Pattern Literacy in Support of Systems Literacy - An approach from a Pattern Language perspective

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To understand and adapt to the world around us, and to collectively make decisions that can ensure its systemic health in the long run, we must get a grasp of how the systems that our designs generate actually behave and evolve, not only in their 'mechanical' aspects, but also in their psychological, relational, political, and existential dimensions. The skills that this requires may be thought of as Systems Literacy. Systems Literacy involves a set of 'sensing' and mediating capabilities that can help us identify, interconnect and make sense of weak signals of systemic behavior in growing volumes of information. This approach includes leveraging the complementarity of perspectives, knowledges, and know-hows across disciplines and domains of action, and helping us to enter in resonance with each other and our environment, in order for systemic coherence to emerge as a whole as a result of fragmented collective change efforts.

Because patterns are embedded in cognition, and are so essential for both discerning and designing form, we believe that the development of Pattern Literacy could beneficially support the enhancement of Systems Literacy. This paper explores the properties of patterns as units of systemic meaning-making and how these properties could be combined as a system to enhance pattern literacy and ultimately support the development of systems literacy.

Categories and Subject Descriptors: **• Human-centered computing~Collaborative and social computing • Human-centered computing~Visualization** • Human-centered computing~Human computer interaction (HCI) **• Theory of computation~Semantics and reasoning** • *Theory of computation~Formal languages and automata theory* • Theory of computation~Algorithmic game theory and mechanism design **• Computing methodologies~Knowledge representation and reasoning • Computing methodologies~Philosophical/theoretical foundations of artificial intelligence • Computing methodologies~Modeling and simulation • Hardware~Emerging tools and methodologies • Software and its engineering~Patterns • Software and its engineering~Design languages • Software and its engineering~Design patterns** • *Software and its engineering~Visual languages* • *Mathematics of computing~Coding theory*

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1. INTRODUCTION

In this paper[1], we explore, in a brief flyover view, the concept of pattern and pattern language in relation to systems, and in particular complex systems, from a variety of perspectives and fields. We first start by examining the *Systemness of Life*[2] and the innate 'systemic sensitivity' that we humans demonstrate by recognizing patterns, noting similarities and differences, categorizing, and making associations. A process in which patterns hold an essential role. We believe that understanding our individual and collective approach to pattern recognition, creation, association, and our use of language and other modes of expression is an important step towards systems literacy. This leads us to discuss the *Patternness of Systems*, and to consider pattern literacy as an essential component of systems literacy.

Focusing on the relationship between *Pattern Literacy and Pattern Language*[3], we come to acknowledge the 'systemness' of pattern language, both in its structure (resolution of forces and relationships) and in its dynamic intent (generating designs that are 'whole' and 'alive', beyond the design itself), and suggest that pattern literacy, through its systemic aim, could help enhance not only the practice of systems science and systems thinking, but also the practice of pattern language itself.

In this context, and with the evolution of pattern language theory and practice in mind, we examine various roles and functions of the pattern as unit of 'meaning-making', enabling to discern, give, and communicate form. These functions include *The Pattern as Semiotic Sign*, which relates the phenomenological aspect of patterns (patterns in the world as they are observed and experienced), to the cognitive aspects (patterns in the mind as they are perceived and processed), and to the descriptive aspects (patterns expressions as they are structured and represented). In particular, and deriving from this, we examine *The Pattern as Unit of Embodied Cognition* that enables meaning-making -- alternatively making sense of, giving meaning to, and expressing this meaning. Mobilized at various moments of the cognition-to-action cycle, these key functions of the pattern are involved in discernment, interpretation, inquiry, connection, and mediation as well as planning and action. These key properties could be combined to perform as a system, integrating multiple contexts, perspectives, and levels of understanding and design, *In Search for Terrestrial Intelligence,* to better tackle challenges ahead, forming the basis for a language of systems.

Examples of *Pattern Literacy in Action* that we share in the third part of the paper show how some of these functions are currently used: patterns and combinations of patterns mined from experience through inquiry, serving as boundary objects that bring coherence both to understanding and design across domains of knowledge and action from a relational cooperation perspective; or patterns as units for adaptive modeling that can help construct and deconstruct systemic stories as well as systems structures and behaviors in what resembles a hacker's approach. These examples prefigure how the properties of patterns could be further operationalized in synergy to enhance our ability as humans to recognize and mobilize patterns, in particular in their decoding and encoding function, towards the embodiment of pattern language: pattern literacy. The last section of the paper addresses *Pattern Representations and The Quest for Universal Patterns* and discusses ways in which patterns could be shared and interconnected to be kept alive and enable effective knowledge interoperability and transfer.

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[1] This paper continues the work on pattern languages for systemic change presented at Purplsoc 2015: *Towards a Fourth Generation Pattern Language: Patterns as Epistemic Threads for Systemic Orientation (*Finidori & al 2015) and Plop and ISSS 2016: *Patterns that Connect: Exploring the Potential of Patterns and Pattern Languages to Connect Different Forms of Knowledge and Understanding* (Finidori 2016). An encounter at ISSS 2016 with Peter Tuddenham, involved since 2002 in developing a theory and method for Ocean literacy## (reference) and then a project of Systems Literacy initiative (reference), triggered the idea of a joint exploration of the idea of Pattern Literacy in support of Systems Literacy.

[2] Italicized expressions in this introduction are the titles of this paper's sections.

[3] As practiced by the pattern language community, following in the footsteps of architect Christopher Alexander

The view of patterns we adopt in this paper departs from the traditional definition of the pattern in effect in the Pattern Language community. Beyond this exploration, this paper can be seen as an argument that the pattern language community would gain a lot to broaden its view of patterns so as to encompass the cognitive and phenomenological aspects that underlie not only the process of design itself, but also the 'life' of the systems designed, and the generative (or degenerative) processes they unleash in the world.

2. THE SYSTEMNESS OF LIFE

In our childhood, before we encounter the world of different subjects and disciplines, our experience of life systems is without boundaries imposed through arbitrary classification and naming.

We begin our lives relating to the world first in terms of biological connections to parents (for most people anyway) and then the ground we crawl on, the food we eat, and the air we breathe. Experiencing place, water, earth and air, family, plants and animals, and life and energy are the worldly experiences we all share from the moment of our birth. These early experiences, fundamental to our existence, form the basis of, and shape our understanding of the world and the patterns we create to navigate life and the nature of our relationships.

As we mature, we learn about life-providing, and -sustaining processes in more formal and fragmented ways. With the complexification of the world, science and practice tend to specialize, and function with their own vocabularies and patterns, losing the sense of relationships among things, and therefore the sense of wholeness.

The Merriam-Webster defines a system as *a regularly interacting or interdependent group of items forming a unified whole.* Wholeness and 'systemness' are closely related.

Clearly, the issues and challenges the world as a whole is facing are of systemic nature, with systems of different types interacting with each other in more or less predictable ways. They become more unpredictable as complexity grows. To understand and adapt to these challenges we must understand how social systems (systems of people) interacting with technological systems affect the environment and how change actually takes place. This involves not only a transdisciplinary approach across hard sciences but also the 'arts' and some 'hidden' dimensions: political, philosophical, psychological, emotional, relational, epistemological[4], and phenomenological[5], which all contribute to design or maintain the health and 'quality' of socio-environmental and socio-technological systems. The skills needed to cross the various domains of Sciences and Arts and understand the relationships among things may be thought of as Systems Literacy. Systems literacy may not be sufficient to ensure good governance for a peaceful and sustainable world, but it is definitely a necessary component for gaining insights into the interconnected global effects on the planet of the unprecedented human and technology explosion that has occurred and will continue over the coming years.

Systems Sciences and Systems Thinking seek to model and understand interdependencies and dynamics of systems in interaction. As relatively new disciplines, they have been struggling however to reach a critical threshold of practice and disseminate across disciplines, and thus their adoption still remains limited. The upside is that these disciplines seek to find general systems laws and concepts that cut across domains, to generalize issues and integrate knowledge. The downside is that they are so abstract that people who are not experts cannot 'relate' to the concepts and language. Added to this is

[4] Relating to the theory of knowledge, especially with regard to its methods, validity, and scope, and the distinction between justified belief and opinion.

[5] Relating to the observation of phenomena or events as they arise in experience

the multiplication of methodologies and approaches to systems that make communication and consensus within the systems community difficult.

A Systems Literacy Initiative process was launched as an ongoing international, coordinated effort comprising the ISSS[6], IFSR[7] and INCOSE[8] to create a greater awareness and understanding about "Systems" and to increase systemic capability, and broaden the adoption and practice of systemic approaches.

A direction of this work on systems literacy that we find the most promising and upon which we are building here is to focus on the level of embodied cognition, enhancing human's innate 'systemic sensibility': the non-disciplinary bounded understanding, the sense of wholeness and systemness that people naturally start out with, as we described above. Embodied cognition is the idea that cognition depends on the whole body sensing and acting rather than only on the brain, with a strong relationship to the natural and social environment. This direction draws on recent similar processes for developing ocean, earth science, and atmosphere literacy (Cava et al. 2005, Wysession et al. 2012). Ocean, earth and atmosphere systems are systems that people can easily relate to because they are part of their worldly experience, and for which natural systems sensibility can more easily be mobilized. The objective as far as systems sciences are concerned is to work at the level of Systemology (the disciplinary field representing the organized body of knowledge about systems) to provide clear concepts and a common language that gives people the "capability to articulate and reflect on this innate sensibility, and act on it in a considered way. "(Edson et al. 2017).

Without both enhancing systemic sensitivity and generating powerful insights from systems sciences, we cannot begin to address the interconnected and global effects on the planet of the unprecedented human and technology explosion that has occurred and will continue over the coming years.

We believe however that working directly on systems language and concepts is not enough, and that it is possible to work one level deeper on embodied cognition: on humans' innate ability, while 'in presence' in the world, to discover, recognize, associate, mobilize patterns, an ability which underpins systemic sensibility. We will discuss later on in the paper how different types of patterns and processes are involved and related in the embodied cognitive process of cognition-to-action. This inter-operation of patterns is what must be emulated in group settings to enhance systems literacy. In this respect, we suggest that patterns and pattern language can play a critical role in formalizing the clear concepts and common language sought for in further research in Systemology. Working at the pattern 'instinct' and pattern literacy levels can further enhance systemic sensibility and help it transform into systems literacy. We will outline how in the next sections.

3. THE PATTERNNESS OF SYSTEMS

In particular, we believe that working at the pattern level can help overcome differences in epistemological types and languages, or in other words, differences in cultures. These differences arise from the co-individuation[9] processes from which cultures and languages are shaped, resulting in differences in mental models or world views (Maruyama 1980) and in design forms or representations, both at the individual and the collective level.

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[6] International Society for Systems Sciences

[7] International Federation for Systems Research

[8] International Council on Systems Engineering

[9] Co-individuation, a term coined by Bernard Stiegler, is the process of collective individuation (after Gilbert Simondon) through which individual persons become distinct from each other (forming the identity of the I), in relation to each other (forming the identity of the We)

General Systems Theory was developed around a quest for general systems principles common to all sciences and disciplines, revealed through finding *structural similarities or isomorphisms in different fields* (Bertalanffy 1968). These isomorphisms, also called *isomorphic patterns* in the literature, can be seen as a variety of instances of a general systems principle, or general systems pattern, which applies across sciences. Helping to reveal these underlying similarities in all of life's experiences by recognizing isomorphic patterns that exist in multiple levels and in multiple domains is a hope for systems literacy.

In a similar approach, the US National Research Council (NRC) and the American Association for the Advancement of Science (AAAS) have developed the Next Generation Science Standards[10]. The NGSS contain Cross Cutting Concepts that apply across Core Ideas of science and in the Practices of science, which can be used as a starting point to consider the relationship between science or systems literacy and pattern literacy.

There are seven cross cutting concepts. The first one identified and described as one of the most fundamental cross cutting concept is that of Patterns, which we distinguish here from the other concepts because it is different in nature, with a broader encompassing scope. In Appendix G of the NGSS this first concept is defined as: "Patterns: Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them." The pattern is a unit of observation, a cue, a clue, a center around which hypothesis can be built, which can be related to other centers or hypothesis.

The other six cross cutting concepts are: Cause and effect; Scale, proportion, and quantity; Systems and system models; Energy and matter: Flows, cycles, and conservation; Structure and function; and Stability and change. Each of these concepts enable the understanding of specific aspects of systems. All come into play and are interrelated when it comes to describing configuration and behavior of systems. A form of pattern language?

These six cross cutting concepts could be thought of as pattern categories forming a sense making framework that, as a relations system, can help find its instantiations in terms of patterns. Patterns here can be defined as the units of systemic meaning-making that repeat and can be recognized and modeled, or designed to influence the course of things. These patterns in themselves, when interconnected, can provide insights and perspective at various levels of granularity, from the micro to the meta.

Both General Systems Theory and this approach to cross cutting concepts however are of the first order[11]. Focusing on the objects and systems observed, they leave out interpretations and representations of these observations[12], which may vary across disciplines or domains of observation. They also leave out the influence that the observation may have on the observer and the object observed[13].

One of the goals of this work on pattern literacy and systems literacy is to enhance our recognition and comprehension of patterns, and further develop—around pattern categories such as the six concepts listed above and beyond—sense making frameworks and tools that can help track, compare, confront, use, and create patterns to better understand or design systems, of which observers are a part. One way to achieve this is to describe patterns and represent systems in multiple languages and multiple

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10 See https://www.nextgenscience.org/

11 First order considers the observation "objective". Neither the thing observed nor the observer are influenced by the process of observation

12 The semiotic aspects that we address later in the paper.

13 The cybernetic aspects, not so much elaborated on here, but which can be found in Finidori 2016.

representations, e.g logograms, kanji, hanzi, 汉字; 漢字 graphical patterns, pictures and diagrams as well as words, and seek to make connections between various factors and dimensions involved in the observation, interpretation, and representation processes.

More generally, pattern literacy involves developing a set of 'sensing' and mediating capabilities and tools that can help 'unpack' and 'read' the different dimensions of complexity. This involves (1) making sense of salient patterns and weak signals in growing volumes of information and knowledge, (2) leveraging agency and the complementarity of perspectives, knowledges and know-hows across disciplines or domains of action, and (3) helping change agents to enter in resonance with each other and their environment. This is where the theory and practice of Pattern Languages can help.

3. PATTERN LITERACY AND PATTERN LANGUAGE

Christopher Alexander was strongly influenced by systems sciences and systems thinking in the conceptualization of pattern language theory and structure. As a result, there is a strong resonance between pattern language, on one hand, and systemic inquiry and modeling, on the other. Systems archetypes are the commonly found patterns or generic structures responsible for recurrent patterns of behaviors in Systems Dynamics.

Inspired by the process of design of vernacular cultures—their 'timeless way of building'—grounded in tacit knowledge, Christopher Alexander (1979) endeavored, through his work on pattern language, to tap into the layers of our 'low cognition' by making the implicit explicit. Alexander's goal was to produce specific generative, functional, or esthetic qualities in the built environment through pattern language. These are systemic qualities.

Alexander's work and legacy in architecture and patterns of programming however focused mainly on design aspects and less on recognition and interpretation of patterns[14], which are essential elements for learning and embodied tacit knowledge, and key for the acquisition of systems literacy.

Most efforts of pattern language communities have been dedicated to discovering, capturing, and writing patterns to make them available to practitioners in physical form, but little has been done to 'embody' or re-embed this work back into the lower cognition of practitioners and users as opposed to that of experts. In particular the sensing and sense-making aspects of patterns and pattern languages have been neglected, even if these aspects are omnipresent and underpin most of the pattern language work and literature. This is probably why it has been regularly reported that Alexander succeeded from a theoretical perspective, but failed in the application of his theory, as pattern thinking and pattern design failed to become 'embodied' into know-how, and their expected results failed to show up in buildings produced.

Pattern language thinking and systems thinking may suffer shortcomings of a similar kind: neither of their practice is truly embodied and embedded in tacit knowledge and therefore neither truly contributes to the establishment of a scalable literacy. They remain in the realm of expertise or documented knowledge, with either too steep a learning curve, or too prescriptive a knowledge form. Documented best practices may not be as effective as initially thought. Recent research suggests that they are less valuable than processed micro-narratives as reflections of embodied experience to obtain results in transforming cultures or creating an understanding of existing dynamics (Snowden 2009).

The work of Takashi Iba and his students in this respect is noteworthy, as it is grounded closer to the embodied practice mentioned earlier, with patterns constructed as small narratives. Iba introduced pattern languages of human action (learning, creativity, collaboration, change making etc.), heavily

[14] The semiotic and pragmatic properties that we describe further in the paper.

anchored in pragmatism (Iba & Yoshikawa 2016a), with the recognition of a strong relationship between thought and action, and an objective not only to describe what people should do in a given context, but to change, through practice, people's habits: these actions that occur 'un-selfconsciously' over the long term. Iba also looks at the pattern as a 'psychic tool', the sign and mediator between the object and the subject (Iba & Yoshikawa 2016b)[15]. Iba's reflective work is put into application and further integrated as learning during pattern dialogue workshops where students reflect over their own learning through discussing patterns. We will further develop this approach in the context of pattern literacy in action later in the paper.

We think there is room in the pattern language practice and for the pattern language community to take a broader perspective on the pattern and expand its definition, and to assist in finding ways to help people 'grow' pattern perceiving and sense-making organs, in order to develop a pattern literacy. With the enhancement of pattern literacy, people would be able to 'speak' or 'practice' pattern language, to design alive wholes and to grasp the systemness of things without having to refer systematically to written material. We could think of practicing pattern language as we are currently practicing prose: using vocabulary of which we master the definitions, reading or writing the story with a mastery of the grammar rules and syntax without needing to go back to the user manual in order to understand or compose. Isn't this the essence of literacy? We think that the pattern language community would provide valuable insights to help develop and maintain a language of systems, and find ways to put it to work. In return, the pattern language community would benefit from the expansion of pattern literacy and from introducing some 'systemness' in pattern language work.

4. THE PATTERN AS SEMIOTIC SIGN

Patterns are not only recognizable units or instances of scientific observation and understanding within categories of cross-cutting concepts, as described above (in the realm of the 'objective'). They are also interpretations or mental schemas of these observations (in the realm of the subjective), as well as expressed descriptions or models of these observations (enabling the intersubjective).

We can envision the concept of pattern as a semiotic sign (Peirce 1903) with three facets (often confused with one another) that all come into play when we seek to understand a system or the world around us. These three facets are (1) the signs and cues that we notice in the environment (the 'Object' or system under observation in Peircean semiotic terms[16]), (2) the inferences and mental models through which we make sense of and retain these cues which trigger and shape our decisions and actions (the 'Interpretant' in Peircean terms), and (3) the representations we create to describe and communicate about them (the 'Representamen' or 'sign-vehicle' in Peircean terms). This triadic definition of the pattern as semiotic sign corresponds to Kohls' three 'views of patterns': *patterns in the world*, *patterns in our heads,* and *pattern descriptions*, and offers a coherent way to interconnect different kinds or instances of patterns.

At the individual level, *patterns in our heads*, as models of the *patterns in the world* that are salient enough for us to perceive, and the ways we express our understanding of one or the other in *pattern descriptions* shape each other through an intricate set of cognitive feedback loops (Kohls 2014 see figure below). These feedback loops are essential in the process of individual understanding and

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15 This is not very far from the pragmatic and semiotic perspective grounded in Peirce's work (1903) that we are taking ourselves and develop further in this paper.

16 In Peircean semiotic terms, the pattern is at the same time (1) an *Object* or elementary system under focus (a phenomenological ontological 'form', static or dynamic, in its abstractness), (2) the *Interpretant* or understanding, interpretation, or mental 'decoding' of the object perceived (the form it takes in the mind), and (3) the *Representamen* or sign-vehicle that represents, signifies or 'encodes' this object in relation to its context and interpretation (a physical or explicit formal representation or expression such as a symbol or artifact) through which we communicate). All these forms may reflect observed systemic behavior or structure (observer external to the system in consideration), and they are also subject to triggering behaviors and new structures (observer part of the system in consideration).

learning, and in the acquisition of any form of literacy.

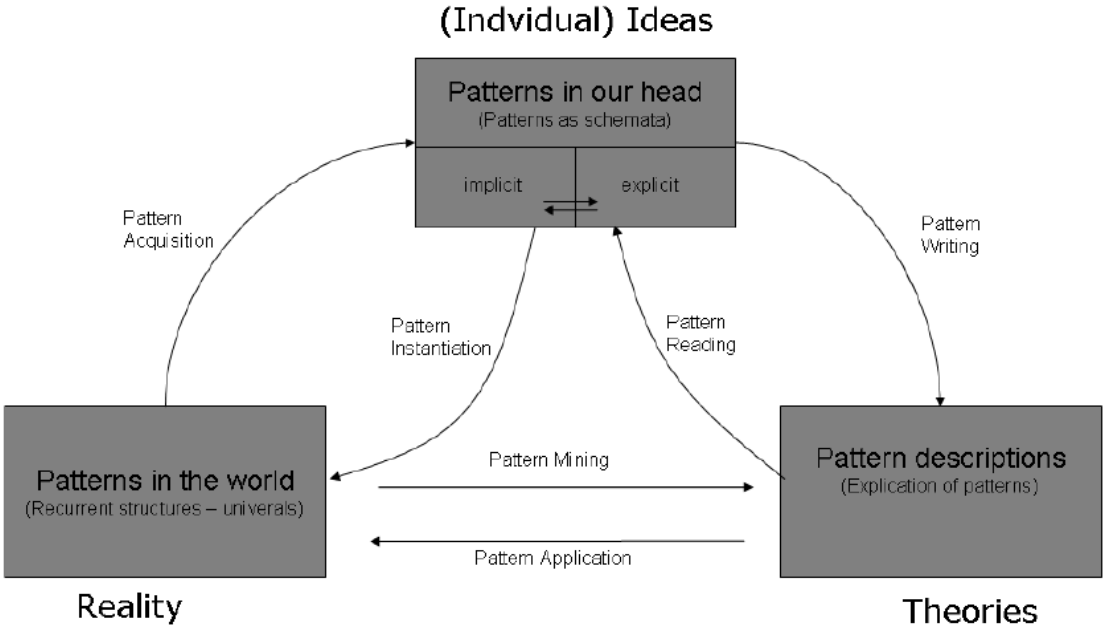

Figure 1: Christian Kohls' refined frameworks of different views of patterns (Kohls 2014)

Seen at the group or social level, the same pattern or phenomenological object observed (pattern in the world) may generate multiple interpretations (patterns in our minds) and representations (pattern descriptions). Each interpretation by an observer may be represented using a variety of media, and each representation may in turn generate a variety of interpretations. As a simple example: a tree may be represented by a picture, a pictogram, or an oral or written description. An observed tree may be assumed by different observers to be an ash, or an elm, which look alike. Each observer may depict an assumed ash or elm in different ways, which in turn could be interpreted by others as yet another kind of tree. If not surfaced and made explicit, this multiplicity of representations and interpretations of a same phenomenon may lead to misunderstandings.

When they are revealed however, multiple interpretations and descriptions can lead to better collective understanding by diverse people as it enables each to uncover unknowns, blind spots or differences in perceptions from what others may know, jointly discovering what is unknown to all (Johari Window, Luft & Ingham 1955). Interconnecting a diversity in interpretation and representation at various degrees of granularity, allows the combinations of a rich variety of networks of signs and meaning of different natures, and the collective navigation of broader areas of systems knowledge and understanding (Brier 2008, Johansson 2013). As a more elaborate example: one could imagine relating patterns of climate change at various levels of interactions with the various worldviews and positions thereof, and the various types of evidence and communication produced. This would provide stakeholders with a broader picture of the challenges at stake and how different groups approach them: helping to 'unpack' and discuss different aspects of the complexity of the issue at different levels, highlighting areas of convergence and divergence, and leading the way to some form of mutual recognition, if not mutual understanding.

By helping us interconnect the variety of our perceptions, interpretations, and representations, a higher awareness of patterns and a literacy thereof could help us interconnect more facets of our inner and outer worlds (the implicit and the explicit) and of our inter-subjective interactions as diverse agents in the complex systems we seek to understand and shape, raising our consciousness in the process.

5. THE PATTERN AS UNIT OF EMBODIED COGNITION

In addition to its connective and integrative power, the pattern also has a significant cognitive power as a medium for discovery, decoding, and encoding, or in other words learning, with a direct and indirect impact on our decisions and actions. This is why pattern literacy is so critical to systems literacy and systemic change and a potential accelerator thereof.

Patterns play a great role in our cognitive processes seen here as embodied action. One of the essential attributes of the human body/brain is its propensity and ability to recognize patterns to infer meaning, trigger action, and learn. The figure below is an illustration by computer scientist John Sowa (2015) of Peirce's pragmatic cycle, onto which we have positioned (in red) the three aspects of the semiotic pattern and the pattern of action. Different types of patterns and different facets of the pattern as semiotic sign are involved at each 'moment'[17] of the perception-to-action cycle, connected through different types of cognitive meta-processes. These 'moments' are context and perspective dependent.

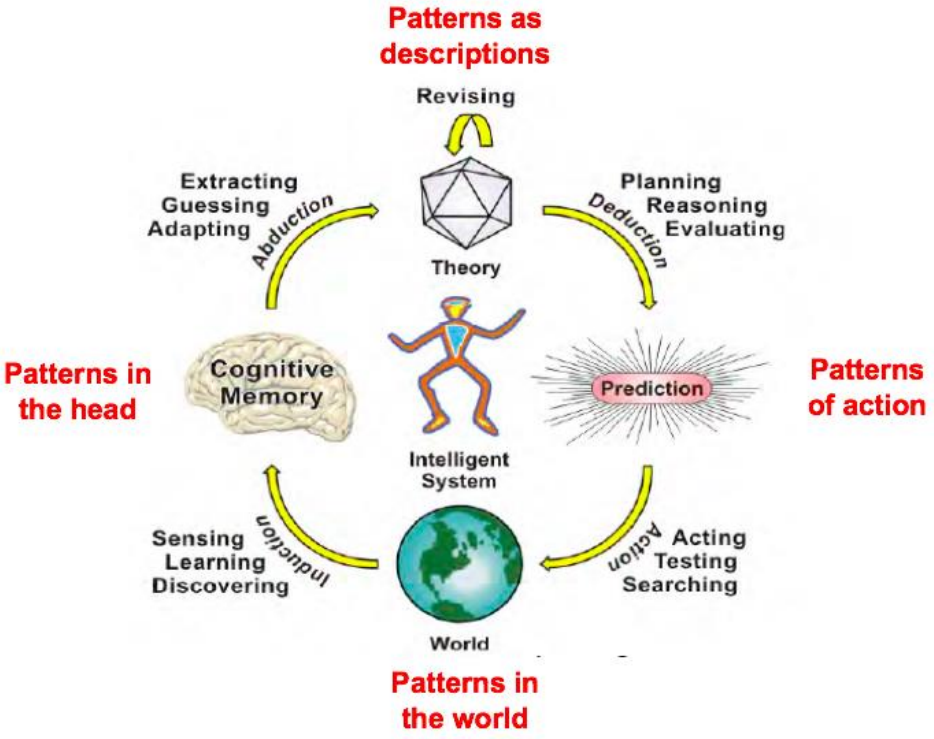

Figure 2: Peirce's Pragmatic Cycle Illustrated by Sowa (2015)

How brains process signals is a key capacity of humans that technology and in particular artificial neural networks have been trying to emulate in machines, with some success as far as big data processing and machine learning are concerned.

For social scientist Howard Margolis (1987), everything in thinking and judgment is reduced to pattern recognition. Margolis describes P-Cognition as a sequence or cycle where a pattern (whether static or

[17] I am borrowing here the notion of 'moments' from Gerald Midgley's 'moments of inquiry' (2000), which I apply in the context of the cognition cycle, a connection Gerald Midgley did not directly make. I will be exploring this notion of moments further in my research.

dynamic) prompted by cues in a context, becomes itself part of the context, and triggers another pattern. Conscious or not, this cycle can happen in multiple cognitive dimensions at once, such as playing the piano while having a conversation. World War Two pilot John Boyd (1995) decomposed the fighter pilot intervention cycle into an Observation, Orientation, Decision, and Action (OODA) loop where patterns at various levels play a key role. The OODA loop, which Boyd then adapted into a situational awareness model applied to management, unfolds at various paces and with various degrees of reflexivity/consciousness depending on how fast a situation can, needs to, or does trigger a response (immediate sensory/affective or acquired reflex of the fighter pilot, or matured reflection in a strategic planning process).

We do not know how the mind/body works to accomplish this, and in situations of uncertainty we cannot predict or anticipate which patterns we will find and what they will trigger in a given context. For quantum physicist and mathematician Freeman Dyson (2014), the structure of thought appears to be associative and essentially a-logical, with chains of thought connecting one memory (or pattern) with another. In a 'pattern language' manner? "*It is by logic that we prove, but by intuition that we discover*": Henri Poincaré (1908) studied the role of intuition and analogy in physics and mathematics, exploring his own experience (he was a productive mathematician). For Poincaré, analogical reasoning, at the basis of creativity, consists in finding hidden similarities and revealing deep identity of structure among what appears divergent in associations between seemingly disparate concepts or ideas brought about by intuition (Paty 1994). One can argue that intuition is the manifestation of subconscious analogies or the discovery of new forms, which are then validated or formalized into new patterns in the mind.

The human brain associated with our sensory capacities and motor production capabilities is a pattern-processing and model-making device. The pattern operates at a 'low cognition' or un-selfconscious level. In the subconscious, the liminal zone; at the level of embodied cognition, where the tacit, the implicit, the mastery, or 'art' lie. At a level 'before' or deeper than articulated language. The language of thoughts? The language of systems? The language of systems thinking? This is what Christopher Alexander captured so well, and what we would like to re-articulate so that patterns and pattern languages can be operationalized into tools and methods that can help further develop pattern literacy and better serve systemic inquiry and action[18].

6. IN SEARCH FOR TERRESTRIAL INTELLIGENCE[19]

How then can humans enhance this pattern-processing and model-making capability to understand and integrate multiple contexts, perspectives and levels of analysis and synthesis, and tackle the challenges ahead, which come not only from complex issues but also from the very technological solutions we are putting in place to address them?

In his Medium article *Alien Knowledge: when machines justify knowledge*, David Weinberger[20] highlights the increasing reliance of humans on 'aliens', i.e. computers, to develop their own models for understanding the world and the hidden order in systems. These machine learning models bring in so many different variables and contexts that they are often beyond human comprehension. This makes Chris Andersen's statement on the end of science to the profit of big data a prophecy. "*The new availability of huge amounts of data, along with the statistical tools to crunch these numbers, offers a whole new way of understanding the world. Correlation supersedes causation, and science can advance even without coherent models, unified theories, or really any mechanistic explanation at all*." (Wired

[18] This is the topic of Finidori's PhD

[19] This is also the title of an Essay by Olivier Auber (find link) that Finidori helped translate into English.

[20] https://backchannel.com/our-machines-now-have-knowledge-well-never-understand-857a479dcc0e

2008).

Weinberger suggests that computers have surpassed us in the sense that we cannot reproduce the reasoning that led to a delivered result / output. But do we need the reasoning? He asks. Or do we need the ability to see the richness of the 'true' world, which is not the 'reductions' that our models are presenting us, to grasp both the big picture and the outlier[21], and a sense of direction as to where change is coming from and where it is going? "We thought knowledge was about finding the order hidden in the chaos. We thought it was about simplifying the world. It looks like we were wrong. Knowing the world may require giving up on understanding it." he writes.

We have entered an era where design surpasses human ability in terms of understanding structures and processes at play as well as outputs produced. As Richard Gabriel envisioned and suggested in a 'Design beyond human ability" talk, we have designed technology that behaves increasingly like living autopoietic systems, that can not only self-monitor and self-correct or self-repair, but that can also self-design, as they continually (re)create themselves, all the while they continue to produce outputs external to themselves.

The challenge, then, is to keep a capacity to think critically individually, and collectively about the validity of the outputs, and the 'intentions' or biases or possible unethical criteria that humans may introduce, knowingly or not, in machine algorithms that will iterate into the outputs, only elements visible to us. A pattern language to express algorithm intentions, test the intentions against the code to detect algorithmic bias, and the outputs against the intentions could make the validation process easier. This would enable systemic assessment as well.

The following question[22] was asked on a systems group on Facebook, which totally encapsulates the questions we as authors are having: "how do you know your algorithms are doing what you intended?" "How do you know the actions you took based on algorithmic insights did not have adverse unintended consequences?" And "have you ever compared your Big Data insights to those of human sensor networks?"[23].

Dave Snowden (2009) has been deploying technology augmented human sensor networks[24] designed on a science-based approach to the understanding of cognition in the areas of hospital experience and community care, street entrepreneurship in Columbia, and more, which rely on human rather than machine interpretation for detecting patterns, and in particular on communities analyzing and interpreting their own data. Originally used in natural disaster recovery actions, the practice has been extended to other types of interventions. Human sensor networks enable the harvesting and analysis of community data and micro-narratives in real time.

Human systemic skills and insights could be enhanced, and human sensor networks such as developed by Snowden could be enabled at broader scales through the expansion of pattern literacy. Human sensor networks would be a good place to start experimenting with methods and tools for pattern literacy.

A proactive development of pattern literacy can help bridge human and artificial intelligence to better tackle systemic challenges. In hindsight, we are wondering whether that wasn't what Christopher

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[21] In Dave Snowden explaining the Cynefin Framework at http://www.youtube.com/watch?v=N7oz366X0-8

[22] Question by Bruce Waltuck, complexity focused organizational change consultant.

[23] In our conversations for the finalization of this paper, Richard Gabriel offered another perspective: "A more difficult and scary question concerns algorithms that are doing exactly as you intended, but what they are doing / accomplishing is beyond your ability to recognize them as correct.". To be worked out.

[24] Watch Dave Snowden on Human Sensor Networks: https://www.youtube.com/watch?v=ugtCr81C8H4

Alexander was after, ahead of his time[25].

7. PATTERN LITERACY IN ACTION

Because of their ubiquitous and versatile qualities, as connectors of reality, thought, and expression (semiotic aspects), and as mediators among different forms of inference and engagement (perception-to-action pragmatic aspects), patterns and pattern languages can be operationalized into tools and methods designed to enhance pattern literacy 'hands on.' Such tools and methods, oriented toward learning by doing, can be conceived to leverage the cognitive aspects of patterns, those from which an embodied cognitive apprehension of systems becomes possible.

In the following paragraphs, we share a few examples of how patterns and pattern languages, as recognizable connective and mediating objects and systems, can be used to develop sensing/perceiving and sense-making capabilities. We show how experience-based peer learning methodologies (in particular through co-exploring, comparing, and confronting perceptions, representations, and interpretations), and how adaptive modeling and design skills using simple pattern-based artifacts can help 'construct' or 'deconstruct' collaboratively encompassing both 'art' and 'science' perspectives.

7.1 Reading the signs in the environment to find deeper patterns

Tracking patterns on or below the surface (Gooley 2016, Glanzberg 2017), seeing the obvious or the unseen, and reading weak signals (Holland 2012) are key capabilities that helped humans survive or thrive over the ages: the stripes of the tiger, the footprints of the bear, the flight of the eagle or the hawk (Underwood Spencer 1990), the sound of an approaching storm or the anticipation thereof, the alignment of stars in the ocean night, the distress of a loved one or the anger of an enemy…. Human's innate ability to sense, process, and mobilize patterns has been lost. Somewhat, our sensing organs have been numbed, and amid the noise generated by information overload and complexity it is urgent that we reclaim them. It is not enough in our current contexts to use our reasoning to model, optimize or maximize in lengthy planning processes. Humans need to re-learn to surface patterns they have perceived but not yet formulated, and to process signs as they arise, much like the fighter pilot does with the OODA loop mentioned earlier in the paper, to adapt their actions to uncertain changing complex conditions. Like the acquisition of natural language or the mastery of an art, the process of acquisition of pattern literacy builds up in time, starting with simple forms, and evolving with practice.

7.2 Acquiring new skills for observing and 'sensing', for pattern discovery and sense-making

The (re)learning process includes a (re)discovery of patterns. According to Richard Gabriel and Jenny Quillien, the best design patterns aren't actually 'designed', rather they are 'mined' in a way similar to scientists mining the universe for mathematically 'simple' facts (Gabriel 2017[26]), and then polished into 'stable' design forms. Patterns already exist out there, ready to be discovered. Jenny Quillien (2007) on the tracks of Jane Jacobs offers a method to 'Unravel Problems of Organized Complexity' by untangling the variables and the smaller segments that compose them:

a) First 'preparing for analysis,' where the concern is still with "collection, description,

[25] This may seem a stretch… but the intervention of Alexander at Oopsla 1996, exhorting the software / computer science community to design systems that not only 'do what they are told' but are able to create a better world, indicate he might have been, if AI had been more advanced at the time…

[26] Private conversation during the shepherding process.

classification, and observations of apparently correlated effects."
b) Identifying a specific variable just as the biologist singles out, say, an enzyme, and then follows its relationships with other variables.
c) Making our observations in terms of the behavior and not just the mere presence of other specific (not general) variables.
d) Focusing on specific processes and, like Sherlock Holmes, seeking 'unaverage' clues that reveal larger patterns.
e) Realizing that these variables "do not exhibit one problem which if understood explains all. They can be analyzed into many such problems or segments which are also related with one another." And, "when the segments are separated out the behaviors of a variable when in the presence of other variables can be discerned."

Taking the process to another level, Takashi Iba (2014) uses pattern languages to mine, analyze, and visualize experience, in a feedback loop generative simultaneously of additional pattern languages and pattern literacy. The process is illustrated in the figure below.

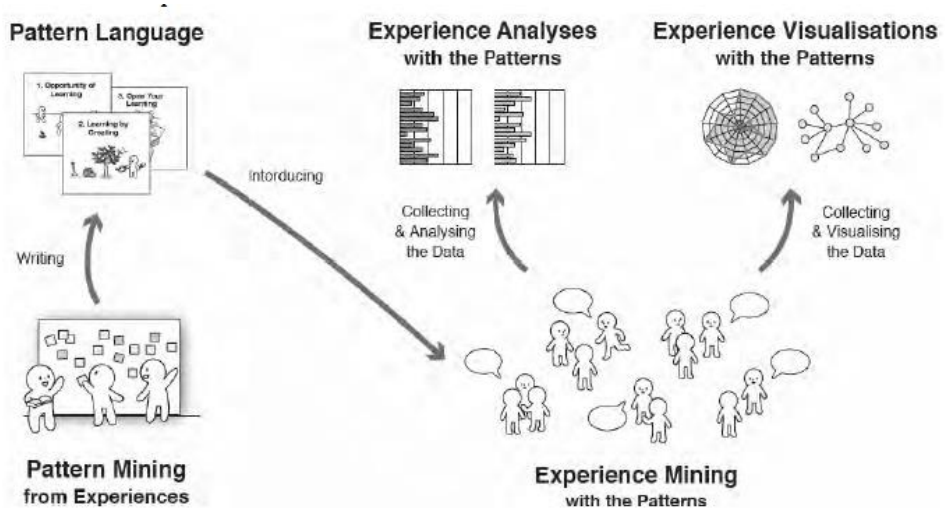

Figure 3: The overview of experience mining, experience analysis and experience visualization with patterns (Iba 2014)

The pattern and experience mining processes at the same time require and help enhance pattern literacy, in a dual learning loop.

7.3 Crossing boundaries

As the popularity and flourishing of domain-related pattern languages show, it seems relatively easy or at least feasible to find clues and act in concert across shared, transversal, or adjacent domains of experience.

Crossing boundaries in multi-stakeholder, trans-experience domains may be more of a challenge, because what is salient to perceive and retain is not cohesive or of a similar nature or form across contexts, nor are the visions, values, or priorities that drive action.

Iba (2016b), working with patterns in the transversal domain of human action, highlights the role of patterns and pattern languages as vocabulary for communication and media to exchange about different kinds of experiences.

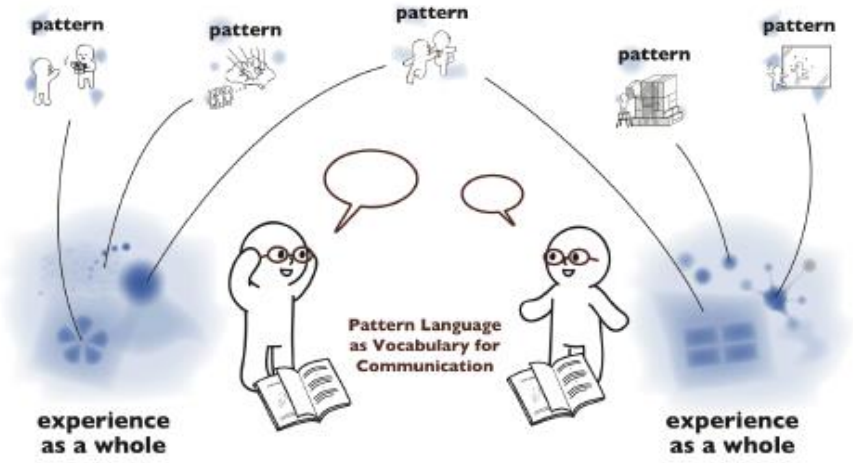

Figure 4: Exchanging about experience through dialogue via patterns and pattern language (Iba 2016b)

Bridging diversity requires tools and methods, as well as mutual learning contexts where possibilities for interoperability can be found, and where diversity of perspectives and languages can be interfaced at the boundaries of adjacent or disjoined fields of action and knowledge, in view of creating convergence of understanding and action, without necessarily aligning goals and pathways.

7.4 Patterns as Boundary Objects

With their ubiquitous forms, versatile functions, and potential to be represented in a variety of formal structures that can be standardized and digitized, patterns mined from stories or events and expressed as units of micro-narrative, untangled variables or small segments, or systems of interacting forces, can be used as boundary objects.

Boundary objects are known in sociology as "*objects which are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use. They may be abstract or concrete. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation. The creation and management of boundary objects is key in developing and maintaining coherence across intersecting social worlds.*" (Star & Griesemer 1989, p393) There is some clear resonance with the pattern here, although patterns as defined by the pattern language community are much more structured than what is described here.

For Dave Snowden (2009), stories are the fundamental patterning devices through which we communicate, learn, and understand the world in a fragmented unstructured anecdotal way. This patterning occurs using micro-narrative rather than complete stories. Stories are fractal in nature, and the capture and exchange of large amounts of micro-narratives determine how our identities are shaped. This is what operates at the family table when we exchange pieces of family stories and consolidate our family identity. When we consciously reflect on these patterns, bringing them from the unself-conscious realm, to the conscious realm, they can serve as boundary object, or objects of inquiry.

Focusing on patterns and combinations of patterns as micro units of meaning at various levels and scales seeks to build coherence among perspectives rather than cohesion. It can help avoid the temptation, all too frequent when groups with multiple identities come together to cooperate on

complex issues, to seek alignment on vision, values, priorities, or vocabularies—or in other words, to build complete stories meant to guide cooperation—as a preamble to their work. In practice, many such efforts lead to frustration because conflicting interests and difficulties to articulate what is shared get in the way and result in waste of time and energy.

Patterns as boundary objects or units of micro-narrative have a key role to play in collective meaning-making and in mediating communication within and across groups, in 'plastic' ways, when it is easier to reflect on smaller elements of a bigger picture, than on a one-piece story or model from which the individual parts are more difficult to apprehend, and which may elicit 'take-it or leave-it' types of attitudes. They are effective tools to be used in the course of hermeneutical inquiry[27] (Kinsella 2006)—a co-exploration in interpretation of meaning and intention at various levels of granularity- and in joint discovery journeys, where participants mutually learn from each other. Once patterns are discovered and made explicit, they act as attractors or centers around which opinions can be expressed, clustered and mapped, boundaries probed, controversies identified, and points of view and interpretations confronted and meta-stabilized, using Wikipedia types of processes. What lies 'in between' can be explored as boundary objects as well, enabling navigation across complexity factors and dimensions, and ultimately the construction of broader and more structured systemic stories.

In the workshops documented in the figure below, systemic interpretation symbols[28] are being used to compose or decompose 'systemic stories', seeking to highlight patterns and show the 'systemness' of what is narrated fractally. The stories composed during sessions held at Purplsoc 2015 and PLoP 2016 have been very diverse, including topics such as modeling a known pattern, relationships in the workspace, organizational issues, power relations, new business models, business processes, scaling of good practices, continuous improvement, new technologies, the processes of good journalism, or urbanization. In this type of intervention, the patterning process, as learning process, is as important if not more important than the patterns themselves and the final story as far as the conversations generated and the acquisition of pattern literacy are concerned.

Figure 5: The pattern as unit of micro narrative: cards are used to tell each other systemic stories. Here at Plop 2016[29]

[27] Hermeneutical inquiry seeks to interpret meaning and intentions.

[28] Such as those in appendix II

[29] Finidori photo archives

Figure 6: Dialogue Workshop with Learning Patterns at Keio University (Iba 2014)

Iba's patterns are expressed as small stories, which make them very attractive and easy to take ownership of. The image above shows freshmen students in their first day at Keio University, learning sets of patterns with Iba's Learning Patterns, exchanging the knowledge they acquired, self-evaluating their knowledge, and choosing the areas for further learning. Around one thousand students are engaged each year in such sessions, bringing the total number to seven thousand since 2011.

7.5 Adaptive modeling, constructing and deconstructing with our heads and hands: a Hacker's approach.

Because they can be expressed or dealt with, with various types and degrees of formalism, in narrative and natural language, and from the most 'artistic' mode (low cognition driven mastery of the art) to the most 'scientific' (using reasoning and thorough systematic methods), patterns have the potential not only to become systemic intervention tools, but also systemic research tools, as suggested by Cunningham and Mehaffy[30] (2013).

Initially named diagram in Alexander's early work (1973), and described as "an abstract pattern of physical relationships, which resolves a small system of interacting and conflicting forces", the pattern is a subsystem of a 'near decomposable complex system' (Simon 1962) recognizable by the human mind, and recombinable into new models or forms, following grammar-like rules. This does not necessarily mean that patterns are combined following strict syntactic rules that form structured sentences, but rather indicates a breaking down into discrete elements which can be recombined[31], following simple association rules, forming the 'language' part of pattern language.

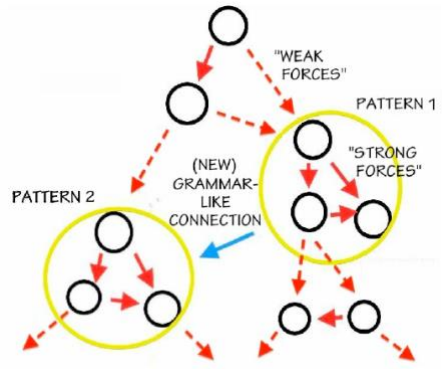

Figure 7: The structural logic of pattern languages. Image from Cunningham and Mehaffy 2013

[30] As a conclusion to their 2013 PLoP paper p.16, Cunningham and Mehaffy suggest that patterns and pattern languages have the quality to become scientific research tools.

[31] The study of the language aspects of pattern language is something the authors would like to explore more in depth.

Unlike one-piece designs, models made of combined patterns created and improved one at a time can be probed and adapted in a purpose-seeking rather than goal-directed manner, thus enabling exploration and learning. Complex adaptive wholes evolve 'piecemeal' in the process without predefining specific structures in advance. Fractal stories reinforced through the combination and repetition of micro-narrative follow a similar process.

Such 'grammatisation'[32] of the design or modeling process provides a method for collaborative sense-making which enables inquiry for each pattern considered, and at each connection (Finidori 2016). Grammatization provides possibilities for understanding and a learning and design experience different from those offered by closed one-piece cyclic models such as Systems Dynamics Archetypes[33]. Cyclic processes are often illustrated by feedback loops which are hard to 'get into', prompting questions such as where do we start? There are probably no clear or even real beginning, nor end to these pathways. But the first thing observed or the first step taken is always a good step in that it provides a beginning for an inquiry (Finidori 2014b).

In practical terms, purpose-seeking/context-adaptive modeling supported by pattern language as agile technology (Cunningham & Mehaffy 2013) would consist in decoding (i.e. interpreting and/or articulating) and encoding (modeling and prototyping) problem situations and responses with and into patterns, in order to track changes in configurations, processes and behaviors of pattern encoded objects, and adjust orientation in relation to intent as suggested by Finidori, Borghini & Henfrey in their work on fourth generation pattern languages (Finidori & al. 2015).

This resembles a hacker approach, where objects are deconstructed and reconstructed. The Lego Serious Play method, illustrated below, based on creative imagination and metaphor, where participants 'learn to think with their hands', uses 3D Lego forms as shared language for modeling, group discussion, knowledge sharing, problem solving and decision making. How could these types of tools and methods be adapted for pattern literacy and systems understanding?

Figure 8: Hands-on construction—Lego Serious Play ©—Source Avea Partners.

The process of mining and finding patterns, breaking them down into smaller segments as described above, probing their sustainability and trueness to purpose, assembling them into sequences of aggregate patterns and probing again, and finding ways to express or represent them is part of a peer-to-peer learning process that will enhance systemic awareness and systems literacy.

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[32] Grammatization here is the breaking down of a temporal continuum into discrete spatial elements, reproducible and recombinable. Not the design of syntax and rules for composition. See http://arsindustrialis.org/grammatisation

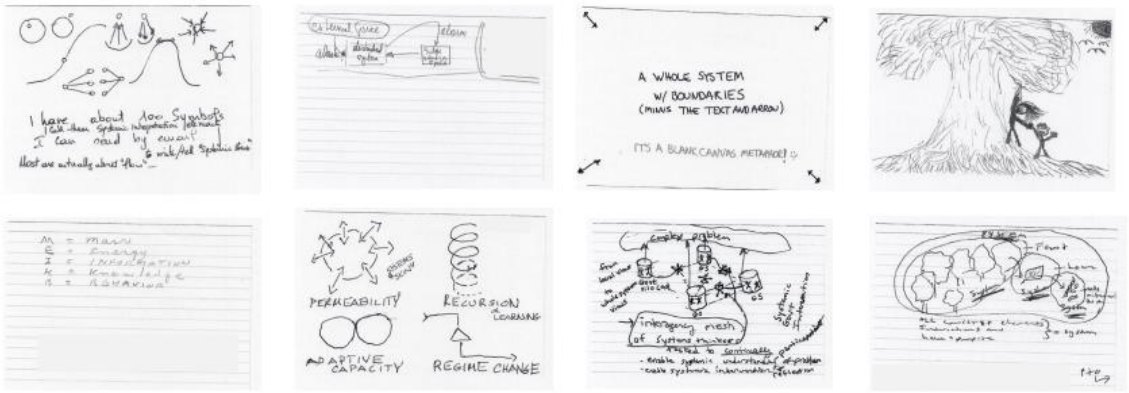
[33] Systems Dynamics Archetypes are patterns of behavior of a system over time, expressed using stocks, flows, internal feedback and causal loops, table functions and time delays.

8. SYSTEMS OF REPRESENTATION: THE QUEST FOR UNIVERSAL PATTERNS

Which types of shared systems of representation, then, are to be used or discovered, when there are multiple learning contexts, and multiple possible languages and forms to describe or approach shared concepts and subsequently multiple understandings and descriptions of the world we live in and of the systems, socio-environmental and socio technological that constitute it?

This multiplicity was illustrated in an exercise proposed during a plenary keynote at the International Society for the Systems Sciences Annual conference in Boulder Colorado in July 2016. White cards were handed out and delegates were asked, in addition to using words, to use symbols as representing principles, big ideas, or concepts in a systems literacy effort; to take the card and "draw a system" and/or draw symbols to represent essential principles or big ideas of systems.

Delegates then drew on the cards while they watched two short videos on ocean literacy. At the end of the plenary the cards were collected and photographed. Below is a sample of a few of the 34 cards received. The full set is appended in Appendix I:



Our harvest (see full set in Appendix I) shows the different points of entry, modes of representation, and vocabularies used to represent systems, which we attempted to categorize.

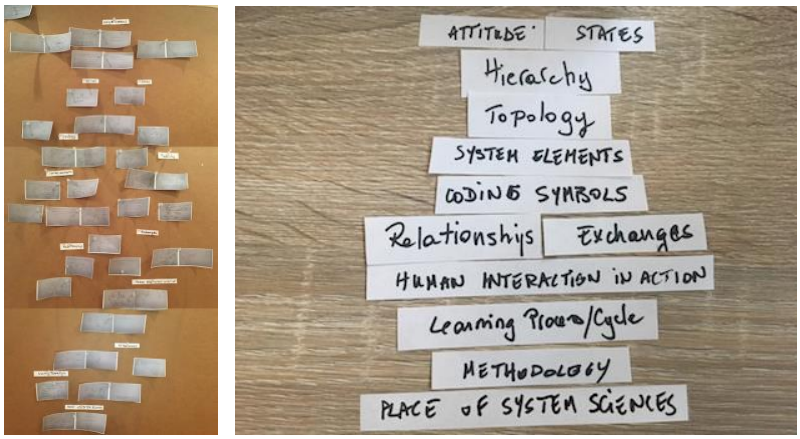


Figure 9: Clustering and labeling. Photos Finidori

We found out that there are multiple ways to cluster and label things, and always some new item that doesn't fit and needs a new category….

Today there is an increasing demand for transdisciplinarity and integrative systems knowledge. Often

however, this materializes by a quest for universals or overarching principles in nature or reality, and for shared visions and representations among observers. Such a quest presupposes 'agreement' on shared priorities, the prisms through which to see things, or the points of entry into an approach, in addition to shared vocabularies and representations. We saw above that vocabularies and representations pertaining to the 'same reality' are multiple. Priorities in terms of approaches and action are not 'interchangeable' as they are paradigm and preference dependent (Meadows 1997, Brown 2005, Finidori 2013). It took for example ten years to come up with the order and wording of the Earth Charter articles.

The quest for universal principles exists in many domains and disciplines, as attested by Alexander's life work culminating in the fifteen principles of wholeness and the quest initiated by Bertalanffy for Unity of Sciences through General Systems Principles.

In his *Quest for General Systems Principles*, Rousseau (2017) notes that "although the existence of principles is inferred from the existence of isomorphic systems patterns… knowing more isomorphisms only increases confidence in the existence of principles without making them easier to find."

In a context where each researcher is developing his own framework, format, and methodology, with a diversity of interpretations and representations, as our experiment has shown, and with the multiplication of pattern languages and recorded patterns, is it possible to find universal principles or patterns?

The world wide web is born from a similar quest: finding interoperability between information systems and solving the problem of information diversity and fragmentation, a challenge that single centralized systems and format standards failed to address. Instead Tim Berners Lee made information interoperable through the hyperlink and communication protocols, enabled by html and error tolerant browsers. Now with the semantic web we can go several steps further as we can assign meaning to connections and create clusters of linked data, semantically proximate on any type of criteria we may decide. Semantically interconnected linked data values difference and keeps data that does not fit anticipated forms. It enables every nuance to be expressed, preserving the richness of the 'long tail' and the interconnection of multiple streams of information that reflect the evolution of things and remain alive. This is quite different from stored data that easily becomes 'dead'.

We subsequently question here whether trying to reach agreement on universal principles, laws, or patterns in systems science or other sciences, and to capture patterns in databases is not a waste of energy and time. Why not try to connect according to proximity and distance, similarities and differences, and find interoperability between observations, concepts and representations in an ongoing manner? Such mapping exercise took place at the PLoP95 conference, where around three hundred patterns were laid on the floor and interconnected using string. Another attempt at connecting patterns along a variety of relationships was undertaken by the Hillside Group that same year (Wirfs-Brock 2017, Buschmann & al 1996). Today the Hillside Group is seeking ways to gather, search, and interrelate patterns, so the community can provide feedback to keep them alive and make them evolve. This work could help draw relationships on the basis of systemic homomorphism and semantic proximity.

Gabriel suggests that observing a repeating pattern in the world may lead to some coalescing and generalization, and perhaps extrapolation of what the 'cause' of this pattern might be[34].

The interconnection of isomorphic patterns of multiple kinds (in words, image etc.) via semantic relationships into networks or clusters of linked data would create mutual learning environments enabling conversations and the recording of controversies around system issues and general principles. These conversations and controversies, generated around patterns as boundary objects

[34] Private conversation July 2017 during the Plop shepherding process.

using methods of collective hermeneutical inquiry as described above, would meta-stabilize around strong 'centres' such as they exist now in Wikipedia. This would accelerate and bring visibility to a coalescence around 'similar causes', making generalizations and extrapolations toward 'universals' within reach.

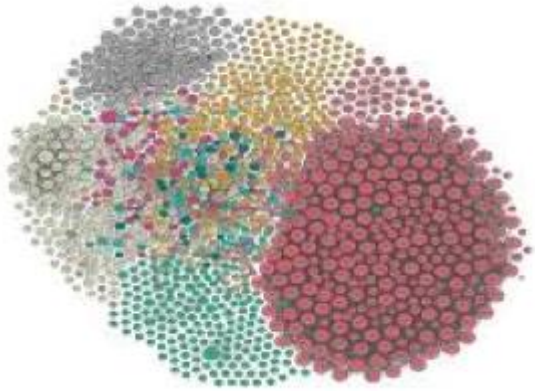


Figure 10: Semantic relationships graph enabled via linked data[35]

Just as words are interconnected in the visual thesaurus[36], where one can physically and visually travel in the word space; one could imagine traveling in clusters of interrelated symbols and non-visual representations of patterns such as those gathered in Appendix II. As an example, the figure below shows Christopher Alexander's fifteen principles of wholeness illustrated by four different authors including himself. These could be interconnected, and further connected to other patterns and representations to expand the boundaries of Alexander's work.

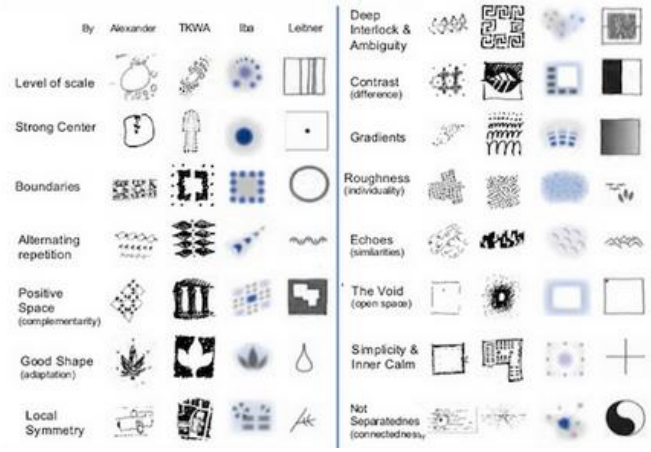


Figure 11: Alexander's 15 principles - 4 different representations[37]

Nora Bateson's idea of 'multiple descriptions and interfaces', and search for 'relational data' to show 'multilayered interactions' in complex systems (Bateson 2015) could be powered by a system such as described above, with patterns used as mediators and connectors at the boundaries between and

[35] Image from: Linking Open Data cloud diagram 2017, by Andrejs Abele, John P. McCrae, Paul Buitelaar, Anja Jentzsch and Richard Cyganiak. http://lod-cloud.net/
[36] https://www.visualthesaurus.com
[37] Icons come from: Alexander 2010, Iba 2015, TKWA 2011, Leitner 2016

among the different aspects, levels and dimensions of systems, and the different perspectives and representations thereof.

The examples above show how we could be working in participatory ways towards comparing interpretations and representations of 'mined' patterns, drawing semantic relationships among them, and studying clusters of 'isomorphic' patterns to better collaboratively describe common objects of study and discuss or debate among domains. Adopting the approach of the geographer[38] and understanding the different levels from which an observation is made, could help create topographies, networks of 'patterns that connect', enabling navigation in the pattern space, and projecting in time (not history projections, but probabilistic—anticipating or possibilizing change).

A key systemic literacy skill would be to be able to recognize one's own space and the existence of the space of others, to navigate within this connected knowledge, and to understand our position in it. This is where pattern literacy becomes essential.

Conclusion:

The relation of patterns to embodied cognition and to the understanding of systems is explored here as an introduction to determining the importance of pattern literacy in support of systems literacy. Building upon work on ocean, earth, and atmosphere literacy as introduction to systems literacy on the one hand and on work on pattern languages and design on the other hand, this paper describes various properties of patterns. It outlines how patterns can be understood as 'potentially structured,' scientifically, cognitively and socially recognizable, and interoperable units of systemic meaning-making that can be operationalized into learning tools and methods that can lead to a natural appreciation of patterns in systems, and thus to a better understanding of dynamics of systems and complexity.

The authors believe that by taking a broader perspective on patterns and by expanding its definition, in particular as far as the phenomenological and cognitive function of patterns are concerned, the Pattern Language Community could help develop tools and methods to enhance pattern literacy, thus contributing to reinforcing the use and development of pattern languages in general and to enhancing the 'systemic' evaluation of patterns in particular. This broader perspective could in addition help the development of a collective intelligence that connects the patterning capability of humans and machines to design and evaluate the sustainability of socio-technological and socio-environmental systems.

We are looking forward to get the communities of Systems Sciences / Systems Thinking and Pattern Language and artificial intelligence to work together on pattern literacy to support systems literacy to this effect. We think, moreover, that the pattern language community would provide valuable insights to help develop and maintain a pattern language of systems, and find ways to put it to work. As a first step, the workshop on tools and methods to enhance pattern literacy held at PLoP 2017 highlighted a great interest from the pattern language community for the topic of pattern literacy. There were discussions for building a pattern language for pattern literacy drawing on the existing knowledge and practice of pattern languages. And we would strongly encourage the inclusion of systemic elements in this pattern literacy pattern language such as notions of flows, forces, relationships, levels of scales, and wholeness. Such an initiative would answer a need expressed by several of the PLoP 2017 attendees to keep patterns and pattern languages alive, and to encourage the development of a pattern language

[38] See the example of Google 'weaving' different types of images visualizations in Google maps: https://www.wired.com/2014/12/google-maps-ground-truth/

community more focused on the practice and use of pattern languages, on knowledge transfer across disciplines and domains, and on producing designs that are themselves generative, than on writing patterns and pattern languages.

This work will contribute to creating new ways to communicate what pattern and systems literacy mean. It is a work in progress, establishing steps toward pragmatic application to the complex issues we are encountering, enabling people to explore possibilities from the place where they are located, and learn from there.

We would like to thank our shepherd Richard Gabriel for his insightful comments and support during the drafting of this paper, as well as Jenny Quillien, MaryLynn Manns, Aracele Fassbinder and Chris Richardson for their constructive comments during the *Roughness group* writer's session at PLop 2017.

Appendix I

Exploring ways to represent systems

At the ISSS Annual Meeting and Conference in Boulder in 2016 during a plenary session on Systems Literacy the participants were asked to take a 4x6 card and to either 1. Draw a System and or 2. Draw symbols to represent essential principles or big ideas (of Systems). The 4x6 cards were a blank space upon which different interpretations of the question were made explicit.

A total of 34 Cards were handed in at the end of the plenary. They have been photographed, anonymized and reproduced below.


Perhaps a spiral for recursion? Something showing you do not return to starting point.
Transformative Learning
Disruption
Challenges
Assumptions
Dialogue
New Information
Creates
Sources
Sinks
SoI
BEING A CONSCIOUS POINT WITHIN THE WHOLE, CONSCIOUS OF THE WHOLE WITHIN THE POINT. UNLIMITED INFINITE ENERGY → LOVE
360°
a system
natural system
Symbolic Socio-ecology
Ideas
Expectations
Environment
Contributions
Wastes
PSS
Positive Systems Science

Appendix II

Symbols and non-verbal representation systems

We gathered here a variety of different types of symbols and non-visual representations that could be used to 'describe' or represent systems.

Can we settle on a universal set? How could they be interconnected to find correspondences and enable navigation among different universes of meaning, looking at what clusters appear.

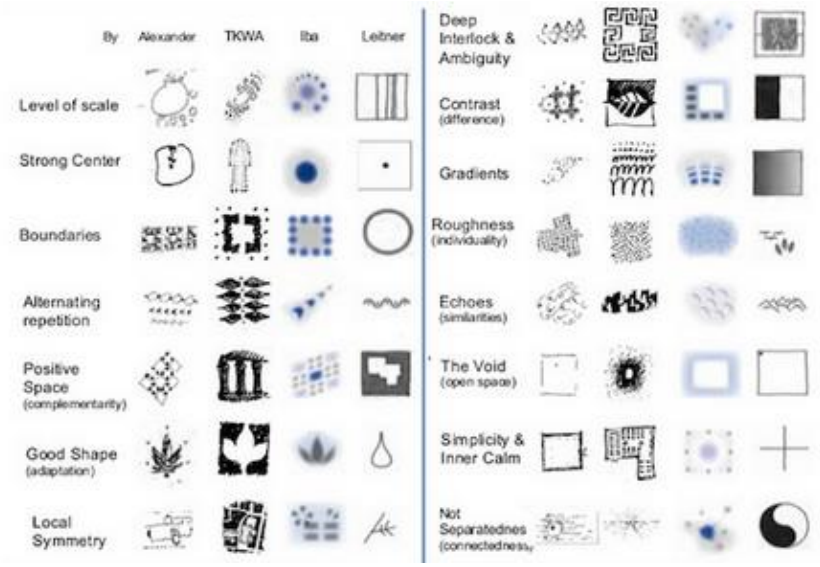


Figure 12: Alexander's 15 principles - 4 different representations[39]

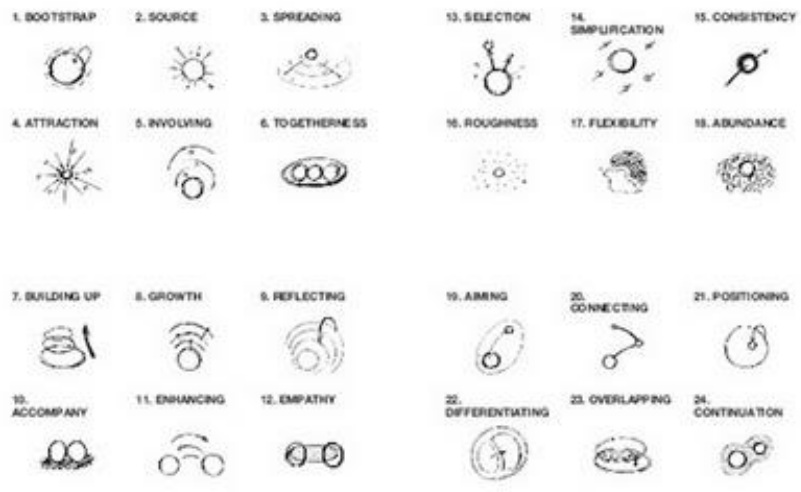


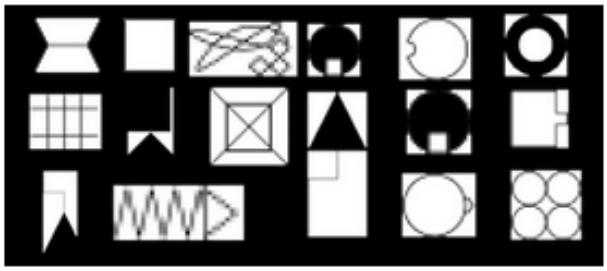
Figure 13: Iba's Fundamental behavioral properties (Iba 2015)

[39] Icons come from: Alexander 2010, Iba 2015, TKWA 2011, Leitner 2016

Figure 14: Finidori's sets of systemic interpretation symbols cards (Purplsoc 2014, Purplsoc 2015, Plop 2016)

Figure 15: Pattern Dynamics - Consulting Practice (Private conversations 2014 and forward).[40]

[40] See < http://patterndynamics.net/>[accessed 19 July 2017]



LEGEND of SYSTEMS SYMBOLS and FUNCTIONS

Symbols	Mnemonic shorts		Subsystems (critical)	Functional character features & qualities
△	S	1	Input transducer	sensor, sighting, receptor, detector, perception, receiving
⌶	H	2	Internal transducer	coordination, inside monitor , feeler gage, harmonious correlator , home-base sensing
⌷	D	3	Decoder	diagnose, designation, distinction, interpret, translation, categorize, synoptic labeling, construe, situation-control, identification
⌖	P	4	Associator	projective planning, prospect vision, assemble, relate, strategic intelligence, anticipation, presage, decision switch
⬭	G	5	Decoder	goals & objectives-keeping, purpose guidance, motives, drive, policy, steering-control, impeller
⋈	N	6	Channel & Net	net (work), communication, circulate, relaying,
⍌	M	7	Memory	remember, message-retainer, filing & retrieval, retrospect
⍈	E	8	Encoder	explicate, external translation, expression-former, outcoding, public report
▽	A	9	Output transducer	action, activator, actuator, exploit, deed, implement, sending, effector,
◷	T	10	Timer	time-keeper, cycle-setter
⍋	J	11	Ingestor	injector, jet-entry, intake, reception, job-entry
⍐	F	12	Supporter	foundation, firmament, ground, substance, sustain, maintain
⍗	C	13	Converter	conditioning, prepare, transform, rework, refinery
⌦	K	14	Producer	maker, generator, facture, repair, mending
⍟	Y	15	Motor	move, motility, mobilize, ambulate
⍇	L	16	Distributor	pipeline, transport linkage, route, line entrenchment, liner fairway
◇	O	17	Storage	supply store, stockpile, queue, cumulation, reservoir, depot, deposit
⊠	X	18	Extruder	exit, outlet, exhaust propulsion, remove, discharge, unload
▭	B	19	Boundary	border, shield, fence, wall, enclose
◿	Z	20	Reproducer	replicate, template, zoon, remake

Figure 16: Living Systems Symbols from Ilan Riss[41]

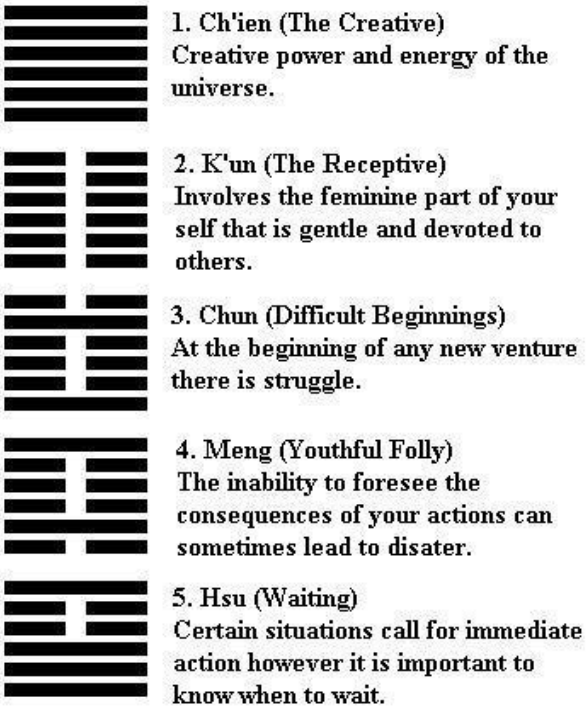


Figure 17: The Tao i-chin

[41] Presented in Peter Tuddenham's Keynote at ISSS 2016

Figure 18: Adinkra concepts: used in African pottery and textiles

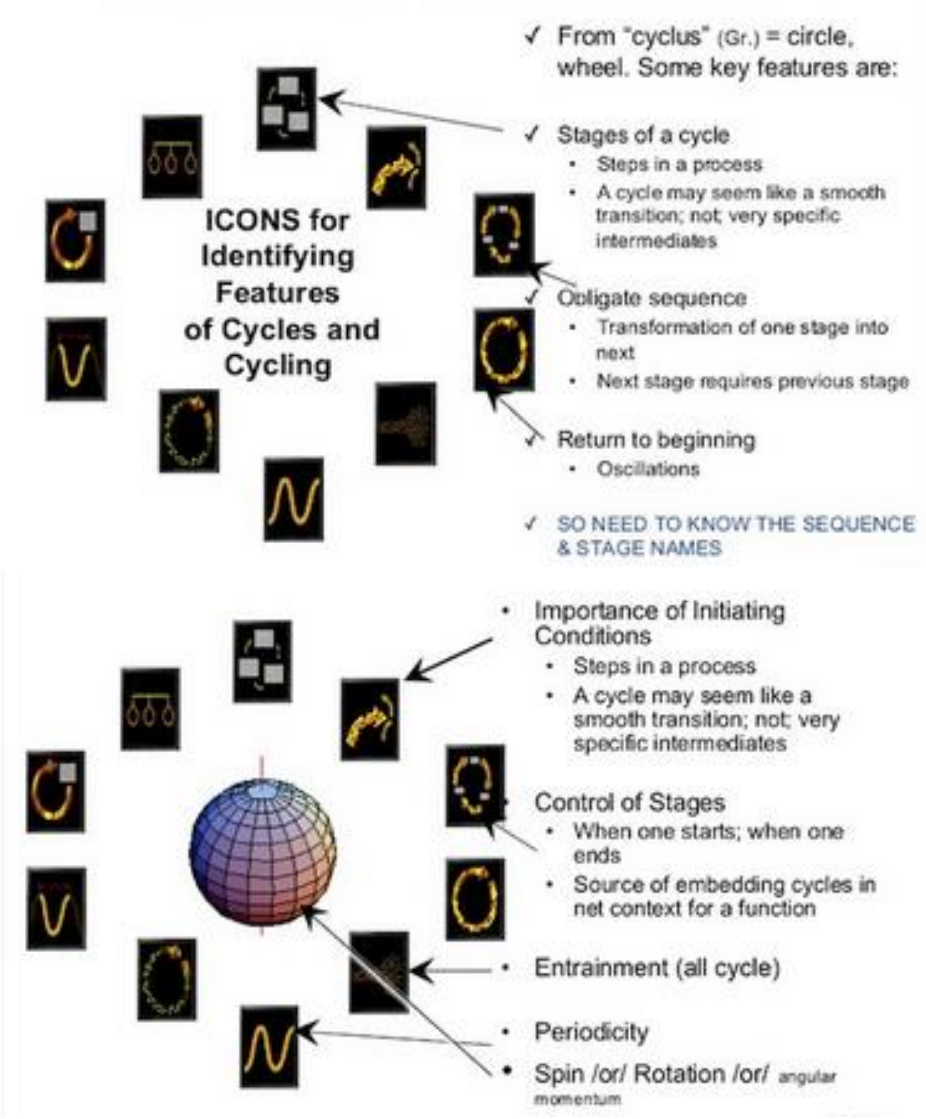


Figure 19: Len Troncale's Isomorphies: Icons of Cycles (Workshops at ISSS2016 and previous)

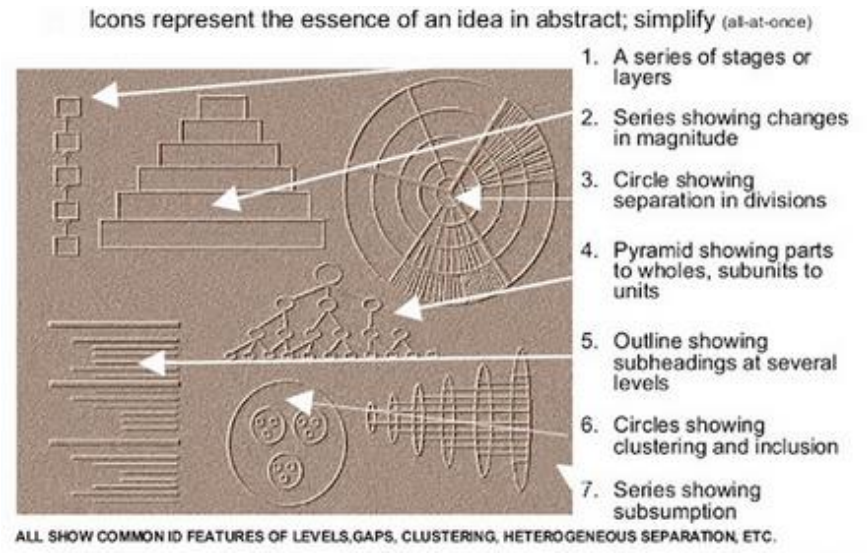


Figure 20: Len Troncale's Isomorphies: Icons of Hierarchies (Workshops at ISSS2016 and previous)

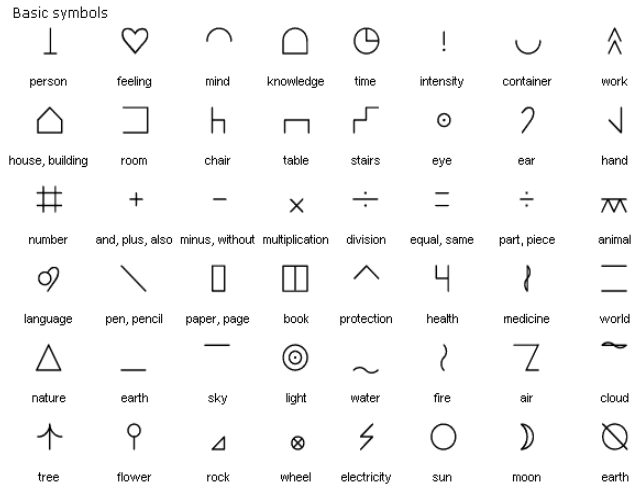


Figure 21: Bliss Symbolic - The written equivalent of the language of signs[42]

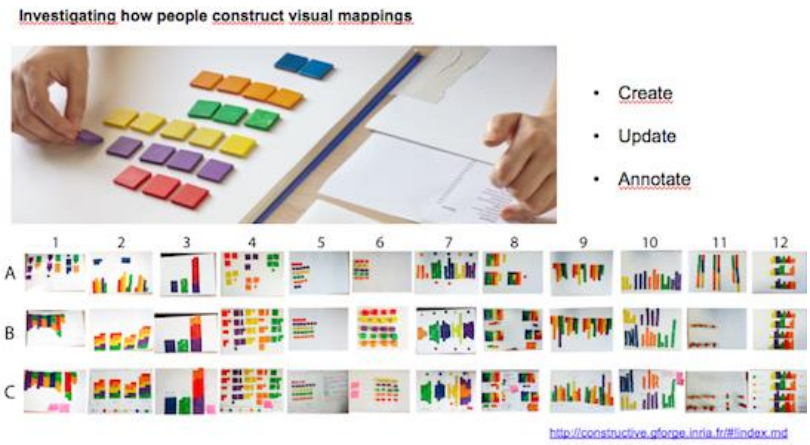


Figure 22: Another type of exercise - Investigating how people create visual representations.
Here: Visual Construction Tools: Tangible Tokens - S. Huron Inria[43]

[42] See http://www.blissymbolics.org and selection of Bliss Symbols: https://www.omniglot.com/writing/blissymbolics.htm
[43] See http://constructive.gforge.inria.fr/#!index.md

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