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Living entanglement: toward an entangled design nexus

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Human-nature encounters more and more take forms of conflict, struggle, resistance, and denial. Beneath the surface question of "how to survive", these encounters reveal "entanglement" as the fundamental condition of the world. This new world view, supported by systems thinking and posthumanism, radicalizes the anthropocentric reductionistic belief. The shift informs a reposition of design from a method to produce (techne) to an invitation to co-becoming (phronesis). This article starts with a cross-disciplinary literature review to elaborate the concept of "entanglement" in three levels: relationality, co-becoming and blurred subject / object division. Then, a proposal of an "entangled design" framework is made. This framework is the output of a research through design process. Multiple vignettes of the design practice of an ecoliteracy program ("The Muddy School") is shared to illustrate how such "entangled design" could be done in practice. We propose a new design proposition that a) redistributes power, b) builds knowledge in an open-ended process, and c) catalyses creative emergence. We argue this new design proposition is not and should not be restricted to speculative works. Rather, it sheds lights in the actual worlding by expanding design's role into the world of organization/organizing. The possibilities of an "entangled" design approach may be further explored in various tactical design-making practices as well as organizational or political contexts.

Keywords: entanglement; complexity; systems thinking; organizing

1 Introduction

With COVID-19 leaving our doorway, we don't need to be reminded how unpredicted crises create panic and trauma. If previously chaos appears arguably an illusion enabled by technology and thus increased access to information, it is now clear that we are indeed living in a more turmoil time. Transdisciplinary readings of literatures in ecological thinking, systems thinking and posthumanism suggest seeing the world not as object for interpretation, but as conditions of "entanglements" weaving human and more-than-human together through spatial, temporal, and ontological connections. Human beings situate deeply in these "entanglements", both connected and confined at the same time.

Crises are not necessarily challenges dreading for solutions. Rather they provide feedback from real world and shed light on our flawed assumptions – assumptions that we live in a world under our

control and without constraints. In the context of sustainability, these ideas have been explored under the terms of "spaceship economy" (Boulding, 1966), "overshoot"(Meadows et al., 1972), a "full room" crowded with human being and its activities (Daly, 2004) and "planetary boundaries" (Raworth, 2017; Rockström et al., 2009). However, the confinement we are facing is not only static "limits" to be modelled and monitored to keep "sustainable" development in check (Meadows et al., 1992; Nordhaus, 1993). Rather, the confinement we are facing consists of layers of "entanglements" that weave human being in as a part of the condition itself. Solving one problem, consequences may arise in other connected yet unexpected places.

Led by feminist scholars in science and technology studies (Barad, 2007; 2002; Haraway, 2016), the condition of entanglement has gained popularity in humanities and social sciences (examples including Alaimo (2010), Elspeth (2016), Tsing (2015)). Within the field of design, more-than-human design (Forlano, 2017; Tarcan & Pettersen, 2022) started to challenge the anthropocentric legacy of human-centric design, and scholars in HCI suggest "entanglement HCI" (Frauenberger, 2019) as the new wave in HCI considering the complicated relationship between human and technologies. Despite these pioneering works, the vast of design field and particularly design specialisms like systemic design, service design and transition design eyeing on participation in wider socio-economic contexts are still dominated by a problem-solving mentality built on the basis of representation of static reality through various mapping approaches and a top-down understanding of design.

What does entanglement mean as a condition for design? How can we design with this updated understanding of the world and human's embeddedness in it? We set off with these research questions in mind. This article presents the outcome of a "research through design" (RtD) process (Koskinen, 2012), with a notable difference from conventional RtD projects in that the design artifact is not a product or service, but practices of organizing. An ecoliteracy education company "The Muddy School" was created by one of the co-authors in 2021 as part of the research process. The organizing of the company as a prototype of "entangled design" was tested in the "field" to generate new knowledge for theorization. As the lines between design and organization studies blurs, the RtD process at times resembles action research (Chevalier & Buckles, 2019; Lewin, 1946; Marshall, 2016), marked by a constant loop between theory and practice. On one hand we sought suitable theories of "entanglement" that matches real-life in various literature; on the other hand, practical design decisions were informed by theories. The Muddy School itself is a small experimentation in the field, however the learnings generated from this experimentation shed light on how design may play a bigger role in dealing with the conditions of entanglement and lead to systemic transitions in contexts beyond education.

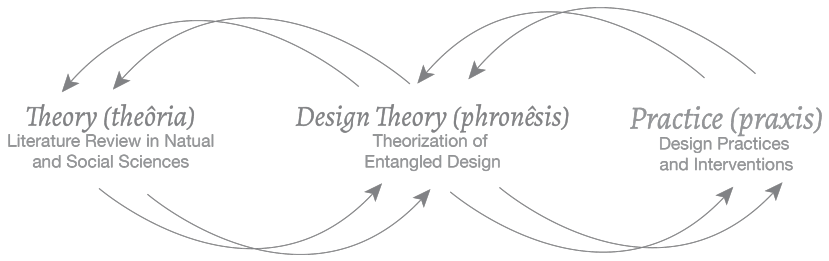

Figure 1. Entangled Design acting as the bridge between theory and practice, emerging from iterative research processes.

The detailed documentation of this RtD process requires a much lengthy writing than what this article could host, while for this article our goal is to summarize the key findings from this process which is an integrated framework of "entangled design" (Figure 2). Rather than deep dive in one or several theories relevant to entanglement, this article attempts to build a holistic understanding of entanglement weaving literatures in different disciplines including systems thinking, biology, ecology, complexity science, new materialism, posthumanism philosophy. In section 2 through extensive multidisciplinary literature review we construct a spatial-temporal-ontological framework to understand entanglement. In section 3 we explore new modalities of design under the condition of entanglement. We build on the systems thinking framework from Fritjof Capra (1996) to think of a new entangled design in its "Matter", "Process" and "Form". Each subsection in section 3 starts with a short vignette of practices in The Muddy School. The goal of these vignettes is not to prove validity of the framework, but to bring often elusive concepts to practical terms.

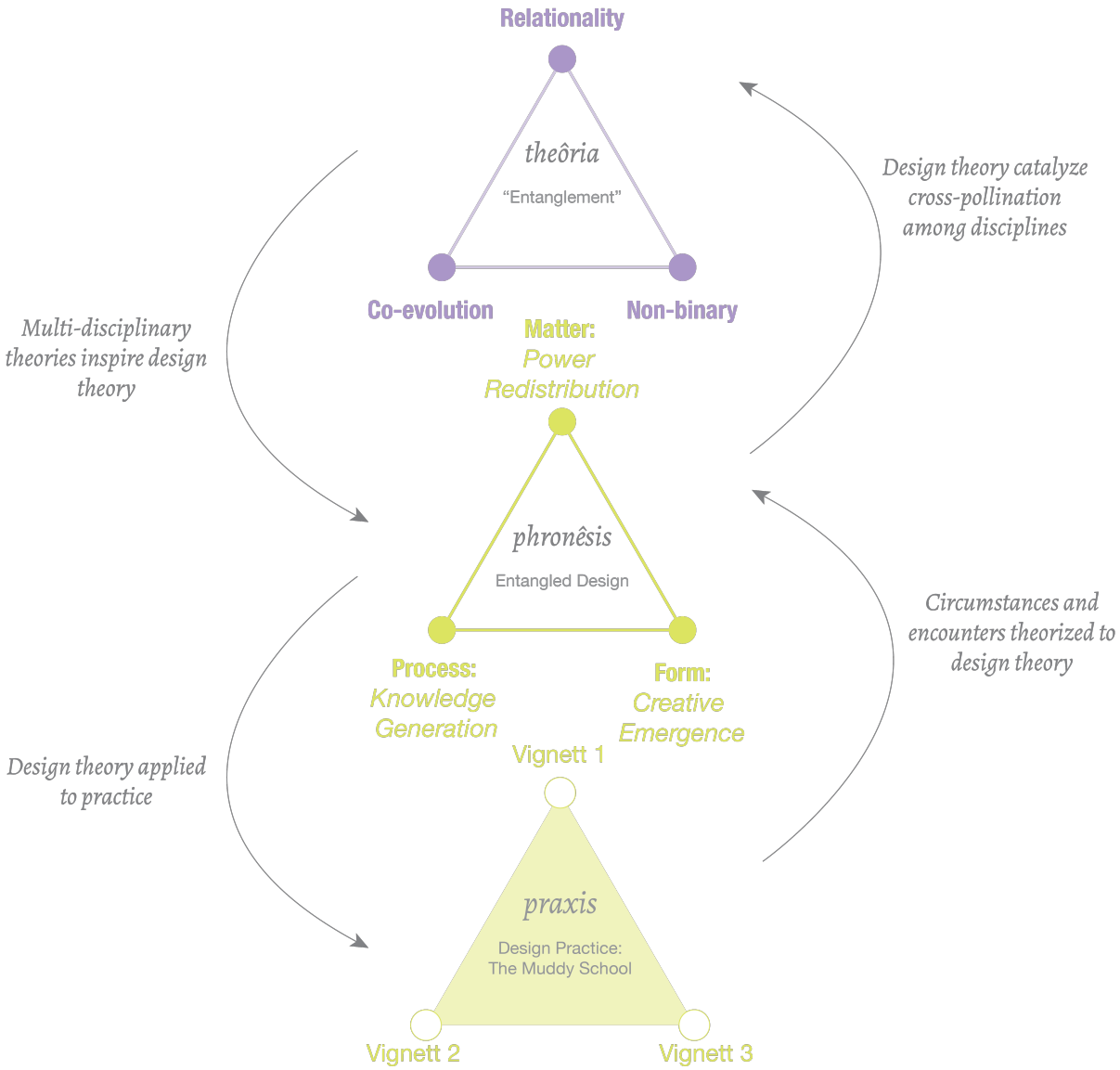

Figure 2. "Entangled" Design Framework

2 The condition of entanglement

The etymological origin of “entanglement” traces back to mid 14th century. In Scandinavian languages “tangle” (“thangul”) means “seaweed”, which entangles with itself, with other lives in the sea (e.g., fishes), or with inanimate objects (e.g., oars and nets). Very quickly the world “tangle” evolved with negative connotations – *taggla* in Swedish means “to disorder”. This linguistic evolution perfectly captures the essence and perception of entanglement – the norm in nature, yet with the spirit to search for ultimate order and control, it creates trouble.

In this section, we explore the conditions of “entanglement”. With reference to scientific discoveries in biology and ecology as well as systems thinking and posthumanism, “entanglement” is characterized as relationality, co-evolution and blurred subject / object division.

2.1 A still picture: relationality

2.1.1 Connectedness and correlation

Reductionism has been a powerful weapon for modern science since enlightenment. With accumulated knowledge in systems thinking, we now understand better how independent elements are connected by complicated causal relationships and form feedback loops. System Dynamics in the domain of Organizational Research, despite its limited scope of only human activities (in particular economic and political ones), provides valuable tools to analyze the complex causal relationships and their cumulative effect (Sterman, 2000).

The progress In ecology also helps us in our understanding of the relationality among organisms. Since Tansley coined the term “ecosystem” in 1935, our understanding of the ecological systems has expanded from hierarchical and systems to energy and information flow between landscape patches. Furthermore, organisms are not only connected through the trophic structure, but are all parts of the various layers of biogeochemical cycles (Schowalter, 2011).

The connectedness of and correlation between different cycles and systems complicate problems like climate change and pandemic. Thinking with systems in mind, human activities are viewed as disturbances pushing systems toward new patterns. Mapping the feedback loops in systems at various levels leads to emerging understanding which not only explains the visible symptoms like temperature rise, but also other consequences along with the evolution of system, as well as the ripple effect from correction actions.

2.1.2 Co-existence

Connectedness describes at the macro level how human being and its living environment are not segregated but part of the same world. For years the link between human and other species are understood simply as different ends of a food chain, or at best, nodes of a food web. This view has been seriously challenged since the term “symbiosis” was created in 1879, defined it as “simply the living together in physical contact of organisms of different species.” Orchid deceives wasp with the look of a female wasp sexual organ for pollination. Mycelium hidden underground not only decomposes debris into digestible nutrients for trees, but also builds the “wood-wide web” transporting nutrition and possibly information in the format of electric pulses. Symbiotic relationships are everywhere in nature and human beings are no exception to them. It is equally unimaginable to think of life without oxygen produced tirelessly by algae and plants and the bacteria within human body that accounts for 90% in terms of number of cells (Gilbert, 2009).

Symbiosis has also been researched at genome level, starting with the ground-breaking work of Lynn Margulis (Margulis & Fester, 1991). Research in microbiology finds out no organisms other than bacteria are not dependent on others. The intertwined relationship goes beyond exchange of energy and matter to exchange of genome, embedded in which the information about environment.

2.1.3 Indeterminacy

The rigidity and simplicity of Newtonian classic mechanics benefited us with rocket reaching the moon, but also inevitably implanted the belief that everything can be and should be measured and consequently controlled. This epidemic quickly spread from science to social aspects including the control of currency (treasury and international finance), of behavior through the utility (economics) and the unconscious (psychoanalysis). All non-linear equations were "linearized" immediately for modelling purpose; all unexplained errors were brushed off the table as "rounding errors" or "residuals" without further explanations.

It is only after our acquisition of computational capability that we could simulate non-linear correlations and with multiple feedback loops. Bifurcation and "butterfly effect" are good examples to understand how small negligible difference in initial condition can be amplified by feedback loops within one system and eventually lead to completely different outcomes. Interestingly, chaos is not the full story, as Capra suggests, "the behavior of chaotic systems is not merely random but shows a deeper level of patterned order" (Capra, 1996, p. 123). The simulation of non-linear equations in complex systems resulted in limited "patterns" in the form of strange attractors. The visual representation of Ueda attractor and Lorenz attractor gave readers an immediate dizzy yet assuring feeling – it is incredibly difficult to pin down which exact point in space or which curve we are in, but at least we know "roughly" the way it works. But don't forget even these representations are still simplified versions of real life – out of the many factors impacting atmospheric convection, Edward Lorenz only chose to start with three differential equations. Whether science will eventually map all the systems ever existed on earth is beyond the scope of this essay. For now, we go with Bateson that "science probes; it does not prove" (Bateson, 1979, p. 30). What science and all our other encounters with nature are probing is not one "truth", but the extended networks and feedback loops that weaves our destiny unbiasedly with all other things around us.

2.2 A process: Co-evolution

The connections between human and more-than-human are not only correlational within a specific time frame. The analogy of tree can be misleading in that it creates an image of evolution of species independent of each other. Rather, different living beings play roles in each other's becoming and therefore making histories an intertwined co-evolution.

2.3 The Agency of more-than-human in worlding

History-making has always been a human thing–- ground-breaking discoveries by scientists and changes affecting millions of lives by politicians. But how is it possible for Alexander Fleming to discover Penicillin if the mold *Penicillium* doesn't grow on his agar plate in the first place? Agency of more-than-human actants can take various forms. Jane Bennett (2010) in her vital materialism discussed different kinds of "thing-power" constantly present and "producing effects dramatic and subtle" (p. 6) through the "contingent tableau" of transient coexistence of things, the self-organization of the inorganic matter, and "Shi" (势) the collective "style, energy, propensity, trajectory or elan

inherent to a specific arrangement of things" (p.35). Maybe the subtlety of the more-than-human's agency lies in the concept of tools or technics. With the anthropocentrism, everything spins around human and is only at disposal to human intentionality. That is exactly what Harman departs from Heidegger's Dasein (and maybe over-correct) with object- oriented ontology (OOO). Using Harman's words, "the human/world relation is just a special case of the relation between any two entities whatsoever", and the "tool-being" is a truth of all objects, not just of (human) Dasein.

2.3.1 Entanglement as structural coupling

In Darwin's account, random mutations happen to each species independently. The misread by Social Darwinism further distorted natural selection for mere "competition" among variants and omitted the aspect as an interaction between environment and living being. Maturana and Varela (1992) took up this issue and re-established evolution as "natural drift" where autopoietic living beings interplay with their surrounding and swing between stabilization and diversification. To distant itself from deserted Lamarckism and answer the question that how these acquired traits can be transmitted to their offspring, they discussed in detail the process of cell reproduction where variation appears due to "not uniformly distributed components of the original unity", which "are a function of its individual history of structural change."

Bateson (2002) looked at the "survival of traits" from the angle of "logical types". By thinking genetic change as the highest level of "logical types" of somatic changes, Bateson explained natural selection as a layered screening process using bias of homeostatic control. Once achieve homeostasis as the start point, the changes in surrounding exerts pressure to push body functions moving toward new ranges at several fronts to achieve higher flexibility at the price of deeper rigidity. Different levels of somatic changes ensures genetic change being made only when the change in environment is long-lasting or permanent. It is worth noting that the pushing up or down of functional ranges also present "opening and spreading of alternative possibilities for change", therefore making the natural selection not a one-shot live or death decision, but a continuous co-working between the living being's homeostasis and the environment.

Both Maturana and Bateson, with systems thinking and relationality deep in mind, have escaped from an isolated view of evolution. These works collectively demonstrated that the becoming of human being is a complicated history of entanglement. The recurrent interactions between environment, or more fairly, the human and more-than-human surroundings, leave traces not only physical but genetical.

2.3.2 Knowledge generation in entanglements

With all the development in artificial intelligence, deep mind, and brain science, it is easy to forget the term "cognition" simply means "to know". The concept of autopoiesis imply that learning is not merely transfer of knowledge, but a constant structural coupling and coevolution between system and its environment. Knowledge acquisition is not incremental, but involves restructuring of the existing knowledge system involving multiple dynamic loops until new balance is achieved. This is echoed by Bateson in his realization that both evolution and learning are "great stochastic processes" where the randomness of mutation and knowledge is selected by existing internal structures.

Not explicitly discussed by both Maturana and Bateson is the fact that the interactions in the form of structural coupling reveals the "emergent identity" of the organism (Varela, 1997). Importantly, this

new view toward not only shocks but also learning from shocks exempts the human being from the blaming game to a collective knowledge building process, which hopefully will lead to more constructive world-making actions.

2.4 An ontology – blurred subject / object

The co-evolution discussed in the previous section is dependent on the prerequisite of well-defined boundaries between the system and the environment. This confidence is however more and more challenged by quantum physics and microbiology advancements, indicating an even deeper level of entanglement.

2.4.1 Observer / observed

Since enlightenment, science has enjoyed the prestige of absolute "objectivity". Experiments and facts from laboratories are viewed as truth insulated from the complexity of humanity and subjectivity. This, however, is being challenged with the recent Science and Technologies Studies (STS) as an emerging discipline to explore the human dimensions of science. Trained as a physicist, Barad (2007) articulated Niels Bohr's epistemology that "the position and momentum are not simultaneously determinate because they require mutually exclusive experimental circumstances". With the experiment apparatus stepping back and forth across the boundary, the line between the observer ("agency of observation") and the observed ("object of observation") is blurred. This forms the foundation of her onto-epistemology where seemingly objective observations made by the observer are considered apparatus-dependent phenomena. It is no longer a metaphor to say that inanimate "things" like an experiment platform delineates observed (object) from observer (subject) with itself sitting in different sides of the edge.

2.4.2 The question of "self"

Postulated by Lynn Margulis, symbiogenesis is the speciation that involves "the inheritance of incorporated part of genome" acquired from outside of the organism, most striking example of which is the genesis of eukaryotes from incorporating bacteria in its nucleus. The entanglement is so deep in space and time, it is almost impossible to tell what is human and what is not.

The entanglement has behavioral and cognitive consequences too. "Holobiont", a term also coined by Lynn Margulis, is the assemblage of a host and other species living in or around it. It describes an ecological unit that is distant from our impression of an organism or a living being. Kramer and Bressan carried the concept further and claim that "we are not unitary individuals in control of ourselves but rather 'holobionts' or superorganisms", whose "emotions, cognition, behavior, and mental health are influenced by a large number of entities that reside in our bodies" – parasitic brain microbes putting our mental health under risk, gut bacteria making rats more adventurous, imprinted gene that has been silenced accountable for mental disorder.

The question therefore to be asked is not only "who am I", but also "what am I". What's inside human and what's outside? What is a part of human and what is not? What is the subject and what is the object? The cases listed above, even as exceptions, are sufficient to throw our long-hold dogmas about "identity" into an ocean of chaos, and to crack the special status human being has enthroned itself.

The boundary between human and more-than-human becomes porous. There is no perpetual "I" and "the other", the entanglement has long started and etched in gene and in flesh.

3 The Entangled Design

Aristotle makes distinction between knowledge on practical action (*poiesis* and *praxis*) and wisdom (*techne* and *phronesis*). Living in the backdrop of mass production and consumerism, design has long been associated with product and production–- a *téchne* that guides *poiesis* (making). This proposition becomes insufficient with the vision of design to create a better world. What will be unfolded below proposes a new proposition of design as *phronesis* rooted in and guiding *praxis* (action or living). This suggests design to moved away from the focus on artefact and toward wisdom to human's living and enactment in a world of coexistence.

3.1 Matter: power redistributed

"Entangled" design view the more-than-human not as tools or resources for exploitation, but as equals to human being. It deliberately shifts the power imbalance between human and more-than-human by practicing "art of attentiveness". Taking the autopoietic feature of social systems in consideration, the power imbalance between designer and audience is also adjusted to be non-hierarchical.

3.1.1 Vignette 1. Tell the untold story

Luk Keng was chosen as the first location running programs for its superior biodiversity. We designed three different trails in an area of one square kilometre including various habitats: brackish and freshwater wetland, stream, mudflat and rocky coast. Once we waded in knee high seawater at low tide to a little island topped with fine mud and shells, the other time children constructed a bridge over the inlet of stream to the sea with loose logs found around, yet another time they built a tree house in the woods on top of a nearby hill.

For many the most impressive experience is playing in the mangrove forest. Along the coastline hundreds meter of Kandelia candel ("秋茄") expands, with paintbrush-like viviparous plantlets hanging everywhere in spring. Some children imagine these plantlets as magic wands, others wrote with them on the ground. Boys usually quickly moved on to rock skipping in the same area and crab catching – oh those little shore crabs. For many it's the first time they see crabs alive and not in a supermarket / restaurant tank, nor as an illustration / picture next to a concept that always "has 8 legs".

In the context of education, "experiential learning" is considered beneficial for kids' sensorial, physical and social development. However through the lens of "entanglement", much of the point is missing if we stay at the experience level and so many stories of the wonderful *Kandelia candel* remain untold–- its biological features (viviparous plantlets, expansive roots, pumping mechanism, etc.) as a result of "structural coupling" with its harsh environment; its role in the intricate predatory "web of life"; its symbiotic relationships with organisms organisms from algae to crabs and egrets. This difficulty of "learning relationality" applies also for adults. In fact, we humans easily slide in the trap to reduce everything to human standard, assuming the more-than-human as static and passive without any agency.

What if places where organizations carry out operations, raw materials which are introduced into supply chain at different stages, and weather and climate which affect organizations more and more significantly nowadays are seen not as resources for exploitation and objects to be controlled, but as partners who play equal roles in constructing human's embeddedness? Three strategies including

translation, storytelling and rich description may be adopted to represent the under-represented more-than-human actants.

Anthropologist Anna Tsing (2015) uses “translation” to describe the connection embodied by the matsutake mushroom between cultural patches and value systems. By thinking themselves as translators, designers can proactively rebalance the power between human and mthe ore-than-human and become facilitator of communication and collaboration across cultures, values and different forms of knowledge. The rising more-than-human designs (e.g., (Christiansen et al., 2020)) started pioneering such translation for human beings to feel and think for the more-than-human.

Storytelling is another powerful tool bringing us closer to the more-than-human world. Relevance to lived experience works beyond rationality in the realm of affect. For adults the mangrove life resonates easily when compared to their hardships of middle age trying to weather career, keeping healthy and taking up family responsibilities. For children such hardship doesn’t appeal. Rather, they see themselves in the “baby” viviparous plantlets and are never bored finding homes for insects and small mammals, as these experiences are a big part of their own life. These stories bridge theory / concept and the real world and lead to slower pace of moving and more attentiveness.

Anthropology has a lot to teach us in telling intimate more-than-human stories. Several bestsellers in shifted the center of story to the more-than-human (e.g., insects, trees, fungi) by weaving narratives around them (Govindrajan, 2018; Kohn, 2013; Tsing, 2015; Winegard, 2019). Voices have also been raised in the field of social sciences favoring a more “descriptive” approach than rhetorical ones (Vitellone et al., 2021). All these point to a direction where more neutral facts are given allowing multiple / subjective / local adaptation, which design can surely adopt in both its process and outcome.

To summarize, to incorporate the more-than-human world as partners by deliberately rebalance power through translation, storytelling and rich description helps to move our relationship with the more-than-human world from isolation toward more correspondence (Ingold, 2000).

3.2 Process: open-ended knowledge building

“Entangled” design shifts from outcome-driven to process-driven. It seeks to continuously capitalize encounters and conflicts as opportunities for mutual learning. The knowledge-generating process becomes the result of design.

3.2.1 Vignette 2. Bug / human attack

Dotty is one of the kids we welcome repeatedly in our camps he is a bug-spotting expert. A lantern bug on the tree trunk and another stick insects on the shore are just two examples demonstrating his superior spotting skill. Toward the end of that camp day, a bright red bug in the shape of a hexagon caught his eye. A white line cuts in the middle of its body like Fontana’s sword piercing through canvas and leaves a sharp mark, with two strings of pearls hanging symmetrically on each side. Unexpectedly, Dotty caught the bug with his hands. Instantly we smell something vaguely stinky and unnamable suspicious. His finger turned orange yellow right away.

Dotty might have been blind if the liquid injected went into his eyes. After following up with Dotty’s parents and making sure he was fine, we reflected on the accident and children’s reaction. It is an accident out of our control, and we could teach children to keep away from

any bugs thereafter. Telling them that "bugs are dangerous and may make you blind" can easily save us from any troubles down the road from parents, but is the human-bug relation that simple?

3.2.2 Conflict as opportunity

If we accept the idea that human is only one of the many actants, then bugs also have their centre of universe and thus defensive mechanism when attacked. The accident can be viewed as a perfect opportunity for storytelling from the other's perspective. This thought led us to make an enlarged 40cm tall cardboard model of stink bug with a sprayer hidden in it. On our next trip, Dotty, knowing nothing about the sprayer, played himself as a human being attacking the bug, and was caught by water spray in full surprise. Through role-playing predators – bird, spider, human–- they start to truly empathized with the bug. What to do next time when we run into similar situations? No "right" answer was given. Individual choices remains a personal decision depending on their "internal structure" of thinking. But at least the bug is not viewed as a vicious attacker who should be eliminated without a second thought.

Kuhn's seminal text on "paradigm shifts" not only shattered the philosophy of science, but also illuminated theories on innovation. We follow Kuhn on his concept of "anomaly"–- "the recognition that nature has somehow violated the paradigm-induced expectations that govern normal science" (Kuhn, 1970, pp. 52-53). Similarly, the shocks and frustrations we encounter dealing with nature should not be brushed off easily or blamed as mistakes, but as signs of dissonance between two parties (human or more-than-human on either side), and as opportunities for "structural coupling", for evolution and emergence.

3.2.3 Design as practice and process

We have touched in Section 3.1 how design must depart from an artefact-oriented creation process to a process of constant evolution. It differs from a) an iterative process for in such a process iterations are viewed as an in-between process toward the ideal, long-lasting or optimal, b) an co-design process where often the problem, solution and inputs to be taken from participants are defined a priori by design experts, overlooking the intrinsic entangled dynamics.

Systems thinker Peter Senge (2014) in one of his talks affectionately recounted the experience dealing with overfishing problem in one project which eventually kicked off with building a football ground near the workshop venue, so that the fishers could slow down and tell their stories while their kids play nearby. It is this attentiveness, all-around "listening" and the spirit of creating for specificity and unpredictability that is need for design today. Moreover, design interventions create ripples and consequences both in expected and unexpected ways. These consequences changes the environment which design needs to continuously and consciously respond to. In this way design becomes ongoing practices where they are seen as knowledge production "in the interaction of plural and contingent practices within different sites" (Bacchi & Bonham, 2014). The conditions that design is working under are essentially understanding of "a complex group of relations that function as a rule" (Foucault, 2002, p. 74).

This new understanding of design as practice and process cannot be fitted in the conventional organizational structure where the function of design sits at the end of stream of a siloed process. To design continuously from the middle of entanglements requires not only rational thinking based on

representations done in a top-down manner, but also diversified ways of knowing and acting/reacting. Design has a long tradition of valuing embodied and tacit knowledge (Schön, 1983). To appreciate different kinds of knowledge – embodied, indigenous, more-than-human – as an organization requires completely different models of organizing. What if organizations behave as octopus, mycelium or slime mold (Godfrey-Smith, 2016; Sheldrake, 2020)? Design and organization studies have much to learn from biology and ecology.

3.3 Form: creative emergence

"Entangled" design seeks to capture sparks from elusive assemblage and crystalize emergence which can be creative, performative, and playful.

3.3.1 Vignette 3. EcoMaker Speculative Design

Michael and I met in the Masters' studio in School of Design while I was busy researching on systems thinking and posthumanism. Soon he was pulled into our muddy adventures with children as a part- time coach. His special endowment as a trained industrial designer and a practicing maker juxtaposes with our ecological focus on the question of human / more-than-human relationship. Viewing our coming together in The Muddy School as an assemblage, the idea of doing a maker workshop "our way" germinated.

Eventually, we delivered a speculative design workshop. We made up a story that human discovered a livable planet "HT RAE" ("earth" written backward) full of forest. Children and parents were physically taken into the forest in Hong Kong as a trans-planet site visit. This new and playful perspective encouraged participants to look at a country park with new lenses – what if we are to (re)build civilization from scratch? With all the new "enlightenment" about the entanglement, is there anything we will do differently? They then were invited to a workshop where a vehicle for "HT RAE" planet is designed and made into a model.

3.3.2 Think in Assemblage

Assemblage benefits creative emergence in two main ways. On the one hand, the lucidity of assemblage adds layers and qualities to the existing identity. As Bateson (2002) pointed out, it is the difference noticed by the second eye brings 2D into 3D and give an object volume. On another hand, assemblage opens the space of potentiality. In Deleuze and Guattari (1987)'s term, it is the result of travel through lines of flight across strata that creates opportunities for deterritorialization and reterritorialization, thus innovation.

To design for entanglement asks for a sensitivity to think in assemblage and see changes in assemblage as opportunities. What new relationship can be created? How to capture the vitality of the new element before it gets homogenized? In our case, there was a conscious effort to create new connections through new program design. Knowledge generation is viewed as a cumulative evolution of The Muddy School's identity, in which the contingent and ever-changing assemblage plays a big role. At the centre of this thinking is a shifted attitude toward difference which is no longer seen as dissonance but appreciated as opportunities for innovation and knowledge making (Braidotti, 2002).

3.3.3 Performativity

In Vignette 2, the bug accident was responded creatively with bug model and role play games. In Vignette 3, ecology and maker education was integrated through a speculative narrative. Both are examples how design has the power to bring performativity into reality.

What makes a live performance worth is the tension–- the stress from unknown responses, the vulnerability of getting on stage, the improvisation, the heat of stage light, the darkness in audience and the burst of "Bravo". It is not surprising that Fischer-Lichte (2008) argues that the performers, the audience and the unstable components together constitute an "autopoietic feedback loop". A performative design is transformative with its ability to enable the other actants in the assemblage when it makes its process visible as a manifestation; it exaggerates with the goal of affective provocation instead of perfecting the functional object of design; it is open for interpretation and calls for responses inspiring further moves; it is embodied, functioning at multiple senses; and it welcomes improvisation.

Of all these, improvisation acts particularly as a form of knowledge production. Varela (1997) suggests that by constantly confronting the encounters, the autopoietic system action "on what is missing" in the system. The cognitive process – learning, perceiving, acting – is not teleological but is situated by "embodied agent". The improvisation as a "response-to-responses" makes the entanglement between designer, audience and other actants richer, and further expands the space of potentiality.

3.3.4 Playfulness

Narrative 1: Humans have destroyed TWO-THIRDS of the worlds' original tropical rainforest. How can we survive with the crises so close to our face?

Narrative 2: A new planet has been discovered by NASA and named HT Rae! It is covered by tropical forest and looks exactly like the scene from Avatar! Can you design a vehicle for residents on that planet to use?

Of the two options for our speculative narrative, the first one is dominated by shame and horror, enacting defensive reaction and a feeling of paralysis. While in the second narrative, the audience gets excited by the speculative storytelling. Our goal is not a blaming competition, but to arouse appreciation of and affection to nature. It's better to open up rather than shutting down.

Facing the same trap of denial, systems thinker Gregory Bateson and ecological thinker Timothy Morton both seek help from play. For Bateson, play is taking the subject out of context with new sets of relevance, essentially creating a safe environment for trial and error. This safe environment relaxes the nerves and often lead to stronger revelation. Morton (2016), with his dark realism, persuades people to accept desperation as a norm so they could continue having fun. Playfulness may be prescribed for mind-bending (Bateson) or one-step-at-a-time (Morton) purposes. It's not a silver bullet, but at least soothes the anxiety so we could act.

In this section we have discussed how thinking in assemblage, performativity and playfulness bring creative emergence. Despite the potential they could unleash particularly facing wicked problems, these terms are quite distant from mainstream managerial agenda especially on an organizational level. Luckily, design in the past few decades have earned its name on creativity and thus more space

to play around before squared by return on investment. The new entangled way of designing, instead of overly relying on the cognitive skills of the designer (van Aken, 2006), emphasizes contingent, performative and adaptive practices in a complex world by acknowledging varied ways of knowing.

4 Discussion and conclusion

4.1 Design as boundary practice

The brand of design has evolved from aesthetics, serving modernization and mass production (i.e., product design), to humanism (i.e., human-centric design), to creativity (i.e., design thinking). Entangled design proposes a new proposition of design as the bridge between different ways of knowledge making, arguing for legitimacy in embodied and performative knowledge production.

Entangled design is highly relevant to organization and policies, not only because such design requires changes in the practice and function of design but also holistic ways of organizing. Within design research, substantial research has been done to understand tacit knowledge and entangled relationship between human and materiality around craftsmanship (Ojala et al., 2018; Riikka & Maarit, 2020). Echoing recent theoretical advancements in feminism and science and technology studies, design has the potential to bring abstract theories of alternative knowledge into practice. In other words, design can and should participate and even lead a non-representational pragmatism turn connecting theory and practice (Thrift, 2008), bringing "local and perspectival solutions to universal crises, developed contextually through human ingenuity in pragmatic relation to specific materialities" (Bignall & Braidotti, 2019, p. 4).

4.2 Design as practice of organizing

For more than a decade, scholars have started to introduce concepts and theories of design into organization studies under the name of design science (Aken, 2007; Bate, 2007; Reymen et al., 2010). These literatures rightly noticed opportunity for design as organizational studies have difficulty in brining theories into practice for two reasons: 1) its social science orientation and focus on interpretation rather than intervention; 2) its often focus on macro variables rather than actual design of organizations. However, by bringing in design, they see design's potential mostly in problem solving (Reymen et al., 2010) and its evidence-based approach (van Aken, 2006) . What they failed to articulate is a clear differentiation of design as such from the practice of business consultancy of various kinds, whose sole focus lies in solving real-life business problems. As a result, despite the appealing proposal of marrying design and organization studies to "align(ing) business and humanistic value", such proposal was not welcomed in the following decade (Aken, 2007).

The field of organization studies have advanced in understanding the entangled condition, led by Ralph Stacey's seminal works on complexity in the context of organization and confirmed with rising popularity of practices and process theories of organization (Gherardi, 2019; Helin et al., 2014; Hernes, 2014). While scholars in organization studies advocate "strategy without design" (Chia & Holt, 2009), we argue a "entangled design" as a practice of organizing as outlined in this article is exactly what is called for to close the theory and practice gap in the condition of entanglement.

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