In addition to taxonomy and cards, a website[4] was created, with the aim of dissemination of the approach itself, as well as the results of the workshops.
It seemed to us that testing the fundamentals of the realized research in different geographical areas with a wide and heterogeneous range of design students could be an interesting strategy to understand the diversity of responses to the assumptions previously presented.
To date, four workshops have been held in higher education establishments (University of Aveiro, University Complutense Madrid, Polytechnic Institute of Coimbra and Polytechnic Institute of Cávado and Ave).
For a greater understanding of the scope of taxonomy in the generation of new project narratives, we enumerate some of them: App wayfinding (Blue-footed Booby bird - color and step choreography), Musical system for the deaf (chameleon - color/dynamic), Asthma pump (frigate bird - insufflate), Sensory pillow (frigate bird - insufflate), Light blanket (peacock - open/close display), Communicative contact lenses (chameleon - color change/camouflage), Routine sensor (lira bird - coordination/sequence), Alarm system (chameleon - color change/camouflage), Communicative fan (butterfly - flight choreography), Gender violence app (crab - vibration), Interactive shower (bird of paradise - ritual/exhibition), Stress sensor (frigate bird - insufflate), digital folder organizer and personal assistant app (bird of paradise - ritual/exhibition) *(See Figure 5)*.

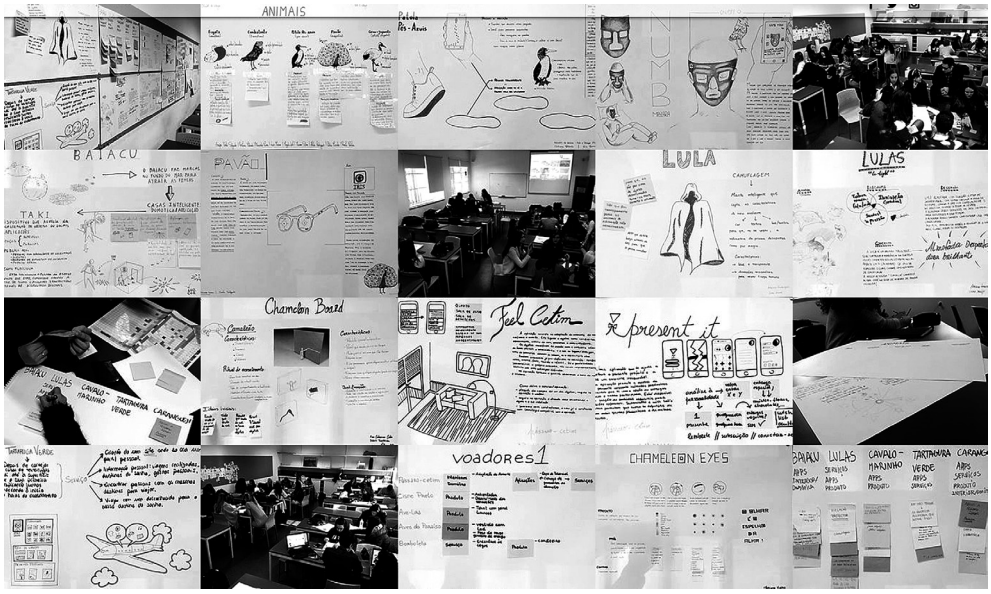

Figure 5. Workshop results in Polytechnic Institute of Coimbra, ESEC (Art & Design degree).

3. Nature´s *Praxis*

Heraclitus, the ancient Greek philosopher 500 B.C., is known for his expression *Panta Rhei* («life is flux»), that sustains the concept behind his philosophy, expressing that the only constant in life is change (Kirk, 1957). This idea, that is today a common fact, was revolutionary at the time but is still by itself a valid reason to assume that a response to something that is in constant flux, should be kept in the same state. Furthermore, as a problem detected today, will be given a solution in the forthcoming, and because the context of that problem is also in flux, so should the solution be malleable in order to react, adapt, and impose the intended change to this new reality. This ethos is even more so when we cross design with the organic, seeing that in biology we associate the idea of replication with the outcome of a procedure. This means that by replicating an operation that processes similar code(s), in a similar way, the outcomes will be identical because they will have the same recognizable pattern as their predecessors, and at the same time they will be original seeing that they materialize as something unique (Nature Education, 2014).

> "[D]esign is handling things before [they] can be knowledge" (Aicher, 1991, p. 89), and if our daily objects are losing their materiality, this means that form is a vaster concept than a three-dimensional amalgam of matter. Loss of materiality (in the traditional sense) does not necessarily signify loss of form, but instead a new comprehension of form – the "particular way in which a thing exists or appears" here the focus should be put more in the existence and less in the appearance.

In living-matter, it appears that the ontology of form and matter are intertwined as one complex metalanguage. Form, is not substrate-independent as one can theorize for the artificial (Sterelny & Griffiths, 2010, p. 358). Organisms, in this sense are "fundamentally different from inert matter, they are hierarchically ordered systems with many emergent properties never found in inanimate matter" (Bedau & Cleland, 2010, p. 94).
In the following chapters, we look at living-matter as metaphorical *membrane* that separates the Nature from the Human. And as all membranes, it's understood as barrier, but also as a place of interaction and exchange. In this context, we speculate on common narrative and propose new ones associated to nature's materiality and unavoidably its *praxis*.

3.1. Materiality of life's unique

Cell theory indicates that "all living [things] are composed of cells", making them the fundamental structural units of living matter, i.e. cells are a form of organized matter that "constitute[s] the smallest level, having the complex of properties that define life" (Thompson & Zeiler, 2017, p. 14).
A cell (in biology) is a "membrane-bound unit" containing the primal molecules, which define its physiology (2019). Each structure inside the cell (that is called an organelle) has a specific function; "organelles in unicellular organisms are the equivalent of organs in

multicellular organisms" (2017). A single cell can be by itself an organism, such as yeast and bacterium. Other cells gain specialized purposes and engage with other neighbouring cells and become part of multicellular organisms, as are animals or plants (Coleman, 1971, p. 33). It is estimated that humans are comprised of more than 30,000,000,000,000 (thirty trillion) cells (Zimmer, How Many Cells Are In Your Body?, 2013) and are the habitat for approximately 100,000,000,000,000 (hundred trillion) microbes (Zimmer, 2012), all (or most of them) cooperating as one single individual.

Ernst Mayr an evolutionary biologist introduced the concept of *emergence* by explaining that, "When two entities are combined at a new level of integration, not all the properties of the new entity are necessarily a logical or predictable consequence of the components" (1961); meaning that new "properties arise in a structure on a higher level of integration which cannot be predicted from knowledge about the components on lower levels" (Reichle, 2009, p. 192). This leads us to the conception that life does not surge from matter itself, that

> Life is a property of form, not matter, result of the organization of matter rather than something that inheres in the matter itself […] life is a kind of behaviour, not the kind of stuff –and as such it is constitute of simple behaviours, not simpler stuff (Langton, 2018, p. 41).

Moreover,

> "[t]here is no single level of function or organization resting on a single level of matter". Instead, it seems like each particle of living-matter takes part of a cascade of multiple levels of functions of any one system (Sterelny & Griffiths 1999, p. 362).

Organized living-matter (organisms), "represent a remarkable form of dualism […], a dualism partly physical and partly metaphysical. The dualism of modern biology is consistently psychochemical, and it arises from the fact that organisms possess both a genotype and a phenotype" (Bedau & Cleland 2010, p. 94). That is to say, although the genotype contains all the information for an organism's existence, it is how its constituting-matter behaves while interacting with environmental factors that defines its phenotype.

Seeing that nature prefers to reproduce in a double/dual system and being information that what results from the comparison of two or more things, nature's offsprings are the result and vessels of that new data, reinforcing the idea that this new whole is something more than the sum of the copied parts, therefore original-copies.

In his book *Analogous and Digital*, Otl Aicher claims, "it is difficult to find a more vivid image of authentic then that of the organ". He supports this idea by claiming, that this is because it is self-generated and by itself a complete entity that is part of a greater whole, and "that it plays a distinctive and irreplaceable role" therefore "it conveys the thought that something authentic must be grown, it cannot be manufactured artificially" (1991, p. 11). Edward Young, the eighteen-century poet stated that humans are "Born Originals" that die as "Copies" (in (Trilling, 1971). Leading to the idea that things that are born, are

looked upon as original, and things that are grown are seen as authentic. Hence, the opposite line of thought can also be extracted, and one can argue that the artificial can never be original and the fabricated will never be authentic, placing all that is human-made (Design included) in the opposite spectrum.

Deriving from this idea that a copy is related to the act of copying, and that an action is a cognitive process that applies change to something, guides us to the notion that originality is related to a state of impermanence and a replica with the hypothesis of constancy (Benjamin, 1969). Still, we cannot abstract from the fact that a copy is a re-creation of something that preceded it, and that previous something is itself a copy of another thing that came before it. This forces upon us the notion of "prime objects". George Kubler, establishes a prime object as a material by-product or idea, which have never before been stated or even possible, and therefore better described as a "pattern". He clarifies this by explaining that they are like "prime numbers of mathematics, because no conclusive rule is known to govern the appearance of either, [and the] two phenomena now escape regulation. Prime numbers have no divisors other than themselves", and for this fact, their existence is not justified by their antecedents (Kubler, 1962, p. 48).

While referring to the natural or the artificial, the grown or the humanmade, there seems to be common aspects that distinguish our perception of what is an original and what is a copy. In both, serendipity and/or impermanence appear to infuse the original with attributes that the copy lacks. Both aspects have one common feature, they are space and time dependent, and it is this time and space dependency that imbues the original with characteristics that "even the most perfect reproduction […] is lacking". This unparalleled existence "underlies the concept of its authenticity" and attributes the original with an "aura" that the replica lacks.

By considering that originality is strongly related to an unpreserved reaction to a particular stimulus, and that this response is catalysed through serendipity and/or impermanence, leads to the idea that an organism's ability to generate original responses is conditioned by its sensory system. Human senses are constraint to a specific physico-chemical range, between the ultra (stimuli above the range humans can perceive) and the infra (stimuli bellow the range humans can perceive). Each organism's sensory ecology gives a unique read of its surroundings and seems to be linked to its ability to generate or not original outcomes. On the other hand, humans are technologically enhanced; grasping their surroundings is more detailed by the day. Consequently, if Design looks to explore new (and original) possibilities that reside within living-matter, it too must incorporate tools in its processes that explore patterns and not just form.

3.2. Materiality of data

Every sentient being has an established set of senses that enable it to subjectively perceive its surroundings. A sense in general is the ability to understand (interpret) something by perceiving and collecting data for interpretation, a "system that consists of a group of sensory [elements] that responds to a specific physical manifestation [light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena]"

(Takyi, 2016, p. 06). In order for something to be perceived by another something, physical or chemical changes must be detected. When a sensor identifies change, it provides an output –signal– in accordance, this signal is then transported, interpreted, and processed by the system. The form in which this data is transported from the sensor to the processor can be analogue or digital, when the signal is analogue it represents in continuous the variable, while when digital, it represents the variable though discrete and –discontinuous– values (Botto, 2003).

We commonly hear that nature is analogue (Schyfter, 2014), although one can speculate that it is only analogue until it stops being, or in other words it is perceived as analogue but in many aspects it is discrete, making it digital-like. DNA, is encoded in a 4 base alphabet representation –adenine (A), cytosine (C), guanine (G) and thymine (T)– each unit is discrete and there are no values between units. The same happens with RNA (adenine (A), cytosine (C), guanine (G), and uracil (U)). Thus, when DNA informs the RNA to produce proteins (Matthew, 2017), the digital logic seems to result into an analogue manifestation. Ingeborg Reichle, explains this analogue/digital duality by describing DNA as "a linguistic code that is not unlike the Morse code or language itself", although it has a distinguishable set-base, it is "a language in the formal sense with a vocabulary" and for this reason, open to interpretation (Reichle, 2009, p. 135). Interpretation is the ability to make sense of, assign a meaning to, a subjective translation, and these are all attributes of the intellect. Thus, who or what is doing the interpretation? For one to see nature, as analogue, is to consider that living-matter has some sort of cognition.

The anthropologist and biologist George Bateson in his book *Mind and Nature –a Necessary Unity*, pointed out that due to the "all-or-nothing characteristic of the neuron" the brain is binary, therefore digital. But like in any digital system, by "multiplying the pathways so that a given cluster of pathways might consist of hundreds of neurons, of which a certain percentage would be firing and a certain other percentage would be quiet," the brain gains the appearance of being analogue (Bateson, 1979, p. 111). Being living-matter phenomena in a constant flux of informed transformation, that outcome from *ceaseless* interactions, one could argue that living-matter is for that account processual and analogic. Therefore, living-matter is apparently an analogue system that is digitally encoded (DNA, RNA, …) and is digitally ciphered (0 and 1 characteristic of the neuron). This paradigm suggests that living-matter, conserves and transmits information (that it wants to keep constant) digitally, but gains its morphogenesis due to the analogic principles that are enrooted in its matter's genesis.

In Out of Control, Kevin Kelly suggests that if "we unleash living forces into our created machines, we lose control of them. They acquire wildness" (1995, p. 04). Therefore, it also seems plausible to consider that if we want living-matter to maintain some continuity, then, its matrix must be kept *digitally*. And, at the same time if we intent for it to keep producing original-evolving-copies, space must be given for the intertwining between this digital data and the analogue dimension that results from the interaction within and between matter. He continues explaining, that "[w]ith new developments in biological computation, the boundaries between organism and computer [are] becoming ever more porous. These developments are also changing our criteria for explanation, in ways that progressively blur the boundaries between the science of organism and computers"

(Keller, 2002, p. 215). Forcing Design when considering living-matter (and if intended to replicate the original) to reside in a state that traverses between the digital (or the code that defines it) and the analogue (or the materiality in witch it will manifest into).

3.3. Materiality of memory and action

Antonio Damasio, explains that consciousness (the awareness of the present) arises when we interact with our surroundings, including others, and that a mental image is associated to a feeling (2000). We also know that behaviours (where feelings have an essential role) are learned not only through the intrinsic mediation between stimuli and response amongst ourselves, and our surroundings, but especially by imitating behaviours seen in role models (Bandura, Ross, & A. Ross, 1961).

Trial and error is in the base of most of nature's actions, and because every trial is new, it has an associated level of randomness. As Gregory Bateson explains, this is not only related to how species interact with their surroundings, in most cases it is also linked to the way those surroundings are perceive in the first place. He does so by employing the metaphor of binocular vision, where he points out the fact that each eye has a different perspective of the same reality and it is the brain that constructs a stereoscopic tridimensional image that is not only the sum of both perspectives but also the mismatch between both perspectives (Bateson, 1979). Things, are not identified by one's sensors as recognizable units they are a sum of stimuli that is filtered and processed into an image that is associated or not to pre-experienced patterns.

This ability of living-matter to produce distinct responses to similar stimuli as Philip Ball explains "is [neither] unique to humans, nor to brains in general". He describes this property as *Agency* –"the ability of living entities to alter their environment (and themselves) with purpose to suit an agenda" (Ball, 2020). Living-matter's disposition to generate original responses to similar stimuli has yet to be understood, seeing that it is impossible to foresee with full accuracy an organism's reaction even when its constituting matter had been mapped down to the last gene and particle.

Bruno Munari expresses that, in theory, if the context of growth were exactly the same, so would the individual future crops outcome be similar to one another. By observing harvests that are farmed in highly controlled environments, as are today's indoor vertical farming installations, and other monocultures, we can see how his supposition is not exactly true. Some variations do still occur, although it is also a fact that the pattern becomes less broadened and crops look, taste and have close to exact same characteristics. Leading to the idea that everything that is mass-produced in controlled environments (with fewer phenotypic interactions) will have less variation in their outcomes. Meaning that the epigenetic process of the grown is not by itself a guarantee of variation. That variation is not inscribed by itself in living-matter, but instead it is apparently closely related to the interactions between its constituting matter and its surroundings.

The Idea that nature never repeats itself, even in identical circumstances (Alexander, 2004); and that we cannot predict the exact shape of something, even with big equations because of nature's ability to turn simplicity into complexity is seen as an assurance of

uniqueness and unrepeatability of form, is not an exact fact. And although the Natural world can be profoundly unpredictable, the natural when extracted from its environment becomes more foreseeable. Raising the possibility that the biggest difference between the form of the natural and the form of the artificial is not only related to their founding elements, but also to their interactive process. By assuming that the main aspect that drives unpredictability is an interactive process, is also to acknowledge that it is the same interactive process that allow it to create new patterns and structures, commonly referred to as natural order. Order and Chaos seem to be deeply linked and one may not exist without the other (Stacey, 2015).

A Pattern is referred to as "something intended as a guide for making something else", a "customary way of operation or behaviour", a "perceptual structure" or a "model considered worthy of imitation" (Spellzone), while diversity is related to variety and heterogeneity. The ability to recognize a pattern and there for being able to apply variation to that pattern in psychology and neuroscience, is described as a cognitive process that relates information perceived by stimulus with data extracted from a memory bank (Eysenck & Keane, 1990).

Systems that are perceived as being random, such as the leaves on a tree, the waves in the sea, stock markets, traffic jams, or prime-numbers are seen as such because they "seem to defy human prediction". We do know that most of these systems are not chaotic, therefore quantifiable, leading to the idea that the notion of randomness lies in our lack of ability to measure all the variables involved. Chaos theory is based on this idea, that any dynamic system can be measured, and on the concept that if "we had detailed information about all the variables evolved, wild randomness could be tamed" (Ede, 2005, pp. 25-26). On the other hand, we have systems with predictable patterns where in most cases the pattern is not of mathematical precision, but "close enough" to be perceived as such (to a point that some come close to being expressed as universal laws). Spiral growth patterns *(See Figure 6)*, seen in sunflowers, pinecones, shells, etc., are explained through the Fibonacci sequence where each number is the sum of the two preceding numbers: 1, 1, 2, 3, 5, 8, 13, 21, 34…). But as we know, variation is embedded into nature's *modus operandi*, meaning that all growth patterns are not following the Fibonacci sequence punctiliously (Pletser, 2017), but are close enough to be perceived as constant by human's ability to see, their common-sense, and capacity of abstraction.

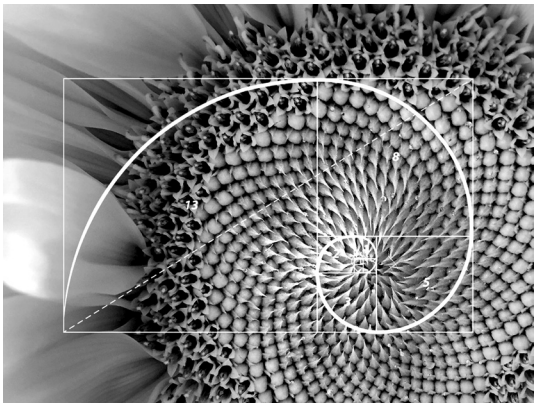

Figure 6. The nature of design: the Fibonacci sequence and the Golden Ratio by Jonathan Cleveland, 2020 in https://clevelanddesign.com/

Design has extensively explored this idea that a pattern in many cases is not more than a perceptual structure. Gestalt principles demonstrate how the human brain tends to "simplify" the sum of individual elements captured by our eyes by perceiving them as a whole (Fishwick, 2006, p. 262). Humans ocular systems are sensitive to illusion, and have brains that are hardwired into seeing structure, logic, and patterns even when they are not a reality. This becomes a tool, but also a challenge for diversity. Our brains tend to make sense of our surroundings and relate the newly observed with previous assimilated concepts and forms. This process of "simplification" becomes a tool, enabling us to quickly grasp a sense of our surroundings even if not in full detail, allowing us to quickly react to a situation; and therefore, also an impediment for diversity, by making it difficult to recognize variations unless they are significant.

Although all matter that is governed by the universal physico-chemical laws seem to be guided by a set of patterns, and have themselves the ability of generating patterns, most of these patterns, although known to exist, are not perceived by sentient beings (McCormack, Bown, Dorin, McCabe, Monro, & Whitelaw, 2014). In addition, patterns that manifest themselves within the human range of sensitivity are still to be subject of socio-cultural and subjective interpretation. This imposes on Design the role of understanding and circumscribing patterns not shapes in order to be able to generate diversity within those same patterns.

4. Conclusion

After looking from two different perspectives on how nature-associated-narratives influence design, the first focus on the *poesies* and *emotional* dimension of these narratives and the second on the *praxis* and *material* dimension, we intend for this article to conclude

as something in-between and for that we rely on the readers' ingenuity. Following the theoretical material that sustains both perspectives, workshops were held to validate both points-of-view, and as a conclusion we present one example of an outcome of each of these workshops. We believe that by visualising an outcome of these workshops, the reader gains a better understanding of the theoretical framework.

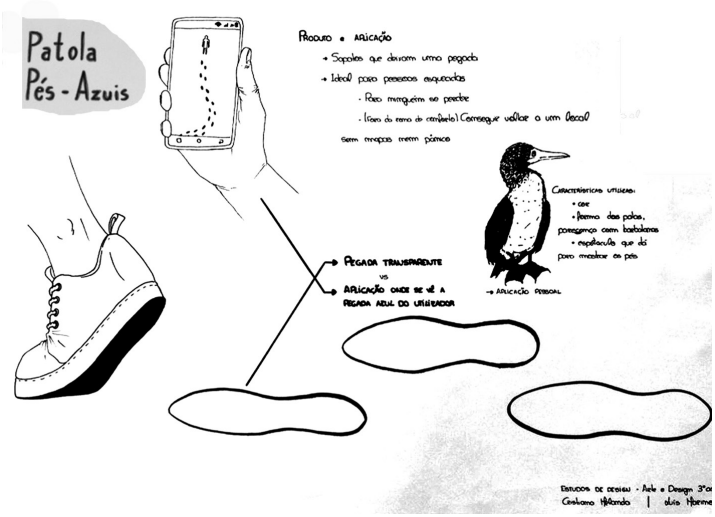

Figure 7. Patola project, authors' personal archive.

Workshop 01 - *Design by Bio-behaviours.* Throughout the workshop, participants disassembled the various studied behaviors through their physical characteristics such as temperature, color, etc. and, later they moved towards an association between these characteristics and ideas for applications. We think it is important to gain deep understanding of the proposed taxonomy in order to generate new project narratives, as in the Patola project *(See Figure 7)*. The Blue-footed Booby bird, characterized mainly by the blue color of its feet and the related dance movements that make up its ritual, originated the conceptualization of a pair of sneakers and a mobile application. The way of operation is for the user to put on the blue-footed Patola sneakers, which, when walking, leave a footprint invisible to the human eye, only visible from the account of registered users in the mobile application. This wayfinding project aims to help the orientation of people with poor memory, but can also serve to mark thematic routes for travelers.

Figure 8. Mycelium prosthetic breast, authors' personal archive.

Workshop 02 - *Designing self-designed mushrooms: an interspecies collaborative approach* held at Good Design 2019 in Izmir, Turkey. Participants during the workshop were invited to collaborate with fungal mycelia, a living organism, to develop functional artefacts that include the organism's morphogenesis as an asset with aesthetic value. One of the outcomes, a prosthetic body parts *(See Figure 8)* proposes an aesthetic and emotional alternative to post-mastectomy products. The design manifests a new act of bodily growth through the use of mycelium, which replicates a prosthetic breast. Variety and randomness in size, colour and shape suggest a more personal experience. It also acts as an armour to prevent strangers from engaging in physical contact with mastectomy victims (Doğu & Pinto 2020).

We believe this article contributes to a better understanding of the importance of narratives when designing with living-materials, and how the narratives themselves sustain the idea that if Nature is considered to *design,* then we must also consider that what nature designs are patterns and not shapes; intentions not outcomes.

Notes

1. The ideas underlying the post-digital concept are mentioned in a 1998 article by Nicholas Negroponte in wired. The name "digital post" was coined more recently by Russell Davies in 2009. Source: Tinworth, A. (2012). what is post digital ?. Retrieved on March 5, 2021, from https://nextconf.eu/2012/01/what-is-post-digital/

2. We consider it important to distance ourselves from the human being, from his habits and rituals, in order to try to promote less conscious and familiar actions with culturally rooted routines, summoning a panoply of meanings inspired outside human archetypes, expanding the possibility of building new individual and personalized meanings.
3. For the visualization of the full grid: https://www.dropbox.com/s/q3qbh373q5tjhrn/RITUALS%20OF%20SEDUCTION%20TAXONOMY%20.pdf?dl=0
4. http://pedrobandeiramaia.wixsite.com/designbybiobehaviors

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Resumen: La naturaleza ha estado inevitablemente presente en la evolución humana, definiendo límites, capacidades e imaginación, o en otras palabras, determinando cómo y por qué diseñamos. En este artículo, intentamos ver la naturaleza en sí misma como una narrativa cultural preestablecida (o conjunto de narrativas) y reflexionar sobre cómo estas narrativas influyen en el diseño en dos aspectos muy distintos. La primera mirada es a las narrativas de la naturaleza relacionadas con la *poiesis* y su potencial para generar referencias emocionales. Mientras que el segundo, se centra en las narrativas de la naturaleza asociadas a su *praxis*, junto con su referencia procedimental para el diseño, como conclusión

buscamos puntos comunes y divergentes entre estos enfoques también con la intención de contribuir a una mejor comprensión de cómo la idea de Naturaleza influye en el diseño.

Palabras clave: Diseño - Naturaleza - Biodiseño - Narrativa - *Poiesis* - *Praxis* - Narrativas asociadas a la naturaleza - Conductas - Emociones

Resumo: A natureza está inevitavelmente presente na evolução humana, definindo limites, capacidades e imaginação, ou em outras palavras, determinando como e por que projetamos. Neste artigo, pretendemos olhar para a própria natureza como uma narrativa cultural pré-definida (ou conjunto de narrativas) e, refletir sobre como essas narrativas influenciam o design em dois aspectos muito distintos. O primeiro olhar é para as narrativas da natureza relacionadas à poiese e seu potencial para gerar referências emocionais. Já o segundo, centra-se nas narrativas da natureza associadas à sua práxis, juntamente com o seu referencial procedimental para o design. Como conclusão, buscamos pontos comuns e divergentes entre essas também se aproximam com o intuito de contribuir para um melhor entendimento de como a ideia de Natureza influencia o design.

Palavras chave: Design - Natureza - Biodesign - Narrativa - *Poiesis* - *Praxis* - Narrativas associadas à Natureza - Comportamentos - Emoções