Making Design Tools Like a Weaver: Four rules

What would happen if we designed CAD systems like a weaver designs cloth? Drawing from our ongoing collaborations with weavers, we suggest four rules to bring these qualities to your own practice: follow the materials, privilege the present and personal, form kinships with the past, and design systems of notations.

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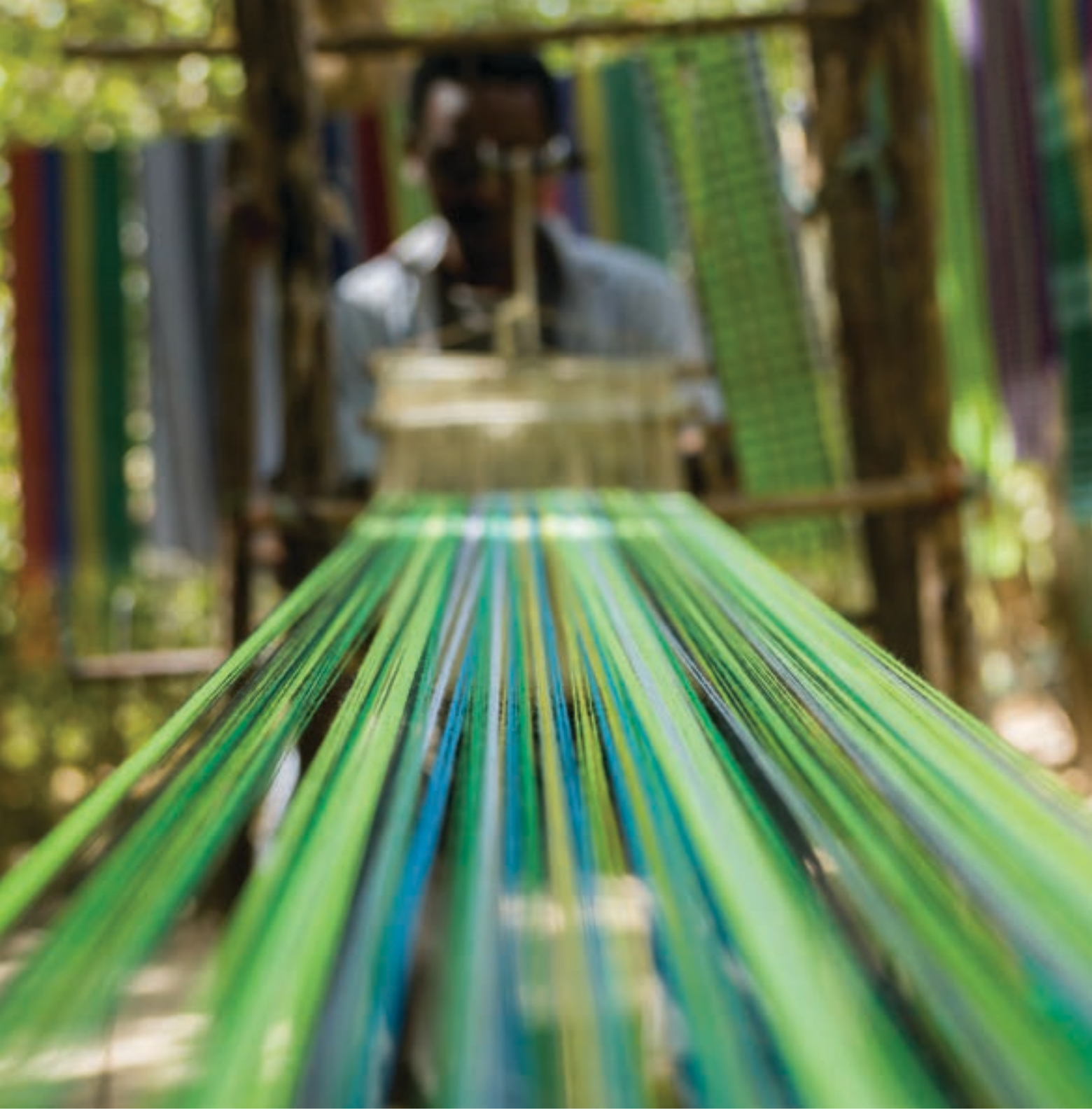
Consider the range of computer-aided design tools and ask yourself, what do they all consider "working" to be? Is working the ability to achieve a highly predictable outcome? Is working the ability to make the idea you had in your head? Is working the ability to create something you may not have otherwise envisioned? What else could working look like?

Could a CAD tool be less of an assistant and more of a collaborator? A conversation partner? Could it push back on you, shape your perception of facets of design you may not have considered? Could it be stubborn or unpredictable?

These questions are characteristic of a "critical technical practice"—a term originally coined by Philip Agre in relationship to the metaphors used to describe "intelligence" in artificial intelligence systems [1] and later summarized and interpreted by Phoebe Sengers et al. in their seminal paper on reflective design as a structured activity for challenging assumptions in design and generating new ideas rooted in alternative metaphors [2]. In that paper, they suggest a tactic of analyzing the central metaphors of a certain class of designs (in the present case, CAD tools), pick alternative metaphors, and explore how the designs would look differently when developed with the alternative metaphor in mind.

Applied to the context of 3D printing, we might see the central metaphor of desktop 3D printers as precision and fidelity to the digital model. Then, we might pick an alternative metaphor, like the ability to let the non-human forces shape the outcome, and develop an alternative system, say, a system in which you become the machine executing the 3D printer [3].

This is what we have been doing in the Unstable Design Lab. Making ma-



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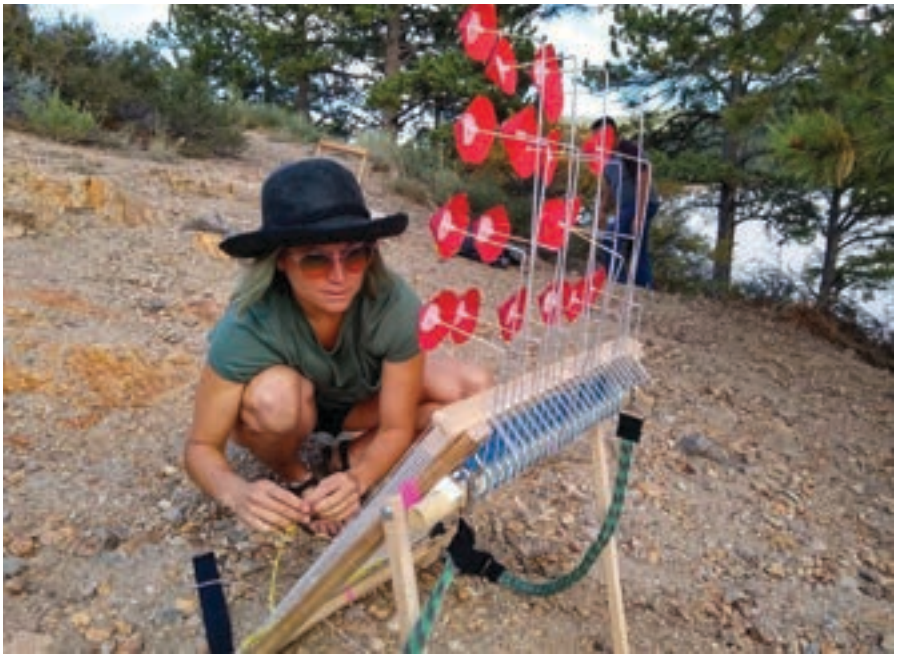
chines and systems that leave themselves open to the forces and whims of not just makers, but materials, histories, and environments. We trade efficiency and predictability of automated systems for the attention, skill, and humility that emerge through negotiation with machines and materials. The metaphor we prefer is "coproduction" [4] instead of "fabrication." So how do we create "working" computer-aided design systems that also create opportunities for collaboration and input from multiple human and non-human stakeholders in the design process?

We find the spirit of coproduction embodied in textile machines, especially weaving looms, in how they blur categories between machine and material, digital and physical, to a degree that it becomes no longer meaningful. These machines pre-date written history, allowing us to sit at the loom and mime the movements in our body performed by people through millenia. They are not "user friendly" in a conventional user interface sense, but they support virtuosity, care, and time with materials, people, and repetitive motion. They make cloth, a flexible and malleable material that we use for most everyday tasks from dressing, to

Figure 1. The wind loom in action.

Designed to provoke human-wind collaboration, the wind loom's red umbrellas get pushed by gusts of wind to create a pattern and then the human responds to the wind-specified pattern. In later work, we called this project "A Machine for Necessary Frustration," because we learned the loom might teach us more about the agency of the wind than allow us to create beautiful compositions.



wiping our faces, to covering our furniture. A weaver designs/programs the loom by threading different groups of yarns onto different frames and raising/lowering combinations of frames to produce cloth. The plan, or as weavers call it, a draft, is "loaded" onto the equipment and then played with a wide variety of materials to give rise to a range of cloth with different visual and textual properties. The draft/plan does not specify the outcome but creates a space within which a weaver plays with the emergent outcomes of their state of mind, material choice, and pattern choices.

How might we design CAD systems as a weaver designs cloth? Through practice, we've distilled this question into four rules that we invite you to take up in your own practice as a thought experiment or perhaps a start to a new project.

RULE 1: FOLLOW THE MATERIALS

In borrowing from Jane Bennet's vibrant materialism [5], we describe a material as anything (physical or not) that has the capacity to affect. This leaves materiality, or the concept of what can be a design material, open to the maker's perspective of what they allow to affect them—be it craft materials like yarn or clay, or histories recently read from a book. Design materials, then, are not simply the stuff our design is made of, but the number of forces one chooses to bring to the process of production. To follow the materials is to give these forces agency in what and how you go about making. It asks the maker to listen to the behaviors of the materials, what they are doing, and to design with them to co-create an outcome.

Tools shape our perception, and thus CAD tools are part of the forces that shape making, shaping (but not determining) how and what we pay attention to and in which capacities. Our tools, then, become channels of communication between makers, materials, environments, and cultures. We attempted to push this concept to the extreme in our efforts to create an interface for the wind to create woven design patterns (see Figure 1). The collaboration of weaver and machine was to seek out environments with interesting wind patterns to capture or encode into the structure of cloth. To make the loom, we attached the tensioned yarns of a tapestry loom to umbrellas that would be pushed by the wind. The process asked us to consider local wind patterns as much as the mechanics of force and fulcrums that would effectively move the umbrellas back and forth and it soon became clear that the wind, as poetic and powerful as it can be, did not want to work on our time schedule. We spent days, weeks waiting for the wind to come in just the right strength and direction to make our loom work and when it did come, we found ourselves fussing with the yarns we were trying to insert as they flew away. The loom, then, didn't make amazing creative outcomes or illuminate the "hand of the wind", it did, however, shape our understanding of the wind and create spaces for us to sit outside on a blanket, with the loom, and wait for gusts of wind.

Weavers intuitively understand how their actions on a loom give rise to both aesthetic and mechanical effects in the cloth itself and among weavers.

Following the materials, to the extreme, created a machine that was not for making cloth, but for making us better understand our design materials. Like many collaborations with materials that do not bend to our will, it cultivated within us a sense of humility and an awareness of a rich history of looms produced historically to allow portability and use within the natural environment (e.g., backstrap looms). It was an example that provoked us to ask, do we really need to realize a preconceived idea of success for our machine to "work." The work it did was on us, as makers, rather than on materials, and points to a broader space of tools and systems that ask us to be better observers of the creative forces in which we live.

RULE 2: PRIVILEGE THE PRESENT AND THE PERSONAL

In human-centered design, we're often asked to determine a population for whom we are designing and to hold firmly to the idea that "you are not your user." Working in textiles and drawing from the practices of weavers who follow their impulses and curiosity, shows us the value of attending closely to our own experience in design. Such an approach shifts attention from user needs to the felt experience the self has when making. What does it feel like to use the tool, to touch the materials, to move in harmony with a yarn? What habits of making do we know through design in a tacit and embodied sense that we cannot articulate?

To illustrate this approach, consider the work of Mikhaila Friske who has devoted their Ph.D. studies to explore how we might understand data through craft. While this began with the design of tools for bringing computational approaches and data to the design of textile objects, like woven cloth and crochet, they became increasingly attentive to the places where their experience and the representation of their experience, through data translated into craft objects, did not align. This prompted questions about what gets lost in representations of data; what facets of human experience resist enumeration; and what opportunities might ambiguity in data objects afford? This has led Friske to work closely with collaborators and fine artists to understand the role of data within their making practices and to, especially, explore the places where their interpretations differed. These differences, or fractures, in the process of data representation become opportunities for conversation and shared understandings. They challenge the notion that there is one "true" narrative in a data object and that leveraging ambiguity can also bring about different emotional sets and visceral experiences [6]. The ultimate form of Friske's thesis research does not aim to make grand claims about how we ought to represent data, nor why we ought to reject representation. Instead, it creates a workbook for a reader to take up the embodied experience of crochet and prompts them to consider the relationships between crochet, data, and lived experience on their own terms through activities and reflective prompts.

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In this case the design tool did not take the form of a digital interface, but a book that leaves the design activities open-ended and subject to the interpretation of the maker [7]. The choice to use a book emerged after attempting to make playful interfaces that ultimately felt too rigid and dependent on digitized data, which had already been cleaned and sanitized. Drawing from the history of craft workbooks and exchanges, as well as projects like Dear Data and the Dear Data Workbook, the workbook allowed us to conceive a design tool as a prompt and space for collecting responses to the prompt that embraced the messy and analog practices of sense making that happen during a craft project. The physicality of the book asks for a different relationship than a digital app or screen, a more quiet and less backlit space for making and contemplation that mixes the activity of diary writing with object making.

RULE 3: DESIGN SYSTEMS OF NOTATION

One thing can be called by many names—a tool, instrument, interface, system—but what we choose to call our tools will also shape what we think they ought to include or not. We advocate that we design CAD systems as notation systems, like sheet music, which mark a series of events and actions. To do so is to specify processes alongside the product and to create your design space as an ecosystem within which many different operators and pathways between operators can co-exist. For us, designing notation systems is a gesture toward posterity as what can be manifested in a tool, and labeled, becomes visible in new ways and to new audiences.

This approach is best illustrated through our development of AdaCAD, a computer aided design tool for making woven cloth [8, 9]. AdaCAD applies the framework of parametric design to the domain of woven structures. In making AdaCAD, we worked closely with our own experiences as weavers, as well as with the community of "complex weavers" to understand their thought processes and needs when designing woven structures. Weavers intuitively understand how their actions on a loom give rise to both aesthetic and mechanical effects in the cloth itself and among weavers. There exists a well-known set of operations for achieving particular textures or for addressing "problems" as they arise. These techniques are called many names, as traditions and languages used in weaving still vary geographically. Because part of the goal of the AdaCAD software is to create a mutual platform for communication between textile artists making cloth and engineers who need achieve specific electrical/mechanical properties in the cloth, the choice to render these knowledges as sequences of parametric design operations served as a notation for one's process. It also allowed for the possibility of other audiences, say, those more interested in parametric tools, to see weaving as a domain within which similar principles apply.

In the AdaCAD case, designing a system as a notation system implies that the notation will be used and interpreted by different audiences through a common frame. It also invites misuse, as the notation can be taken up by someone else as input to a musical program just as the experimental composer John Cage interpreted the blemishes on a piece of paper as moments for musical expression. CAD as notation, as opposed to domain or outcome specific CAD tools, creates open and (our favorite word, unstable) systems that offer themselves for use, misuse, and creative play within the necessary processes of documenting one's process and approach.

RULE 4: CONNECT WITH HISTORY

Beware of the word "new." Often, when we use it, we aim to distinguish ourselves from the past. Yet, craft traditions and building traditions are rich sources of community, inspiration, and new techniques. This is especially true in textiles, where we can learn techniques for new circuitry from gold embroidery as much as specific tools like the Lilypad Arduino. Our last call is not to reject the idea of newness and innovation, but to carefully maintain your connections to the past and honor the sources of knowledge upon which you are building.

If you ask a weaver about their most used tools, they may point to a big, complex loom like the Thread Controller 2 (TC2) digital jacquard loom in our lab, but they may also show you a simple tapestry loom or a humble sewing needle in the same response. The simplest, oldest textile technologies are still important to contemporary crafting, coexisting with their newer evolutions. Another member of the lab, Shanel Wu, made this observation when they realized they preferred weaving e-textiles prototypes on a traditional floor loom rather than the TC2, even though the TC2 allows for the computer control of more complex patterning. However, this complexity means the weaver has to meticulously create a design file that represents the whole fabric, all before touching the TC2 and seeing how the fabric would weave, making it difficult to follow the materials and change the design at the loom accordingly.

The Loom Pedals project became an exploration of how we might use the complexity afforded by the jacquard loom with the improvisational abilities and material responsiveness afforded by other looms. Specifically, the project consists of a system of foot pedals, like effects pedals used by musicians, that can send instructions to the machine in real-time. The pedals allow someone to walk up and weave on a TC2 without spending any time preparing a file in other software, closing the loop between weaver, materials, and loom. The Pedals' hardware input allows for the draft to not be delivered as a monologue, but as individual lines of dialogue and ad-libbed improv. The Loom Pedals build on AdaCAD, adding hardware elements for interacting with the loom as a co-producer. Each pedal links to a parametrized operation, so stepping on a pedal triggers the software to simultaneously update the pattern and send the new design to the loom for production. Thus, Loom Pedals add vocabulary and nuance to the exchange between weaver and TC2. By recovering features of weaving present in older forms of looms (shaft looms/floor looms), it begs the question: Can CAD draw out histories and alternative voices into the futures we make?

What gets lost in representations of data; what facets of human experience resist enumeration; and what opportunities might ambiguity in data objects afford?

CONCLUSION

We offer these four rules as a gesture to ask you to give permission to do things that might not feel like "good science" but open different paths of connection and ideation that cannot be made possible through other methods. We also want to be careful not to misrepresent weaving and weavers; their practices, values, and traditions vary drastically. Our rules, then, are a codification (or notation perhaps) of what elements weaving has brought to our practice. Namely, they have allowed us to do the work of technical development while being mindful of the connection and relationships we want to maintain with our families, communities, and environments. They allow us to see alternative presents or "proximate futures" where we might form different, more mutual relationships with our making technologies that produce more artful, and sustainable, interventions into our worlds. We invite you to take them up as provocations in your next ideation session to see what emerges.

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Biographies

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