Making at the End of Nature

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Insights

- The conceptual distinction between nature and culture is morally irresponsible yet widely recognized.
- Entrenched disciplinary boundaries frustrate attempts to work outside of the nature/culture divide or to create a new, hybrid basis for responsible action.
- Progress has been made but more concerted efforts are needed to fully recognize the hybridity of nature and culture.

The rim spin of the satellites around the planet has ended nature ... When you put the earth inside a manmade environment the earth becomes an art form ... and nature is over ... ecology is born ... The idea of a totally programmed planet takes the place of just a haphazard nature [1].

What I take from geo-engineering is that it helps us to think ... about what we might wish to try and plan to do as well as what we might wish to avert ... Examining the world in this way, appreciating it in its complexity the way you can only appreciate complexity if you are actually trying to think about how to change it. That's a really valuable thing, that's a valuable way

of looking at the world, thinking about the world as an artificial place [2].

It seems naive—if not potentially criminal—to maintain the belief in a separation between nature and culture, between society and technology. The above quotations, separated by almost 50 years, demonstrate that the commingling of human and non-human agencies is not in itself a recent conceit. The first quote is from a speech given by Marshall McLuhan on the event of the first international television satellite transmission in 1967. In it, McLuhan notes the way enclosing the earth within a “rim spin” of satellites turns

it into an “art form” and an “ecology.” Here McLuhan is emphasizing the ways in which human agency becomes complicit in the production of a world that is no longer entirely natural. The second quote is from a radio interview with Oliver Morton, author of *The Planet Remade*, a 2015 book on geo-engineering [3]. Both here and in his book, Morton continuously emphasizes the artificiality of our environment after hundreds of years of dramatic human intervention. Rather than argue for what he sees as an impossible return to a “pure” natural world, Morton encourages us to acknowledge our complicity in, and to move toward, deliberate rather than accidental interactions. Importantly, Morton emphasizes the ways in which understanding the complexity of a world that is already artificial is helped through considerations of how we might intervene differently.

Both McLuhan and Morton highlight the role of making as a source for intervention and, equally, as a source for thinking about how and why we intervene. The idea that making is a reflective and cognitively complex process that generates both material effects and conceptual insight is, of course, commonplace these days. Whether under the frameworks of constructionist pedagogy, reflexivity in practice, concepts of craft knowledge, or generally under the auspices of the “Maker Movement,” a continued belief in the value of hybrid material-conceptual work is evident. But how, specifically, can making serve us in a world in which nature and culture are interconnected? If we acknowledge how we are collectively remaking the planet, what, then, are our responsibilities as citizens, scholars, and researchers of human-technology relations?

My own response to this challenge has been to study and perform what I and others have generally called *critical making* [4]. Critical making

employs modes of engagement with sociotechnical work that incorporate criticality, intervention, and reflection, based on an appreciation of nature-culture hybridity. Rather than focusing on a method or a specific practice, critical making involves an evolving series of commitments that include a sense of complicity and responsibility for the state of the sociotechnical world and a desire to transform it. Critical making research also attempts to better understand the ways in which sociotechnical transformation is limited by prevailing ideas about what constitutes legitimate academic work in different disciplines. This epistemic goal is necessary given the ways that critical making work tends to run up against the traditional structure of academic disciplinarity. Many disciplines continue to operate under the assumption that knowledge associated with the natural world—the natural sciences and engineering—and knowledge associated with the social world—social sciences, humanities—should be studied separately. This reduces the capacity of individual researchers to carry out work that takes the nature/culture configuration of the world seriously. Nature, so goes the architects of the university, the grant agencies, and the funders, sits over there in the engineering buildings and the science labs. Culture, on the other hand, sits over there in the English department, the design school, the anthropology and media and communication faculties—to name just a few of the more prominent locales of cultural exploration. Such separations make it extremely hard to engage with what ecologist Eugene Stoermer and atmospheric chemist and Nobel Prize winner Paul Crutzen have called the *Anthropocene* [5], a term they use to signal humankind’s growing influence on the global environment. McKenzie Wark [6], among others, has used this term to signal the deeply

interconnected social and technical world that characterizes this moment in historical time, and to highlight the need for new theories, new strategies, and new conceptual tools. Slavoj Žižek, in his review of Wark’s work, starts with the point, “If there is one good thing about capitalism it is that under it, Mother Earth no longer exists” [7]. Žižek’s point here is similar to what McLuhan meant by “the end of nature” and Morton describes as “the planet remade.” When we can no longer depend upon the possibility of a return to a homeostatic nature, to a rebalanced Mother Earth; when we can no longer rely on purity at all—what are our options?

The stakes are therefore high—nothing less than the fate of our planet—and raise other questions, such as: What should we be doing in an age of geo-engineering to fully address the hybridity of nature and culture? What are our responsibilities? Importantly, what are the intellectual resources that we can draw upon to figure this out? It is clear that the desire exists to explore alternative conceptions of the academic enterprise with work in design and HCI, and scholarship in fields such as information, informatics, science and technology studies, and the digital humanities, all often focused on opening space for addressing the hybrid sociotechnical world. More recently, novel programs such as those in “design informatics” at University of Edinburgh, “culture and technology” at the University of Toronto, and “interactive arts and technology” at Simon Fraser University work against the disciplinary boundaries described above—and these are just a few examples. But for many reasons, a sophisticated approach to the hybridity of nature and culture remains for the most part on the fringe of research in many disciplines, including, unfortunately, HCI [8]. I do not want to underestimate the restrictions that continue to be imposed by structural influences such as funding agencies and university accounting structures. However, I also think we can do more directly and substantively to come to terms with this gap. This is only to say again that we are all complicit and responsible. Perhaps, more simply, the real issue is how traditionally technically focused disciplines can incorporate and develop theoretical

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and methodological insights that will support an apprehension and appreciation for culture while retaining their current strength in understanding and negotiating with nature. Equally, how can traditionally socially oriented disciplines incorporate and develop theoretical and methodological insights that will support their apprehension and appreciation for nature while retaining their current strengths in parsing culture?

RECONCILING THE GREAT DIVIDE BETWEEN NATURE AND CULTURE

A starting point is to rethink the relationship between humanity and technology. This has long been a theme within academic scholarship, particularly in disciplines such as those named above, whose focus is on the co-construction of human social relations and technological systems. Such work is often directed toward bridging what has been termed *the great divide* between social and technical understandings [9].

One of the best-known and widely used rearticulations of this divide occurs in Donna Haraway's *Cyborg Manifesto* [10]. Haraway emphasizes that both science fiction and contemporary medicine are “full of cyborgs, creatures simultaneously animal and machine, who populate worlds ambiguously natural and crafted.” Her goal in analyzing the cyborg is to rework the relations between nature and culture, so that “the one can no longer be the resource for appropriation or incorporation by the other.” Her core insight is that such a reworking is equally problematic for “Star Wars [11] apocalyptic visions” of the future as well as progressive social and environmental movements, both of which require a strong divide between technology and humans in order to support their arguments. While the former uses technology as a mode to dominate social reality, the latter calls upon an imagined original natural world as a site from which to resist domination. Haraway, while recognizing the increasing need for resistance, argues that such resistance would be stronger through the rejection of the nature/culture divide and the recognition of the hybrid natural-cultural world as a starting place.

Bruno Latour has similarly explored hybridity in his own work, using equally rich metaphors to highlight the incongruity of a pure separation between humans and their environment:

Naked humans are as rare as naked cosmonauts. To define humans is to define the envelopes, the life support systems, the Umwelt that make it possible for them to breathe. This is exactly what humanism has always missed [12].

Like Haraway, Latour's goal is to provide a counter-example to the “official” grand narrative of modernity and technical progress. In this story, humans are constituted as agential, self-reliant, and complete actors who make and use tools to solve the issues engendered by an uncontrolled and uncontrollable nature. The purity of human agency is perturbed rather than constituted by what we might call cultural features—laws, social rules, cultural mores and norms, ethics, and so forth. In the best cases, such “social shapings” should be minimized to support the widest engagements of humans in their fight with nature. Technologies feature only as aides to this battle, as passive enhancements of human agency that work transparently to increase human capacity. But Latour also notes the “unofficial” story of modernity, one of partiality, affect, and engagement—a story that (secretly)

highlights the constitution of humans through their material and social attachments. The cosmonaut quote here emphasizes these attachments, noting that defining humans cannot stop at their skin, their physical envelopes, but rather must expand outward to incorporate the systems by and through which they live.

Whereas Haraway pulled her examples from science fiction to make the point that the great divide was untenable, Latour uses more mundane changes in modern life, namely the expansion of the term *design* in current discourse. For Latour, the meaning of the term has grown to include a much wider scope of objects, as well as more of the processes by which they are produced. Objects such as iPhones can be designed, but so too can cities. Design does not refer just to processes by which the surface features of objects are reshaped to make them more desirable, but also expands to include the totality of the objects themselves. For Latour, such expansions are a “tell tale” of a change in the ways in which we understand the relations between humans and our material environments. To say that something is designed, whether it be a city or an iPhone, is to claim the role of human agency in its production. It is, as Latour puts it, a change from considering the world as made up of

“matters of fact”—solid, unyielding, inhuman—to seeing it as composed of “matters for concern,” things that stand in relation to humans and must be debated, discussed, critiqued. Design is the linchpin here that reconnects the wheels of nature to the axle of culture and makes it possible for the development of hybrid approaches and practices.

Design as a field and as a set of concrete practices has long embraced such hybridity. Participatory design, for example, developed initially from a specific social/political issue, namely relations between labor and management, but has embraced a much broader sociotechnical agenda in recent years [13]. Similarly, critical design, a term most associated with Tony Dunne and Fiona Raby, lays out a framework of design as research, with the overt goal of moving our understanding of technological objects beyond the current dominant values of optimization and labor saving [14]. Scholars such as Bill Gaver carry out practices of “ludic design” [15], creating objects that encourage users to think about social issues and to engage in open-ended activities—play—rather than provide simple, deterministic answers. Carl DiSalvo engages in “adversarial design” [16], a bridging of Dewey’s construction of publics with Chantal Mouffe’s adversarial politics. All these forms of design (and others) share a set of common features that can help extend hybrid social-technical work beyond the fringes of HCI and related disciplines. These features include a bridging of disciplinary separations between aesthetic, social sensibilities and technical goals and needs; an overt political or social agenda; and material engagements with these agendas intended to facilitate and encourage reflection rather than create objects of propaganda. These are not newly discovered features of design, as the work of Andrea Branzi [17]

and Ezio Manzini [18] demonstrates. Instead, they describe a continuing engagement between criticality and practice within design, the value of reconnecting nature and culture, and the centrality of design as a distinctive “third way” between the humanities and the sciences [19].

VERTIGO OF TECHNICAL AND NON-TECHNICAL DISCIPLINES

This is not to say that the path ahead is easy. While design broadly construed offers a way to instantiate the pragmatic and conceptual commitments of critical making listed above, the hybridization that is required is often uncomfortable both individually and institutionally. Phil Agre’s development of what he terms a *critical technical practice* [20] stands as an important statement on the difficulties in bringing together critical social analysis and technical practice. He defines critical technical practice as requiring the development of a reflexive mindset by technical practitioners such that they become able to analyze the dominant and marginalized forces within their own disciplines and therefore reveal the workings of these forces within current technical systems. Engaging in this kind of critical reflection provides the impetus to unpack the values and assumptions inherent in processes of technical work. For Agre, these values persist within the ordinary practices of technical disciplines and are related to the “self-reinforcing conceptual schemata” typical to these disciplines. Reflecting and revealing these schemata creates the possibility for designing and developing technical systems predicated on alternative values.

To explore these themes, Agre draws deeply upon reflections on his own transition from an engineering discipline (artificial intelligence) to a social science and humanities context.

It is these reflections that serve as one of the major contributions Agre provides to the development of critical modes of making. One particular challenge Agre notes regarding his own attempts to link critical social theory and technical practices involve the ways in which discursive, epistemic, and historical differences between technical and social disciplines enforce certain value propositions. For Agre, the main epistemic dimension of technical disciplines such as AI is the requirement that conceptual insights—no matter how complex, well-described, or defended through existing literature—must be legitimated through their instantiation within technical systems. Typically, for these disciplines the “only legitimate form of critical argument is that ‘my system performs better than your system.’”

Key to Agre are the limitations of technical functionality—“better performance” as the primary mode for evaluation of insight. But he also uses his own experiences to describe how difficult it can be to move beyond such modes of evaluation once they have been instantiated within a discipline. Specifically, while Agre acknowledged an ability to read work from outside technical fields, he also felt that “I had incorporated the field’s taste for technical formalization so thoroughly into my own cognitive style that ... I insisted on trying to read everything as a narration of the workings of a mechanism.” His breakthrough came when he decided to try to read humanistic texts such as Heidegger’s *Being and Time* and Garfinkel’s *Studies in Ethnomethodology* on their own terms—not as specifications for technical systems, but as descriptions of everyday life. Doing so required him to change his understanding of the precision of language, to see a different sort of value in what he was reading, and to develop not just new vocabulary, but a whole new way of parsing the problems he was trying to address. Agre’s description of how he felt as he began to bridge between technical and non-technical discourse is evocative:

I still remember the vertigo I felt during this period; I was speaking these strange disciplinary languages, in a wobbly fashion at first, without knowing what they meant—without knowing what sort of meaning they had.

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I have encountered similar issues while studying interdisciplinary work between classical archaeology and computer science. Drawing upon the classic work of Gregory Bateson, I described the resulting situations as *epistemic double-binds* [21]. Bateson emphasized the ways in which “double-binds” result in situations in which there is seemingly no way out for individuals. Epistemic double-binds work similarly and happen when, in cross-disciplinary work, the value propositions of one discipline stand in opposition to the other. This conflict produces moments of misrecognition by adherents to the traditional disciplinarity on both sides. Such double-binds cannot simply be willed away; addressing them requires concerted effort. As Agre’s description of “vertigo” highlights, these difficulties often come as much from ourselves, from our own inculcated modes of understanding and evaluating our own and others’ work, as they do from institutional prerogatives and restrictions. Moving forward therefore requires us to remake the normative systems by and through which we carry out scholarship.

FROM ACADEMIC CRITIQUE TO SITUATED INTERVENTION

Can we embrace the vertigo described by Agre, take seriously Haraway’s cyborgs, turn the important systems of the world from Latour’s “matters of fact” to “matters for concern”? Can we encompass these ideas and move toward productive hybrid research that leverages resources from both technical and social registers? More important, what explicitly can such perspectives provide for those scholars and practitioners who, at the end of the day, need to produce real systems, actual functional interventions? I turn now to examples from my own recent work that highlight potential ways to reconnect nature and culture within technically oriented projects—and the need to do so.

As noted earlier, since 2007 I have explored the ramifications of the term *critical making*, using it strategically and discursively to clear space for a form of work embedded in the social sciences focused on direct hands-on experiences with technical systems. I have written about this work extensively, so I do not want to belabor

Rosaline walking with her 3D-printed prosthetic.

the meta-level points here. Suffice it to say that my work has been squarely focused on bringing technical work more centrally into critical social scholarship, particularly academic domains that address the complexity of emerging sociotechnical systems. Some of the themes that I and others have explored in this way include the enclosure of the open Web, network neutrality, changing mediations of citizenship, privacy and surveillance, and big data and information visualization [4].

I bring these up not to toot my own horn but to point to the limitations of this work. While all of these activities have resulted in relevant academic insights and some impact (as measured by such things as citation indexes), none of them engaged directly with the sociotechnical systems they were intending to address. While serving a pedagogical function, the drag-racing robots that my colleagues and I created as a metaphoric engagement with problematic modes of Internet usage did not in and of themselves provide an alternative material conception of network management systems. Similarly, while the wearable experimentation and data-gathering and -processing work that occurred within a recent workshop on big data provided (we like to think) new insights

to participants, the question remains as to its wider impact. I highlight these gaps in order to make myself (and not my co-organizers necessarily) complicit in the limitations of academic work that purports to have a critical sociotechnical impact. Performed within the safe walls of academic conferences and journals, and in a few cases brought into forms of public debate through artistic exhibition, what effects can this kind of work have? Certainly such projects might provide potential guidance to those that attend to such genres, including policymakers, the designers and engineers building new systems, and financiers making decisions about what and how to build emerging digital technologies. And certainly the incorporation of design methodologies, technological and material work, and shared experiences and experiments with sociotechnical systems must enhance previous instantiations of critical work that were primarily discursive in analytic scope. But is this enough to address the critical issues we currently face as a society? Is this a sufficient response to the needs of a world marked by cultural and natural hybridity?

Since 2013 I have been involved in a project called 3Dprintability that serves as an alternative form of intervention. I do want to point out

that this project emerged somewhat accidentally from the intersection of critical making workshops on “DIY prosthetics” and the interests of nonprofit and hospital partners who came looking for assistance. While it has resulted in the development of a direct sociotechnical intervention into a critical healthcare problem in the developing world, this outcome was less planned and more from the sort of “drunkard’s walk” consistent with my own critical making processes.

As part of our ongoing research, we have developed 3Dprintability, an inexpensive 3D scanning, design, and printing toolchain designed and built to be utilized in orthopedic workshops in developing-world contexts to help increase access to prosthetics. Simply put, the system makes it possible for prosthetists and orthopedic technologists to scan, design, and print below-the-knee prosthetic sockets and ankle-foot orthoses. The system utilizes relatively inexpensive components, including a commodity 3D scanner (Sense, 3DSystems) and an open source 3D printer (Taz5, Lulzbot), free 3D design software (Meshmixer, Autodesk), combined with software that we have written ourselves (Orthogen, Nia technologies). Recently, we have also integrated our solution with a professional 3D CAD/CAM prosthetics and orthotics software solution (CanFit, Vorum Inc.) based in a strategic partnership between Nia Technologies and Vorum.

Currently undergoing its second clinical trial by Nia Technologies, a nonprofit started to scale and mobilize this intervention, 3Dprintability has been used to fit approximately 40 children with 3D-printed prosthetic legs and other assistive devices. Between July and December 2016, it is expected to be used in multiple clinics in Africa and Southeast Asia to fit approximately another 100 children. The purpose of this system is relatively

straightforward; using the current manual processes of plaster casting, rectification, and thermoplastic molding, a prosthetist in a developing-world clinical setting can produce a custom below-the-knee prosthetic leg in about 40 hours of combined manual labor and waiting time. Using our system, the same prosthetist can produce a similar leg in about two hours of labor and six hours of automated printing time. A clinic in the developing world can therefore increase the clients they serve many times over, using the same labor resources. This increase in service matters, since one of the biggest barriers to patients receiving devices in the developing world is the lack of trained prosthetists working in those contexts.

Viewing this work as simply a technical intervention into a social problem does little credit to the majority of the work associated with the project. While it has involved technical work including novel material testing, computer simulation, and the development of software and hardware, significant effort has gone into the social analysis that has informed our process. Such analyses have started from our deep commitment to the hybridity of nature and culture noted above and the related understanding that every decision we make is informed by and also shapes social and material conditions. This commitment has influenced every aspect of our project, from our choice of coding languages, software tools, and hardware, to the organization of the workflows. And we were helped in this goal by our deep connections to the social context and planned users from the very start of the project.

3Dprintability started in a rather unique way. Plastic surgeons at CorSU, an orthopedic hospital in Uganda, learned about 3D printing through a jaw reconstruction surgery in which it was used. In conversation

with a major nonprofit funder, CBM Canada, they expressed an interest in using 3D technologies to better serve their clients. Simultaneously, the leadership of CBM was reading media reports about the use of 3D printing to produce prosthetic hands for children. From this common interest, CBM reached out to the University of Toronto and ultimately to my lab to generate a research project. Following a series of in-person and distributed meetings with CorSU clinicians, CBM leadership, and Toronto-based prosthetics and orthotics experts, we decided to initially focus on lower-limb prosthetic sockets, viewing these as objects that balanced social impact and feasibility.

Around this same time, researchers in the Critical Making Lab were participating in a series of ongoing workshops focused on DIY prosthetics. These events were intended to involve the public in critical discourse about technology and human augmentation through engagement with prosthetics. The workshops, organized by artist, scholar, and curator Nina Czegledy, were open to the public and widely publicized through local artist groups and makerspaces, resulting in participants from a range of identities including makers, engineers, prosthetics designers, medical students, artists, and several users of prosthetics. The goals of the events were exploratory, and while they engaged participants in technical forms of work, including simple casting and some basic electronics prototyping, these forms were used to guide reflections rather than to produce novel devices.

I believe the workshop participants left the event with an enhanced appreciation for the complex ways in which technologies and bodies relate to one another and the importance of values such as ethics, privacy and security, autonomy, freedom, social acceptance, and dignity as a necessary part of any design process. But what is absolutely clear is what we the organizers walked away with: a much deeper appreciation for the complex relations between patient and prosthetist, and between bodies and prosthetic devices. For us, the workshops provided a concrete site where we experienced the hybridity of nature and culture, given the ways

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in which prosthetics wearers who attended our events discussed their bodies and their devices. 3Dprintability, as it developed, became a site where we as critical makers could extend, develop, and materialize the initial insights generated during the DIY prosthetics events.

While much of our thinking during the DIY prosthetics events focused on patients and their relationships to their own bodies, prosthetic devices, and social contexts, during 3Dprintability we found our focus shifting to that of the prosthetist. At that time, having read only initial media reports on projects such as Not Impossible's Project Daniel (<http://www.notimpossible.org/labs/project-daniel>) and the E-nable Foundation's prosthetic hands (<http://enablingthefuture.org/>), we had little appreciation for the role of front-line clinical staff in the production of well-fitted prosthetic devices. The media reports that attended the above projects highlighted the direct benefit of patients in need and the role 3D printing played, and understated or even ignored the role played by medical professionals. Prosthetists rightly resented the implication that their work could be easily replaced by technological processes, particularly given the craft-based skills they have developed as a profession. In fact, such activities and media coverage played into a longstanding tension in the prosthetics profession regarding craft, science, and automation through computational technologies. Our initial interviews with trained prosthetists pointed us to a much longer history with CAD/CAM technologies, with initial research having been done in the mid-1980s [22].

Such research was often framed around the expertise of the orthopedic staff, with computerization being seen as a way to overcome the subjectivity of the prosthetist in casting and fitting a patient [23]. In other words, as has been the case in other computerization efforts [24,25,26], the computational prosthetics systems of the past were generally seen as a way to add objectivity to a current labor practice in order to improve its efficiency and the tracking of outcomes. 3D printing of prosthetics was understood by prosthetists as another example of such a system, and they were rightly

Nina Czegledy speaking during the first DIY prosthetics workshop.

leery about participating in such developments. But at the same time, many of the prosthetists we talked to articulated a desire to engage with new technologies such as 3D printing, acknowledging this was the way the profession was moving and wanting to participate in order to assert their professional perspectives and skills as central to success. It quickly became obvious to us that we had to consider our system as situated in broader cultural arguments within the profession having to do with labor, expertise, technology, and relations to other clinical professions including orthopedic surgery. The success or failure of our system would be at least partially based on our ability to produce a system that adequately negotiated these tensions and helped create positive outcomes that were both organizational as well as technical. In fact, after observing prosthetics practices in clinical settings, we quickly recognized the skill of prosthetists and orthopedic technicians, particularly the ways in which they translated patients' own understanding of their bodies and needs into devices that were well fitted to both. We thus made the decision to develop our system in such a way as to enhance their current skills, a design criteria we ended up calling a *computational craft practice* [27]. We

often returned to this criteria to help us scope the choices and trade-offs we needed to make during development. One explicit example of this is how our software treats the possibility of design errors by our prosthetist users. Rather than restrict the ability of users to make such mistakes, we have instead added analysis capabilities to our software. When run, these tools highlight potentially problematic errors to users and give them the capacity to correct them based on their expert judgement.

Our development of a design value that favored user autonomy and control was thus driven by our understanding that the 3Dprintability system would produce both organizational and technical outcomes. This work did not stop at the level of the social organization of the profession but instead ratcheted out to even broader social concerns. Early on in our development process, we considered taking advantage of the capacity to distribute digital files. We imagined a system that would leverage the expertise of developed-world prosthetists to provide services to the developing-world contexts that were the target of our intervention. In such a system, technicians in the developing world would 3D scan patients and send the scans over the

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Internet to prosthetists in Canada. Using standard CAD tools, these prosthetists would modify the scans to produce a good socket and then send the resulting file back to the developing world technicians for printing and fitting onto patients. Such a system was very attractive to us since it involved relatively little technical development and could be deployed easily. Equally, it would take advantage of the technological expertise of local prosthetists and their expressed (to us) motivation to use their skills to improve the quality of life of prosthetics users in lower-income areas. Functionally, it would also solve the main issue our research project was intended to address: the lack of prosthetists and therefore prosthetics in the developing world.

Seen from a purely functional light, this distributed solution met many criteria. But viewed from the lens of global relations, it was far from adequate. A simple restatement of the central proposition makes its problematic assumptions visible; what we were proposing basically involved having the developing-world workers carry out the manual labor, while any expert work was done by professionals in the developed world. Not only did such an instantiation run the risk of reducing expertise in the developing world by replacing it with non-local experts, it also reified existing power hierarchies between the Global North and Global South. While functionally such a system might solve the initial issue, it would create new ones by reducing local capacity and increasing dependencies. We rejected such a proposition and ended up developing a system made to be used in-situ by local practitioners, despite the increased development and training requirements involved.

3Dprintability serves as a good example of a technically focused

project that does not minimize critical social issues. This project forced us to come to terms with the idea that all interventions are both social and technical and produce a system that took seriously a commitment to the interrelatedness of nature and culture. While I would like to think that some of the values that guided our work were based in our own longstanding engagement with this theme from a background in science and technology studies and the work of the scholars listed above, I also think we were a bit lucky. Our engagement was driven as much by the complexity of this issue, by our own experiences of critical making, and by the knowledge and expertise of our partners as by a background in sociotechnical theory and the scholars mentioned here. However, it was this scholarship that helped us come to terms with our partners, with their descriptions of the organization and professional complexities, and with the large-scale global divisions of power that mark work across developing- and developed-world contexts.

CONCLUSION

Earlier I expressed a need to move a sophisticated approach to the hybridity of nature and culture from the fringes of academic work in HCI and cognate fields to a more central position. While acknowledging the difficulties involved in such an operation, I also tried to highlight the ever-increasing need for such an endeavor. We are now capable of engineering the planet; we in fact have been doing so for some time, albeit in an uncoordinated way. We live in a world and a time—the Anthropocene—in which it seems criminal not to believe that nature and humans co-construct one another. Moreover, as the climate change scientists continue to tell us, there is no way back to a pure, original nature, no way to recover Gaia as a system

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apart from us. Scholars have been addressing this issue for some time, so there is no novelty in my saying it once again. Equally, scholars have developed patterns and practices within sociotechnically oriented work that attempts to use design as a “third way” [19], theories and methods that bridge socially and technically focused domains of knowledge. I use the term *critical making* to open up this debate and, at least personally, to remind myself of my own commitments to intervention, sociological sophistication, and technical engagement. More concretely, here I have described one project that engages deeply with this socio-natural hybridity in three key ways:

- as a site to materialize insights regarding the hybridity of nature and culture as part of a direct intervention,
- as a site to incorporate community-level values and engage with contradictory relations of expertise and status and the role of technology, and
- as a site where even larger social concerns, specifically relations between Global North and Global South, needed to be addressed.

To be clear, the above themes and the value-laden nature of sociotechnical development are obviously part and parcel of all interventions. This has long been acknowledged and even methodologized by design-oriented fields such as participatory design and value-sensitive design. My intention is not to diminish the importance of this work or to claim that the work we are doing in 3Dprintability is particularly novel. But I do want to highlight that our starting point, the origin of the values we are trying to support through our work, emerges from our general sense that addressing the large social, economic, and environmental problems we face requires a deep commitment to the hybridity of the cultural and natural world. In the first edition of the *Whole Earth Catalog*, published in 1968, Stewart Brand famously said, “We are as gods and we might as well get good at it” [28]. We might rework and transform this somewhat hubristic phrasing to better articulate our true position and relation to the hybrid natural and cultural world: We are as cyborgs and we might as well be responsible about it.

ENDNOTES

1. McLuhan, M. Nature is over. Recorded during Burrell, D. Our World. Documentary, Music, News. 1967; http://deoxy.org/audio/mcluhan_natureisover.m3u
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