensson *et al.*'s ecology of surgical instruments "suited to the specifics of particular interventions and procedures" [39:44]. For example, the bookbind-
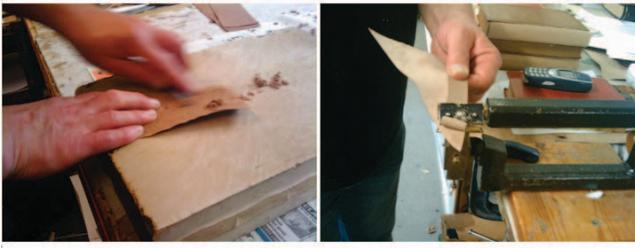
Figure 4. Using (a) "paring knife" and (b) "paring machine"

ing hammer has a rounded rather than flat face so that it does not indent the paper (while "*rounding*" a spine). Each tool is put to use in order to accomplish a particular task—sharpen a corner, trim an edge, fray a cord. Next we see how a round brush is used to apply glue to a piece of cloth that will soon be attached to the book cover.

> *"Splunge!" Peter instructs, glancing over my shoulder. "Let your brush dance across the page." My left hand (holding the cloth) jiggles with each paint stroke. I move the brush more quickly, but it pulls at the surface. "Hold the page still. Don't let it move," Peter directs. I readjust the position of the cloth with my right forefinger and continue to paint, paying close attention to the thickness of the glue across the surface. Peter's voices reemerges: "not too thick!" The glue refuses uniformity. The brush coats parts of the surface that I was not aiming to cover, unevenly distributing the glue across the surface. "Here, here and here," Peter points, calling attention to bits of dry cloth, areas where my brush had not traveled. Frustrated, I scrape the surface with the brush, changing my brush marks from dots into lines. I carefully lift the cloth and remove the newsprint below.*

In the above excerpt, glue is worked into a piece of cloth with the goal of creating an evenly coated surface. Peter urges me to use the brush as a spring, allowing the bristles to push back at my hand and my hand to respond in kind. This rhythmic motion, or "*splunging*," disperses the glue one gesture at a time in even dot-like patterns. When I use the brush as paintbrush instead, smearing the canvas with long strokes, the surface becomes rough and uneven, eventually resulting in visible bumps along the cover. In Peter's words, such work is akin to "*building a castle on top of sand*": the next steps of the binding process may be executed flawlessly, but the book will still collapse.

Here my interactions with the brush, glue and book reveal something more about Peter's direction. By pointing out the look of the surface, the feel of the spring, and the pace of

my movement, Peter is sensitizing me to the various elements of binding. Like the fraying and sawing that came before, *splunging* is entangled with the next stages of binding as well as my role in the workshop. Once again we observe my brushwork as not a static or solitary achievement, but as embedded in materials distributed over time. In this routine activity we find the ingredients of intra-activity [2].

These apparently simple instruments, and their use while binding, also highlight the ways in which different tools become more or less tool-like through their situated use in collaborative environments. While the *tool* has long been contrasted with the *machine* [25], neither concept refers to a particular set of devices in the bindery. Rather, these concepts are evocative of certain values embedded in different devices at different times. Recall Peter's paring knife (Figure 3b)—the tool he used to fray the cords along the book spine. The knife is a standalone metal blade designed for thinning (or "*paring*") leather, *e.g.*, that will cover a box or book. The *paring machine* (Figure 4b) is also designed for thinning leather, but it is attached to a bench, requiring the binder to move the material rather than the tool. Despite its name, the paring machine has few conventionally machine-like qualities: it is simple and lightweight, has no moving parts, and is not mechanically or electrically powered. For a novice, the machine is more difficult to use than the knife and cannot fray cords or sprinkle paint. The machine serves one purpose, remains in one spot, and is one of a kind in the workshop. The knife, by contrast, serves multiple purposes, moves around the workshop, and is one knife among many. Each binder not only has his own knife, but the metal blade is often so thoroughly worn in that using another binder's knife is uncomfortable or infeasible.

The difference between machinery and hand-tools is thus attributed to how they enable or constrain the specialized needs of the binder. The machine designed for cutting large stacks of paper (appropriately called a *guillotine*), serves additional purposes, such as handing off material (see Figure 5). By virtue of its weight and size, the guillotine becomes a stable and predictable location in the bindery, making its flat surface suitable for exchanging unfinished books. Sean stacks sewn books for Peter to re-cover while Peter stacks bound books for Sean to decorate. Yet this use of the guillotine is transitory because the machine is frequently required for cutting paper. Like the paring instruments, the guillotine emphasizes the layered spatio-temporal quality of

Figure 5: The guillotine is used for handing-off unfinished books between the binders (left) and cutting the pages (right).

Figure 6: Sean arranges decoration for an album cover.

collaborative work.

It is the *un-sharable*, *mobile* character of the paring knife, and the *sharable, immobile* character of the paring machine and guillotine, that suggest some interesting possibilities for flexibility and stability in CSCW. Designing digital tools for un-sharability might entail the design of software that can become "worn in": the more it is used the more it becomes assigned to one person or another. Designing for immobile devices involves adjusting material properties (weight, size, plasticity) in response to a given situation: a device that changes its weight based on human proximity—e.g., becoming stationary when it nears a small child. By attending to the temporal aspects of tooling, we might rethink sociomaterial possibilities for flexibility and ownership.

Workshop

After binding, but before delivery, a book is given to a "finisher"—the person who applies text and decorative elements to the cover (such as clasps and gold leaf). Most often forwarding is done by Sean, who decorates the cover while keeping an eye and ear on the work around him. In the next example, Sean is deciding how he wants to decorate a wedding album:

> *Sean: Oh I'll—I'll tell you what we use. No, no, no, no, no. They're lovers, they're in love. They're getting married. We need something unique. [Phone rings] Good morning, [removed] binders... Yeah we can do, no problems at all. Yeah, we can do that.... Well I'm here 'til half past seven tonight... Friday I'm here 'til have past four, so we're here quarter to say quarter to 8 til half past, til half past four . Okay, super, thank you. Bye. Like that? Fancy that?*
>
> *Me: That's nice.*
>
> *Sean: Of course it is. And they're flying away together!*

In this typical exchange between Sean and me, Sean is able to flexibly integrate a range of activities into the task at hand: a new customer's phone call, an old customer's wedding album, and my ostensible assistance to this work (see Figure 6). Sean points to the location on the cover he wants printed, removes a few decorative metal elements from the drawer, and hands me both to consider. When his mobile phone rings, this flow of activity is not broken; instead his humor inserts pause and delay. The pause reflects other

workshop arrangements such as how the laptop is pulled out from under the bench to check email at 9:00, 11:00, and 1:00 each day. Email, or as Sean aptly calls it, "the post," is limited to certain places and times even though wireless Internet is continually available throughout the workshop. This somewhat paradoxical combination of limitation and access, efficiency and delay, is critical to preserving Sean's awareness of workshop activities.

Sean's work at the blocking machine also reveals how coordination takes place among actors inside the workshop as well as outside it: the customers and the standardized production of decorative metal elements. This spatial distribution of work is evident on several counts, as when Sean runs into trouble while using word-processing software to create a new label for an older book:

> *Sean finds a serif font to match the original label, noting, "it just looks right." After typing the title, he struggles to find a tool that allows him to add a line underneath it and tells me that his son usually helps. As he talks, he moves the mouse over a "tools" menu, then "format" menu, then the "tools" menu again. Finding nothing, he returns to the keyboard and inserts dashes one by one. The next day Sean shows me the printed label. Individual dashes have been replaced with a solid line and the font is bold and modern, no longer matching the original book. I ask Sean why the font has changed. With some delight, he explains that his wife fixed the label on their home computer that evening, a computer with different fonts.*

Here we find Sean is less familiar with the software than other instruments, such as the blocking machine. He has trouble finding digital resources to create a desired effect (the solid line) and enrolls human resources outside the workshop to help out (his son and his wife). But people are not the only actors shaping the printed result. Sean encodes his work in a particular file format (.doc) that depends on font files stored on his laptop. When Sean copies the file to his home computer, it is unable to access the same font, and instead links to another. The .doc file therefore spatially stabilizes some aspects of Sean's work and not others.

As we assess implications for CSCW, we find a few key aspects of Sean's workshop activity. First, his insertion of pauses and delay inspires other ways of thinking about the pace of workplace activity. For example, enabling our email clients to receive mail for certain durations and times (hours of the day, days of the week) suggests ways we might accommodate a range of undervalued actions, such as linger-

Figure 7: Sean checks email at his computer.

ing, hesitation, dwelling, and patience. We also find that the spatial stabilization and visibility of a digital font shapes Sean's desired results. Similarly, the encoding of data in JPEG file formats entails perceptually indistinguishable changes that result in irretrievably lost information [4]. Digital information thus deals with similar material constraints to that of leather or glue—in this case constraints of storage. The limitations then offer different possibilities for how the digital is produced, maintained and shared. Like leather and cords, digital properties transform over time, sometimes becoming unusable. Given Sean's restorative intentions, collaborative software might also selectively visualize this complexity—indicating cross-platform shifts and the spatial stability of dependencies and file encodings.

Before we leave the workshop, let us consider one last concern. Each instrument in the workshop perilously left around the bindery, including the laptop, accumulates grease, dirt, paint, and even intricate patterns of glue (see Figure 8). Though visitors often comment on the beauty of these marks, the binders see them as mundane traces of production. The temporal quality to these traces, though seemingly inconsequential, is central to how materials effectively communicate their provenance to the binders. By considering the interplay between different material elements—how work environments leave traces on materials, which reciprocally leave traces on the materials themselves—we might produce more meaningful interaction histories that consider the distinctive rhythms of collaborative work.

THE BINDERY AS COLLABORATIVE SYSTEM

We have seen so far how the bookbindery is an archetypical workshop, inviting us to reconsider how we understand the long-term prospects for CSCW technology—in both non-office work environments and our own practices as systems designers. The unfolding of skill occurs as materials reveal their itinerary to people through, and as part of, collaborations with the workshop environment. But what does this mean for CSCW? How might this formulation of tools, as something materially salient but socially unremarkable, enable us to understand computing?

To begin with, we found the binders engage the particularities of material and those materials have a "say" in the process. Becoming sensitive to delicacy of a digital file, like a cord or a piece of leather, might involve identifying the fragile, or the intricate, by acknowledging the interplay between different computational processes. This activity illustrates *material-material collaborations*, or how constituent elements (digital and non-digital) collaborate to exhibit their intricacies, such as frailty, firmness or pushiness.

When tools come into play, we saw how they demonstrate a bounded sharable and mobile character that affects their flexibility and use in the workplace. The specific limitations of tools (the unsharable knife and immobile machine) suggest design opportunities for the spatially inflexible or temporally unsharable wherein a digital tool is assigned to one person or another through continued wear and use. This

Figure 8: Traces of glue left on the side of the press

observation suggests taking seriously how different elements become more or less tool-like through their situated integration with people in *material-human collaborations*.

As we examined the larger rhythms of workshop activity, we observed the patterned pauses of integrating different resources into work—both inside and outside the workshop. Like Sean's metaphor of the "post," this suggests we might design for the productive combination of limitation and access by enabling email clients or social networking sites to reveal materials according to spatially situated tempos and durations.[3] We also found that the degree to which these materials and their properties stabilize emerges through ongoing practice. As the materials move and interact they leave traces on their surroundings workspaces, which equally shape the materials themselves. Digital tools may allow for the communication of varying amounts of inscription and stability. By tracing material across time, they could foreground the generative processes and evocative histories of interaction. This productive interplay between the workspace and its material constituents exposes *material-workspace collaborations*.

These multiple forms of collaboration that emerged in the bindery prompt us to think critically about the temporal patterning of work and how our materials help to configure their unfolding rhythms. As our personal and professional landscapes exhibit increasing signs of busyness, how we perceive the passage of time might be shaped not only by the design of our software or services, but also by the traces they leave behind. Instead of distinguishing the digital from the physical, this work suggests we consider the vast range of material practices. What might appear to be an individual activity—Peter's cord fraying or Sean's typesetting—is tightly interwoven with the tools, people, and workspaces with which one works. Collaborations are not fixed in time but consist of a spread of events. In the diverse practices of binding we find a different view of work—one that emphasizes the active processional character of material [18].

THE CIRCULATORY FLOWS OF MATERIAL PRACTICE

In sum, this work demonstrates how material continues to be a valuable resource for reflecting on the design and use

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[3] A few existing tools, such as the Firefox LeechBlock Addon, purposefully limit use: https://addons.mozilla.org/en-US/firefox/addon/leechblock/.

of technologies to support collaboration. It is as information technologies become part of our daily lives that the coordination of digital materials becomes increasingly important, particularly in such relatively non-digital contexts as a handcraft workshop. How we consider such technologies in light of human-material collaborations ultimately affects the cultural histories woven into the things we produce. As designers, we must imagine new techniques for coping with modern rhythms of collaboration. In order to better account for these practices, let us now follow Orlikowski [29] in considering the multiple roles that digital technology as material might play. As she points out,

> *It should be quickly evident that a considerable amount of materiality is entailed in every aspect of organizing, from the visible forms — such as bodies, clothes, rooms, desks, chairs, tables, buildings, vehicles, phones, computers, books, documents, pens, and utensils — to the less visible flows — such as data and voice networks, water and sewage infrastructures, electricity, and air systems. [29:1436]*

With few exceptions (*e.g*, [38]), CSCW has approached the material through objects, its most "visible form," rarely framing material practice as anything other than artifactual practice. Yet as we saw with the blocking machine and laptop, not only do tools, workspaces and people influence the work at hand, they have collaborative qualities through which meaningful skills are produced. But as I type at the keyboard now, where is the material? Is it the keyboard and mouse, the cursor, the operating system, the sentence structures and words?

The answer this work suggests is that each of these components is material. Not only am I interacting with the physical constraints of my environment (keyboard, laptop, chair, room, air), my work is highly circumscribed by the operating system, the software, and the data and meaning around which particular functions (such as copy/paste or send) are put to use. Moreover, as Levy aptly notes, *"digital materials, too, need to be properly tended"* [22:119]. For instance, even when written, this document will continue to evolve and dissolve as it passes through many hands and forms.

Materials in this sense are not stable. They are instead bound up in the "generative fluxes" of human and non-human interaction [19]. To overcome the limitations of our object-bias and its trope of immateriality, I propose we approach materials in three ways. First, we should understand materials as *compositional elements*—the matter and substances that make up our environments (presses, leather, glue, word-processing software). This attribute exposes collaborations among constituent properties, *e.g.*, the interplay between fluctuating properties of the cord (round and flat, solid and wispy). Second, we should recognize materials as *surfaces*—the interfaces at which different substances interact and combine (benches, cutting machines, digitally encoded dependencies). As surfaces, materials facilitate interaction between different elements, *e.g.*, the guillotine's emergence as a medium for exchange. Third, we should view material as caught up in *spatial-temporal flows*—

textures of activity continually reconfigured across space and time. Materials as flows stress the circulatory character of their properties wherein materials entwine with workspaces to become the medium through which elements move and mix, *e.g.*, the word processing file did not stabilize all elements of work but revealed the temporal and spatial instability of its properties. As such, materials are active inhabitants whose properties transpire and mutate depending on the currents of surrounding activity [19].

While I have referred to "digitally-mediated" practice in this paper, I have done so with a grain of salt. It is through this lens, or the language of mediation, that we begin to loose sight of the emergent character of materials and their diverse arrangement in social practice. Tools should not be designed to passively facilitate or streamline the process between what one intends to do and what one does. Such technological mediation does not play out so smoothly in practice. As has been long discussed within the CSCW community [37] plans for tool use do not exist purely in the mind, but are enacted and realigned through practice. Furthering this view, the present material practice perspective suggests that we consider how not only artifacts, but also data and digital tools, perform as materials—how they resist and accommodate action as well as form, transform, and evolve.

Thus the tools through which people configure objects are not uniform but made up of different active interstitial elements. In a recent analysis, Schmidt and Wagner compare different accounts of material in CSCW to argue that they often presuppose a "mentalist" notion of artifacts as *"simple vehicles of 'information'"* [34:1]. One focus of their critique is activity theory as understood through Vygotsky's concept of "psychological tools." They claim that through the reification of mental processes *"any notion of materiality is eradicated from the concept of tool"* [34:3]. Looking to material practice, we no longer view materials as inert substrates stably inscribed with perceived characteristics.

This study instead urges us to attend to the temporality of material. It is in the emergent patterns of material activity that we recognize the formative techniques and practices that hold lasting personal and cultural value. Returning to the generative currents of practice, this approach extends our understanding of collaborative work—dismantling digital and non-digital binaries, and drawing attention to the "circulatory flows" of practical work [19]. From raw stuff to the broader landscapes of interaction, we find that the digital is no exception. In Blanchette's words, *"Computing, it turns out, is material through and through"* [4:1].

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