When is it not Craft? Materiality and Mediation when Craft and Computing Meet

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ABSTRACT
Craft has emerged as an important reference point for HCI. To avoid a misrepresenting, all-encompassing application of craft to interaction design, this position paper first discerns craft from HCI. It develops material engagement and mediation as differentiating factors to reposition craft in relation to tangible interaction design. The aim is to clarify craft's relation to interaction design and to open up new opportunities and questions that follow from this repositioning.

Author Keywords
Craft; tangible interaction design; design research; physical computing.

ACM Classification Keywords
• Human-centered computing~Interaction design theory, concepts and paradigms • Human-centered computing~Interaction devices • Human-centered computing~Interface design prototyping

INTRODUCTION
Craft has become a major influence in Human-Computer Interaction (HCI) and related fields in computing. Among others, it has been integrated with a view to education in making [1] as well as Computer Science [2]; as material practice in relation to physical computing [3] and in the role of fabrication tools for production [4]; as reference for experience design [5] and collaborative practices [6]. Combinations of craft and HCI go hand in hand with a rise of maker-cultures and have shaped countless projects, often fueled by technologies that have become increasingly accessible. The meeting of craft and interaction design as originally separate disciplines has proven to be a fruitful intersection for debate and project development and has led to the notion of "hybrid crafting" [7] or "Neocraft" [8]. But the emerging field has also drawn criticism.

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Devendorf and Rosner question whether the limitations of a "hybrid" approach hinder the inclusion of additional references and thus build on a too restrictive perspective [9]. Frayling - an early proponent for the original method of research through design and inclusion of material practices - questions the direct projection of craft onto other fields [10]. Others draw attention to the possible incompatibilities or challenges of such a merger [11, 12]. The practical intersections between craft and interaction design are productive, but far from unproblematic.

Craft, defined by Sennet as work done "well for its own sake" [13] has encountered fundamental changes in the period of industrialization, which led Pye to separate between a workmanship of *risk* (which is largely tied to human performance and possibility of failure) and one of *certainty* (tied to mechanically optimized fabrication) [14]. The digital age continues to challenge craft. As digital technology enters craft processes, any skill- and knowledge-based craft concepts must embrace abstract tools, too. Dormer states that "[i]t is not craft as 'handcraft' that defines contemporary craftsmanship: it is craft as knowledge that empowers a maker to take charge of technology. " [15] In the continuation of these shifts we find a friction between craft and interaction design. The field of tangible interaction design is defined by its use of physical/ tangible components not only for *representation* but also for direct *manipulation* [16]. This focus on materials invites craft as a reference point, but it does not mean that tangible interfaces practice craft by definition.

The goal of this paper is a critical re-positioning of craft to interaction design. It aims to provide a theoretical discussion along three short example cases to sketch out a preliminary relation model.

PROBLEMATIZING CRAFT
To provide an initial structure for this encounter of the domains, we first propose to talk about craft in a framing vs operational way. Any tangible design project can be approached and analyzed "*as* craft," meaning: we are free to deploy craft-related theories, practices, histories, and methods as critical means or as analytical perspectives to further tangible interaction design. In this case, the fields do not merge but open critical perspectives through their differences. In contrast, a tangible interaction design "*is* craft" when it includes actual craft practice in the direct encounter of the material and the computer as a tool in as

unmediated ways as possible, as we will discuss below. Following our own division, this paper focuses on examples where interaction and its design "*is* craft." As we shall see, even these cases are conflicted.

Case: Hybrid Crafting

Zoran and Buechley speak of a "hybrid" approach in their combination of crafted and scanned/3D printed components into a mixed material piece "to merge digital fabrication with traditional craft, thereby combining two creative processes that rarely overlap" [17].

Figure 1. Zoran's "hybrid" crafting combines and contrasts traditional ceramics with 3D printing [17].

The merger is performed as a destruction of the initially traditionally crafted ceramics and a consciously non-functional filling of the resulting holes with 3D printed components (see fig. 1). The critical encounter emerges quite literally from the conflict between the two conditions: the crafted vs the 3D printed. The project is a successful example for a combined approach but not one of an uncomplicated merger. Instead, it operates through the differentiation between the two traditions of craft and personal fabrication/digital media.

Differences between the two disciplines, such as focus on distinct materials and divergent practices, histories, and communities, have fueled emerging interdisciplinary approaches, but also endanger the fields to diffuse into an unspecific amalgamation of neither. This smoldering is further driven by significant commercial forces, such as 3D printing and scanning industries, patents, and publishing interests. The related term of the "maker" is rightly being re-interrogated [18] and has spawned a critical rethinking of what is means to "make" [19]. Some of this critique tackles the making process itself in its formulation and publication (see the self-assembled booklets by Hertz [20]), not unlike Zoran's dysfunctional vases.

The goal, thus, is to avoid a simplistic blending that threatens to stifle the stimulating differences between craft and interaction design. We have to emphasize their differences and incompatibilities to ensure the identity of the partners involved in this obviously productive debate. To this end, we identify two differentiating factors as principles through which we can define whether HCI "*is* craft" or not: *Mediation*, and *Material Encounters*.

MEDIATION

Looking at the improvements in user interface design and inspired by McLuhan, Alan Kay proclaimed in the early 90s "The computer is a medium! I had always thought of it as a tool, perhaps a vehicle-a much weaker conception." [21] The very same notion that computers mediate is reflected in the "multimedia" capabilities associated with computers, the interplay of hypermediacy and immediacy [22] and the idea of "transcoding" one media component into another [23]. Computers mediate by means of transcoding and simulation. By definition, these are processes that detach from the source, from whatever is remediated or transcoded. This inherited detachment prevents computer media such as video games or online worlds from qualifying as craft, instead we "invent the medium" [24] as designers and hand over the result to the user. Not every mediation has to go through a complete numerical abstraction, but digital mediation does. Based on this specificity, we suggest to differentiate between "mediated" (namely transcoded through digital technology) and "unmediated" (namely not transcoded). Mediation's abstraction, then, poses a separating factor from crafting.

Differentiating between "mediated" on one side, and "unmediated" on the other is to be understood as a preliminary tool. Media permeate lived environments and change them, blurring definitions and historic boundaries (see the changing notion of "liveness" [25]). This differentiation proposes not an absolute horizon but a departure from established divisions in HCI into material vs immaterial [26], or tangible/graspable vs intangible [16, 27].

ENCOUNTERS WITH MATERIALS

Traditional crafting practices position the creator and the tool in a very specific relationship toward a physical material [28]. The material is the target of and partner in a process which is enabled by this crafter-tool dynamic, eventually resulting in an artifact which has been transformed, revealed, or made to emerge. During this process, tools are used not only to create, change, or give shape to a material, but also to relay information from the material itself to the crafter, which can in turn inform the crafting process. This is a reciprocal encounter with materials which are continuously revealing themselves and being revealed by us. Although tools have a defined practical function in this encounter, they are also part of the larger relational network at work (for a recent reading of this Heideggerian approach see [29]).

Because each material engages differently, traditional crafting practices vary. However, they all differ from the process of computational mediation/transcoding in several key ways, which can be thought of in terms of the difference between tool and machine. A transcoding media machine necessitates detachment, whereas the craft tool is a conduit for material "listening" as well as physical manipulation. When we put our hands to clay or a chisel to marble, we leave visible traces of our actions, connecting the body directly to the emerging object [30]. Reciprocally, our bodies are attuned to the reality of the artifact which is emerging

through the state changes of the tool which connects us to it. As Merleau-Ponty describes in his example of a blind man's walking cane: the cane-tool extends the "area of sensitivity" [31]. Heidegger makes similar arguments, famously observing that the carpenter is not involved with the hammer, but rather with the nail *through* the hammer, the wood through the nail and so on. The hammer, the nail, and the crafter realize connection and potential within that context [32]. Feedback from the changing materials, felt through the tool, is imperative to the process of crafting. The human control of the tool, and the varying nuances associated with it, such as skill and dexterity, determine that material change as well as the emerging skill and role of the crafter.

In contrast, the computer, operating as a media machine and as a transcoder, will execute a procedure successfully or unsuccessfully, and relay that outcome to the user. The result might be the anticipated realization of the objective, or a crash, freeze, or other instantiation of failure. As we will argue below, computers and hardware can operate on the level of tools, but if we type on the keyboard or operate the mouse, the embodied action does not tell us anything about the process which is making something appear on the screen. Bridging this disconnect between input and output has been a motivating factor in tangible interaction design since its beginnings [16]. One might consider touch-screens on which you can draw with varying levels of pressure, vibrotactile communication devices [33], or haptic software interfaces [34], as a "craft-like." But the operations which facilitate this feedback to us remain ambivalent to our actions as the one interacting with these devices. We might be experts in their use but remain largely ignorant of their workings. Though we are trained in efficient use as we type on our keyboard, we do not receive information back through that same channel. The keys do not shock us. The material properties of the tool—electricity traveling through circuits—are invisible and not incorporated into the experiential participation. The operation – a finger pressing, swipe, pinch, grasp – is mediated to the user. McCullough sees in such expert handling a notion of crafting even if it is interacting with a computer. His skill-based definition of craft argues that the computer as medium "or communications device is inherently a tool for the *mind*-not the hands" [35], but it is a tool in the crafting sense, a "software tool" working via "analogy" and "metaphor" in its interaction design [35]. This might apply to handling interfaces, such as operating the mouse or shortcuts in an application, but is less clear when it comes to the material qualities we highlight here. For McCullough, "[c]oncepts become things" through computers but the role of those things' materials and their changes are less clear.

That is why we turn to Shiner, who presents a strong delineation between hand-tool craft and hand-computer making. Both are separated by the engagement with tacit knowledge on the part of the crafter. For Shiner, the enactment of tacit knowledge reflects a way of making which is characterized by the embodiment of the crafter herself: "Mastery in the crafts is a matter of mind and hand working instinctively together, a kind of practical know-how or tacit knowledge." [36] Shiner is able to distinguish this kind of making from digital design practices, in which, "the designer or craftsperson combines digital design with digital fabrication, the body's contact with 'materials' is so radically diminished that the flow of tacit knowledge normally gained through physical contact and feedback from alterations in the material becomes primarily visual and intellectual" [37]. In that way, digital design tools and related interfaces such as the *Reactable* are still remediators with the additional quality of tangible design integrated into the process of that mediation. Oreggia and White engage this philosophy in their discussion of art and musical practices in particular, stating that, "as with brushstrokes in painting, the materiality of [a] musical instrument leaves traces on the performance, and thus the materiality of the instrument is essential to the semantics of the performance in a way in which the materiality of a computer is not essential to the semantics of programs that are executed on it." [38] We encounter the *Reactable* as physical device but its materiality does not relate to its underlying transcoding operations. The material encounter traced here, as well as by Shiner, presents a second defining moment to differentiate the abstraction of digital production from material crafting.

So far, the argument has introduced *mediation* and *material encounters* as possible differentiating factors between craft and computing. These are based on different forms of engagement with materials: transcoded/mediated vs non-mediated/ tool-driven.

VISUALIZING INTERACTION DYNAMICS

Using the differentiation laid out above, a model can be sketched out that first puts particular modes of production in relation to these two means of the computer as either tool or media machine. Based on such a mapping of modes of engagement, we will later propose a basic mapping of the roles within such a system.

First, the two defining means of computers' role, as media machine or as tool, can help to map out different modes of computer's use. The two key modes here are those of creation (in a direct encounter with the material, e.g. through tacit knowledge) and consumption (in a condition of abstracted mediation of processes, e.g. when using opaque applications).

Second, the combined position of such modes and means on our spectrum of mediated-to-material-encounter can help illuminate the role of the maker, particularly within hybrid practices which draw from both craft and HCI practices.

The model isolates the differences between craft and HCI practices, but it also emphasizes the hybridity of many emergent practices and the flexibility of varying roles of practitioners who move in-between them. In this schema, a computer may be used as a tool when it primarily accommodates material encounters, or as a media machine

when it operates as an opaque abstracting machine of transcoded signs. Likewise, the role of a practitioner may align with various disciplines suggested by the mode of engagement, from designer to producer, crafter to consumer.

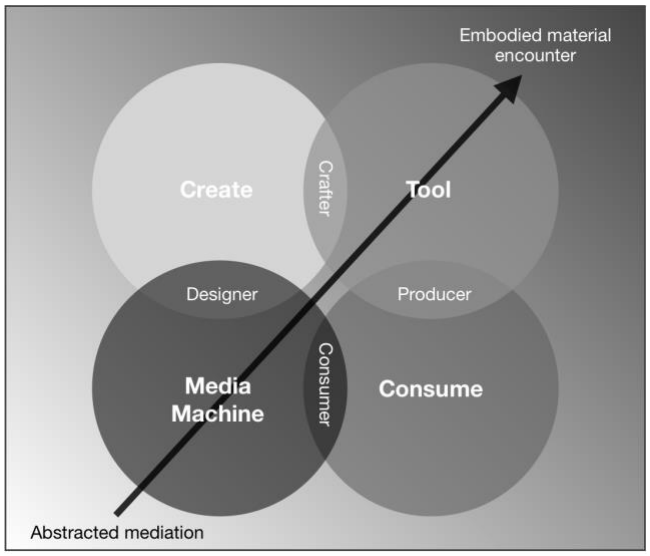

Figure 2. Mapping the different positions of interactors in relation to possible functions of the computer as device.

When a tool is used to create something in the embodied way outlined above, there is an associated direct material encounter which places the creator in a crafting role. In contrast, a media machine being used for the consumption of transcoded media positions the individual in the role of a consumer. Subsequently, the areas in which a media machine is being used to create, or the tool is used for consumer purposes, are where you find hybrid practices such as design and production. The chart presents a broad model, but it helps to position different practices "as craft" versus "is craft" by offering an entry point into interrogating the maker's relationship to their means and mode of production.

ENCOUNTERS WITH TECHNOLOGY

Two short reference cases in tangible interaction design are presented as examples for possible material encounters that support the proposed turn to mediated vs unmediated practice.

Case: Soft Circuits

The field of soft circuits inherently utilizes craft practices and materials: it applies craft-like assemblies and hybrid materials that might be conductive as well as protective, worn as well as sensing, functioning and fashionable. Yet, even the most craft-centric approaches remain obscure to most users as long as the operations remain opaque-as-mediated to them. The end user who purchases a prepared wearable remains oblivious about the way conductivity changes in a soft circuit button or a stretching potentiometer. In that regard, the tangible component represents a physical mediation, much like that envisioned by Ullmer and Ishii [16]. It may be a tangible input-output link, as craft materials are directly experienced in the use of the object. Users get the physical and tactile sensation of a carefully constructed material encounter, but this remains a transcoded encounter. If one wants to integrate craft as an active quality and practice in its own right, then this represents a missed opportunity.

Within soft circuitry, various scholars have addressed this. We argue that the reason why Perner-Wilson's work is valuable in the context of craft in tangible interaction design is not only the resulting object and how it integrates textiles and electronics but also because of the documentation leading up to it.

Figure 3. Perner-Wilson's "Woven Paper Cup Speaker" from the online Instructable [39].

In her online Instructable *Woven Paper Cup Speaker*, Perner-Wilson explains step-by-step the crafting of the simple speaker object and explains the underlying logic. A classic mediating device, a speaker, turns into a material encounter.

If only the final product is concerned, then craft practices, such as sewing, crocheting, or stitching remain obscured as they are not handled by the user but performed by an external maker. Because Perner-Wilson provides extensive documentation on how to create her pieces, these practices become accessible (see also [1, 40]). Craft, as a productive action, is integrated into the design of workshops and educational conditions. Such a productive stance includes designing for a creative encounter of the underlying materials. In such a craft-inspired interaction design approach, the user is not encountering a crafted artifact but engages in crafting as process to deal with the artifact. Digital component involved in this process turn from a mediating device into a tool.

Within the proposed model, Perner-Wilson's artifact construction is a creative act in which material encounters and computation are closely connected – it draws mainly from traditional crafting tools. In the creation of the work itself, the role of the maker is defined by the use of physical tools and the emergence of a material artifact through that relationship. Here the dynamic between the creator and what is created involves reciprocal engagement of raw materials

and that which emerges from a crafting process. This portion of the work, then, sees the role of the maker in a crafting role. However, we must also recognize the shifting role of the maker in later portions of the work, which incorporate computational elements as media: a major function of the piece relies on recording and deployment of documentation via the internet, and so we can see the maker's role shift from that of crafter to a more mediated activity. The role of the maker is fluid, shifting between roles based on the levels of material encounter and mediation in the means and mode of production.

Case: Circuit Bending & No-input Mixing

Musicians who engage in no-input mixing (also known as inputless mixing or zero input mixing) and circuit bending deliberately dismantle the protective shell designed to keep consumers from the inner workings of mechanical systems in order to exploit the electrical activity within the devices. Often, the individuals engaged in this type of destruction-as-construction are non-experts more concerned with "[traversing] through the hidden content inside of a technological system for the joy of entertaining its concealed underlayer" than with complying with the usages imposed by manufacturers and designers of the objects [41]. As Hertz and Parikka explain, this "depunctualization" of black-box technology makes that which is purposefully designed to be invisible to the user, in a technological object which is constructed for a singular use, into an instrument which is technically "broken" yet functional for new, creative purposes.

Similarly, no-input mixing exploits the traditionally undesirable "noise" which is inherent to any electrical system (in this case a sound mixer) and redirects that noise as an input back into the system itself. By amplifying the system noise and passing that signal through the mixer in different ways, a chaotic (unpredictable) feedback loop is created within the circuit, producing pitched loops and beats entirely dependent on the constraints of the largely unknown system. The results are somewhat the opposite of the carefully crafted soft circuits, most often unpredictable, non-linear, and potentially destructive.

"Blackboxing," as a design philosophy, is a method of separating the individual from the material conditions of a system, rendering us users rather than crafters. By re-exposing, repurposing, and redirecting the raw materials of an object, we engage in a craft-like relationship with those objects, even as we potentially destroy them in the process. When engaging in no-input mixing or live circuit bending, the musician not only changes the flow of electricity within the system itself, but imparts their own noise into the process. One of the most prolific no-input mixer musicians, Toshimaru Nakamura, describes the relationship between himself and his instrument: "I often lose my awareness of who does what. One 'who' is the no-input mixing board (my set up for acquiring feedbacks), and the other 'who' is me. Am I playing the machines? Or, are these machines playing me? …It seems like there is quite an equal relationship." [42]

The ongoing encounter with the materials of the object, which are unique to each mixer and instrument, define and shape the creative direction taken by the musician, and the musicians themselves change how the fundamental materials of the object operate—often to detrimental effect. Because the musician is engaging with a mixer on a material level and adapting to the physical properties which emerge as the material is manipulated, they are in a crafting role when performing. There is an ongoing process of creative adaptation to the new and emerging physical and material states of the instrument, and meaning emerges through the in-situ decision-making on the part of the performer.

At the same time, the musician is also playing the role of producer of a mediated experience, as they are likely creating music for an audience who are consuming a product as they attend a performance, and possibly also later through distributed recordings. The extreme end of this production cycle is the consumer who streams a recording of the performance at home, or buys the CD recording for later listening. In this activity, both the means (media machine) and mode (consumption) are highly mediated, placing the performer in a role of producer, and recipients in the role of consumer.

Both sample cases show how material encounter with the immediate operational components of a hybrid piece "is craft." They also show how these pieces shift to mediation and engagement becomes more detached. Roles can shift quickly even within a single performance or maker project.

LOOKING FORWARD

Ultimately, these examples highlight the difficult task we face within the discussion of craft in tangible interaction design. They complicate issues of identity and purpose across disciplines and practices which evolve and change. Today, practitioners have both tools and media machines at their disposal, and depending on their use, one can quickly turn into the other. Increasingly we must account for what Simondon called "technological objects," which can exist "not only by virtue of [their] functioning…but by virtue of phenomena of which [they are], [themselves], the center." [43] This dynamic is reflected in our model, at the poles of the computer as tool vs mediating machine. It is not resolved but mapped in correlation, and through this context we can position any interactor's role as well as the standing of craft in interaction design.

This has the potential to open up a new problem space and opportunity for tangible interaction design.

Moving Craft to Interaction

We differentiate between the computer as a media machine that allows users to produce content through its functionality and the computer as a tool that allows participants to shape and master its functionality in an as immediate as possible encounter with the technology and material at hand. We used

this dualism to map creative and consumer activities in relation to these modes and are able to identify different productive roles for the human participant. Computers as tools allow the interactor to work with the computer as crafter. Here, the tangible interaction design "is craft" in an immediate encounter with the technology on a material level that allows for creation of new practices, objects, even tools themselves. But the two case studies also show that this is not a stable role. In practice, makers shift between different modes of engagement, at times even fulfilling two in parallel. Thus, we can illustrate the dynamic relationship between media machine vs tool and connect it to the role of the interactor in a basic schema, divided into the two positions the technological objects can take and the differing roles for the participator who engages with them. This shifting use of the role of the computer as differentiator mirrors Simondon's approach to technological objects:

"Now, in order that the human function be meaningful, it is absolutely necessary that each man employed at a technical task should acquaint himself with every conceivable aspect of the machine, should arrive at some sort of understanding of it, and should pay attention as much to its elements as to its integration into the functional ensemble." [43]

This necessity refers not only to the human to improve the encounter with the technological object, it ultimately refers to the construction of a "functional ensemble." Much like Simondon's call for a balanced ensemble, we call for a balanced combination of craft and interaction design that is constantly in a state of growing "acquaintance," but based on a differentiation between the two. We suggest *mediation* and *material encounter* as measures of any such growing acquaintance and propose an initial model to map the resulting opportunities. Those opportunities are in the dynamics as much as in the differentiation. We hope to support discussion on two tiers. First, the separation model should help other scholars to position their own projects and/ or discuss craft-related interaction design of others in a new way. Second, we call for more coverage of the transitional states that thrive in workshop settings and educational framings. It is not enough to optimize a project or technology for a single use--in order to feed the necessary growing "acquaintance" we need to support transitional engagements between modes.

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