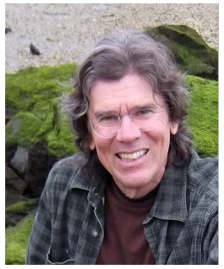
Towards a Systems Engineering Foundation

Panel Session – July 19, 2023 – SE Foundations

An integrative framework for system science

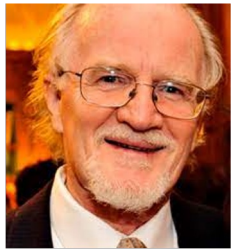
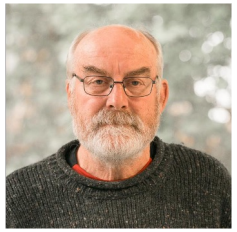
Systems Thinkers in the Field of the Sciences



Formal Sciences

Phenomenological Sciences

Normative sciences

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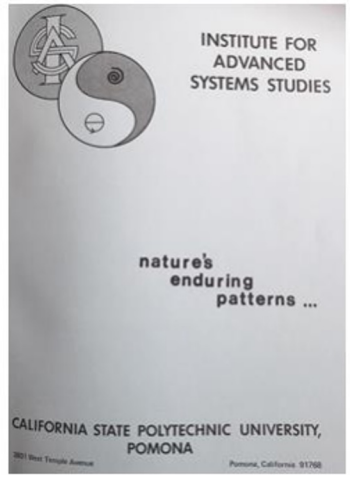
Andreas Hieronymi
Systems Research and Behavioral Science, Volume: 30, Issue: 5, Pages: 580-595, First published: 18 October 2013, DOI: (10.1002/sres.2215)

Knowledge about the nature of systems

"...principles that are applicable to all systems, whatever their nature may be." - Ludwig von Bertalanffy

"identifying common principles..that transcend specific domains and disciplines." - *James Grier Miller*

".. science that is applicable equally to physical, biological, social, and psychological phenomena." - *Norbert Wiener*



"...exchange matter, energy, and information with their environment...systemic interconnectedness and the flow of inputs and outputs." - *Ludwig von Bertalanffy*

"Common patterns, laws, and principles ...fostering a holistic and integrative understanding of reality." - *Kenneth Boulding*

"interconnectedness, interdependence, and interrelations of components..feedback loops and the dynamic nature of systems." - *Anatol Rapoport*

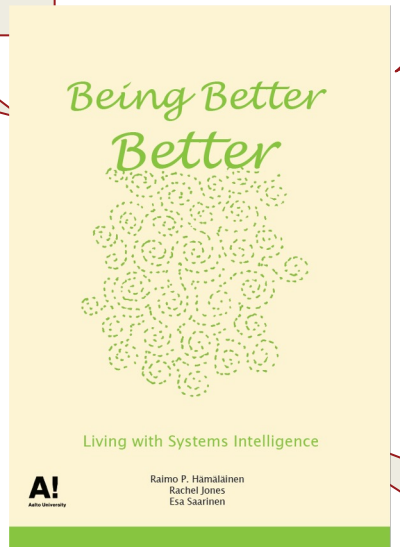
"Cybernetics, a vital component of general systems theory,...control and communication processes within systems, ...feedback mechanisms in maintaining stability and adaptation." - *Norbert Wiener*

Knowledge about how we can be systemic

"The understanding of social systems, organizations, and human behavior can be greatly enhanced by applying general systems theory" - *Ludwig von Bertalanffy*

"It helps us identify leverage points for intervention and navigate system change towards desired outcomes." - *Donella Meadows*

"...viewing organizations as complex systems with interconnected components and interdependent relationships." - *Kenneth Boulding*

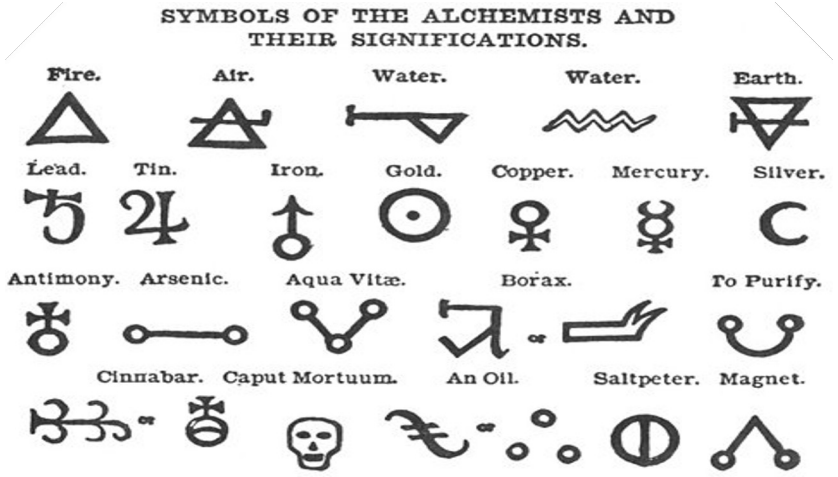


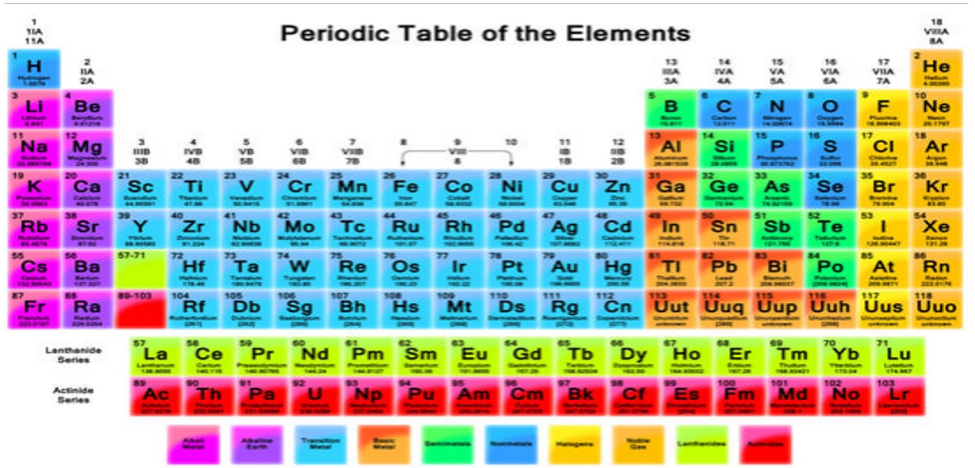
"consider the whole rather than isolated parts in social systems ...a holistic approach to understanding complex problems and designing effective interventions. - *Russell L. Ackoff*

"General systems theory provides us with the tools to perceive and transform the underlying structures and mental models that shape social systems." - *Peter Senge*

"Applying cybernetics and general systems theory to social systems...It helps us design more adaptive and resilient systems." - *Stafford Beer*

Frameworks are required for integration - providing enabling constraints

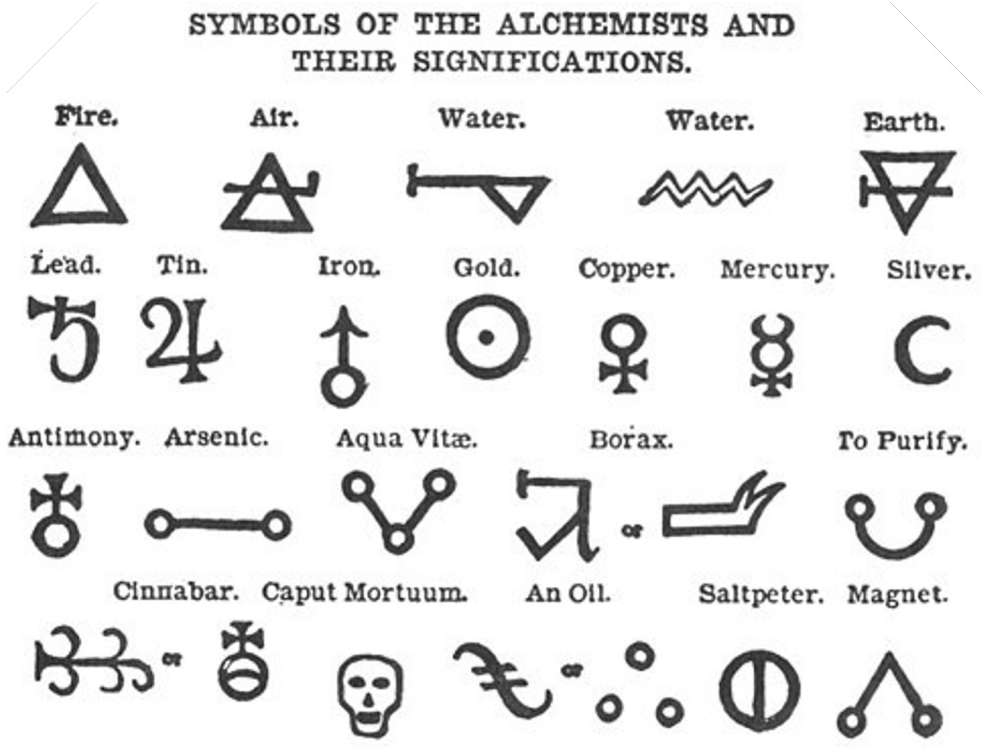




Mystery
Alchemy
Alsystemy

Mastery
Chemistry
Systemry

Without system science, we remain Alsystemists



Together we have a diverse wealth of knowledge….

- Viable System Model
- Systems Dynamics
- Information Theory
- Cybernetics
- Complexity Science
- Relational Theory
- Living Systems
- Critical Systems
- Anticipatory Systems
- Basic Principles of Science
- System Process Theory
- General Systems Theory
- Soft Systems / social science
- Hierarchy / Holarchy Theory
- Panarchy
- Interactive Management (Warfield)
- System Engineering
- Systemic Intervention
- Systems Thinking

...and much more

"Without an integrative framework for organising our knowledge, it might be fair to say that systems science is to a degree stuck in the descriptive (naturalist) stage in the development of a science. In some ways akin to field biologists discovering new kinds of plants and animals prior to the development of a categorical science in which the characteristics of those various kinds could be compared and contrasted in various measurements, those biologists were caught in a process of describing similarities, yet over time seeing patterns that hinted at new possibilities of organisation." - George Mobus, "What is system science?" IFSR conversation 2019

“Vision - System Engineers of the future would apply their understanding of systemics when they manipulate and transform systems”

- With a framework based on general systems theories we will have the ability to **comprehend and organise the ‘general human activity system’**.
- The patterns resident in the framework would be **validated by diverse and numerous heuristic models** that instantiate it.
- The framework would have the ability to **integrate all knowledge in a systemic way** such that an overall system of knowledge development can be realised.
- We would be able to **systematically define, develop and connect core systemic concepts**, drivers, pathologies, processes, principles, methods, tools and wisdom.
- It would provide the **foundations for the architecture of our systems engineering knowledge**, resident in ISO15288, the SE Handbook and SEBOK - and would enhance it as a system.
- When developed to its logical potential this would lead to the **recognition of systems engineering as a discipline with the same degree of authority as other applied sciences.**

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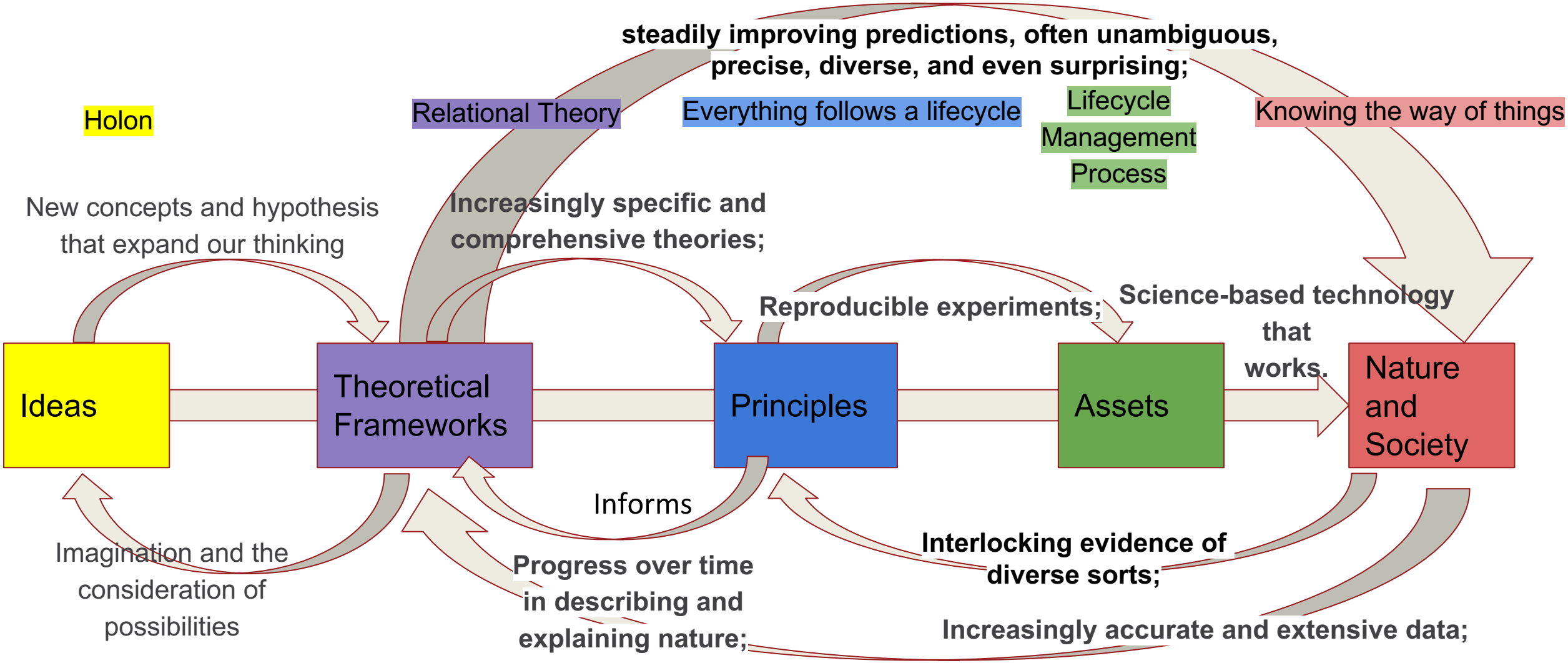
“Science”, a knowledge management “system”



Model built from: Gauch (pp. 63-64 of: Gauch, H. G. (2012. Scientific Method in Brief. New York: Cambridge University Press)

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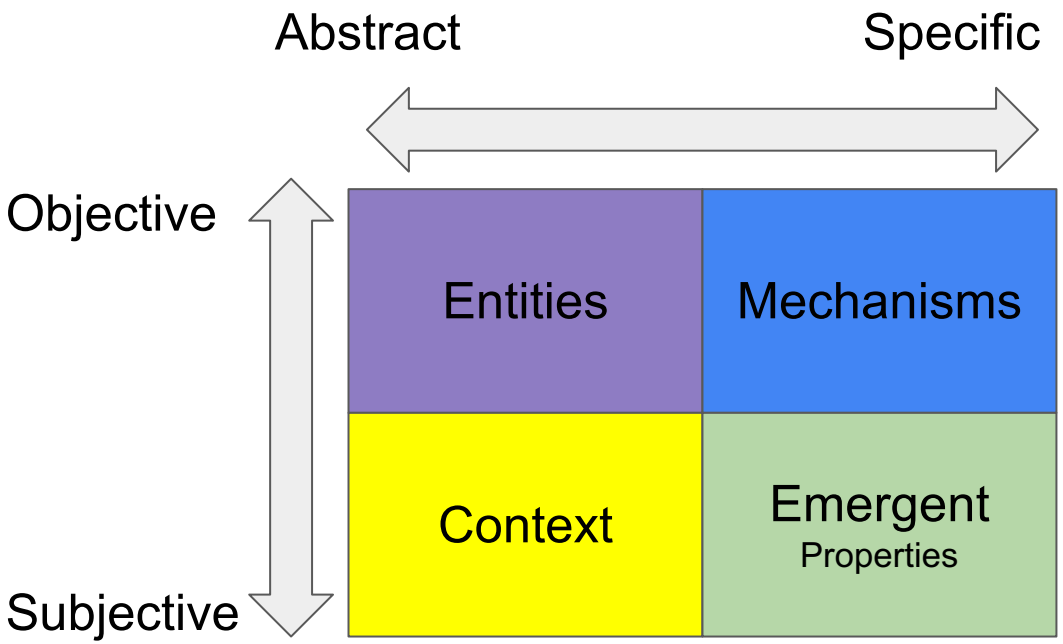
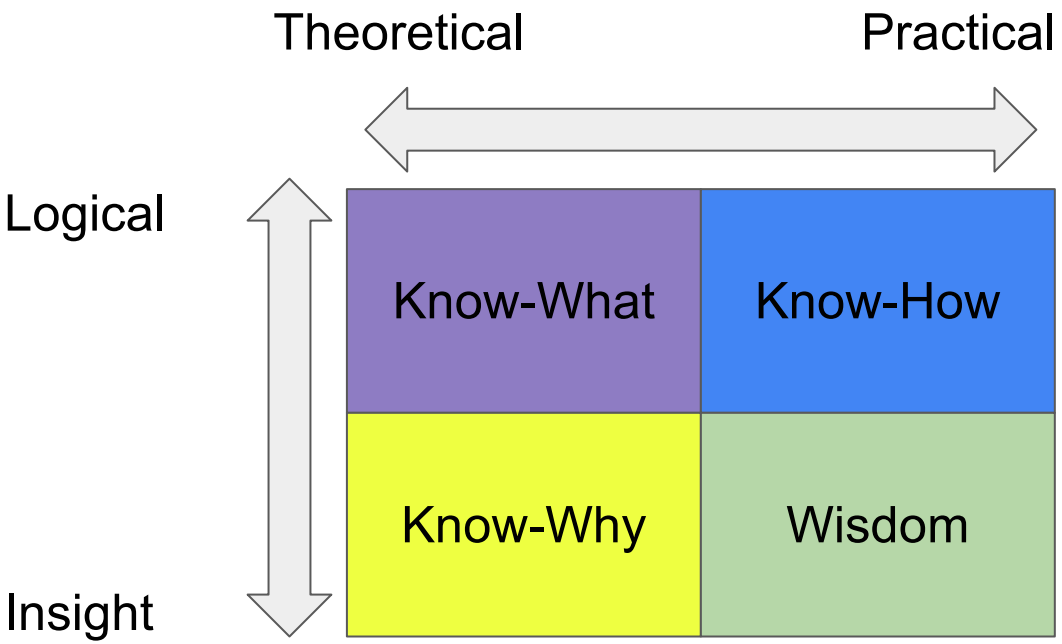
Two general knowledge frameworks that overlay Holarchic and Relational

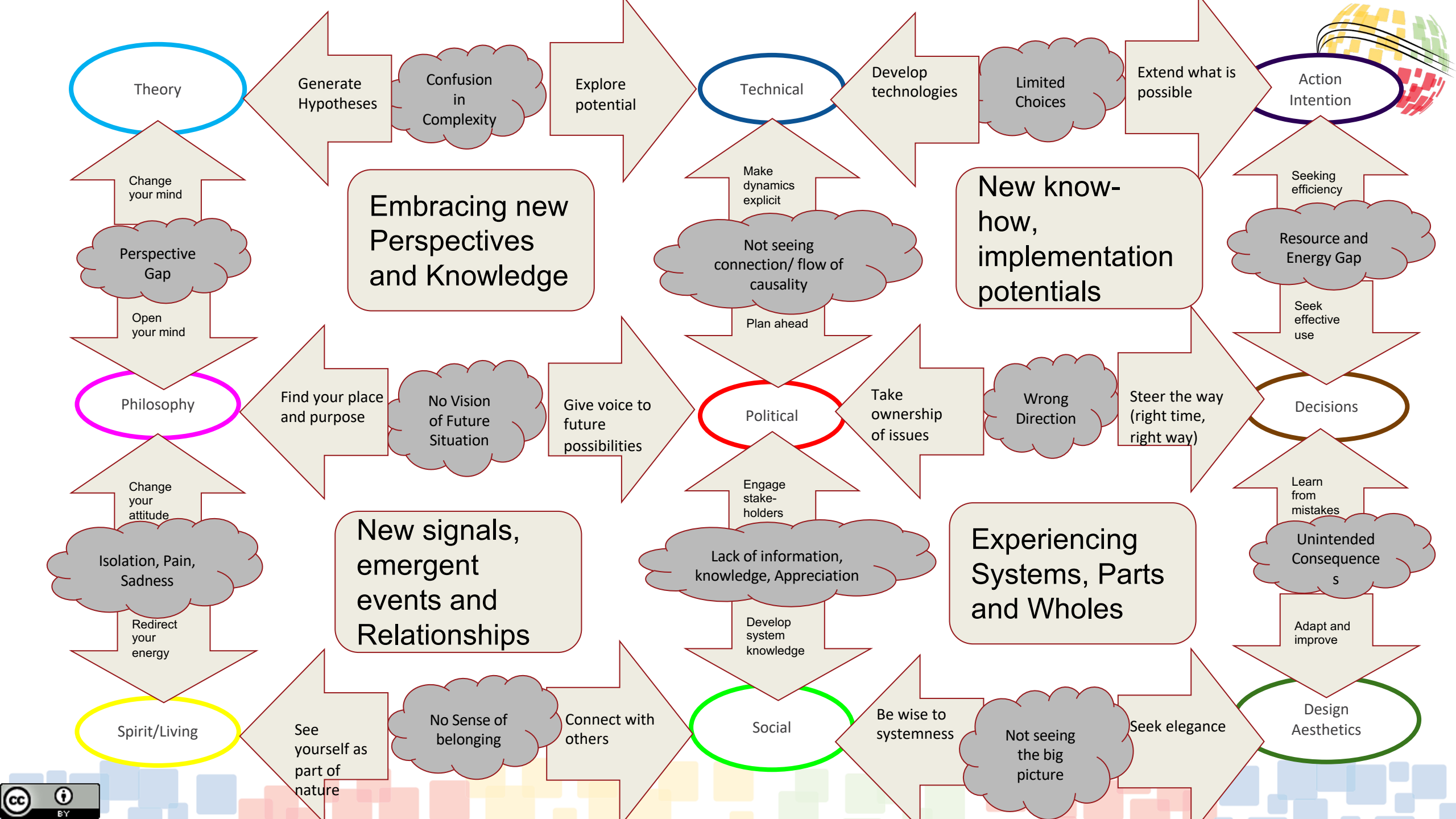


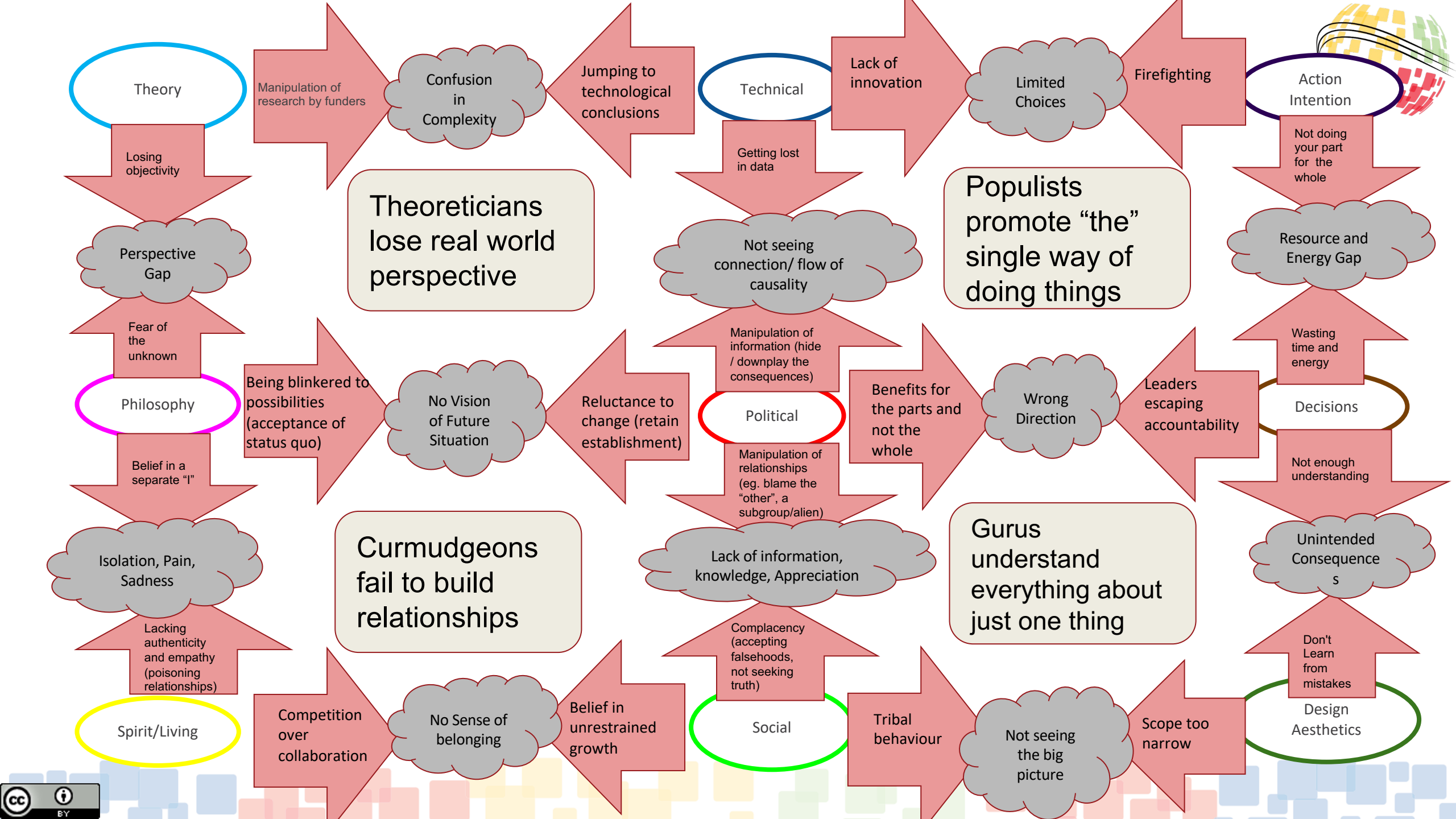
About Systems

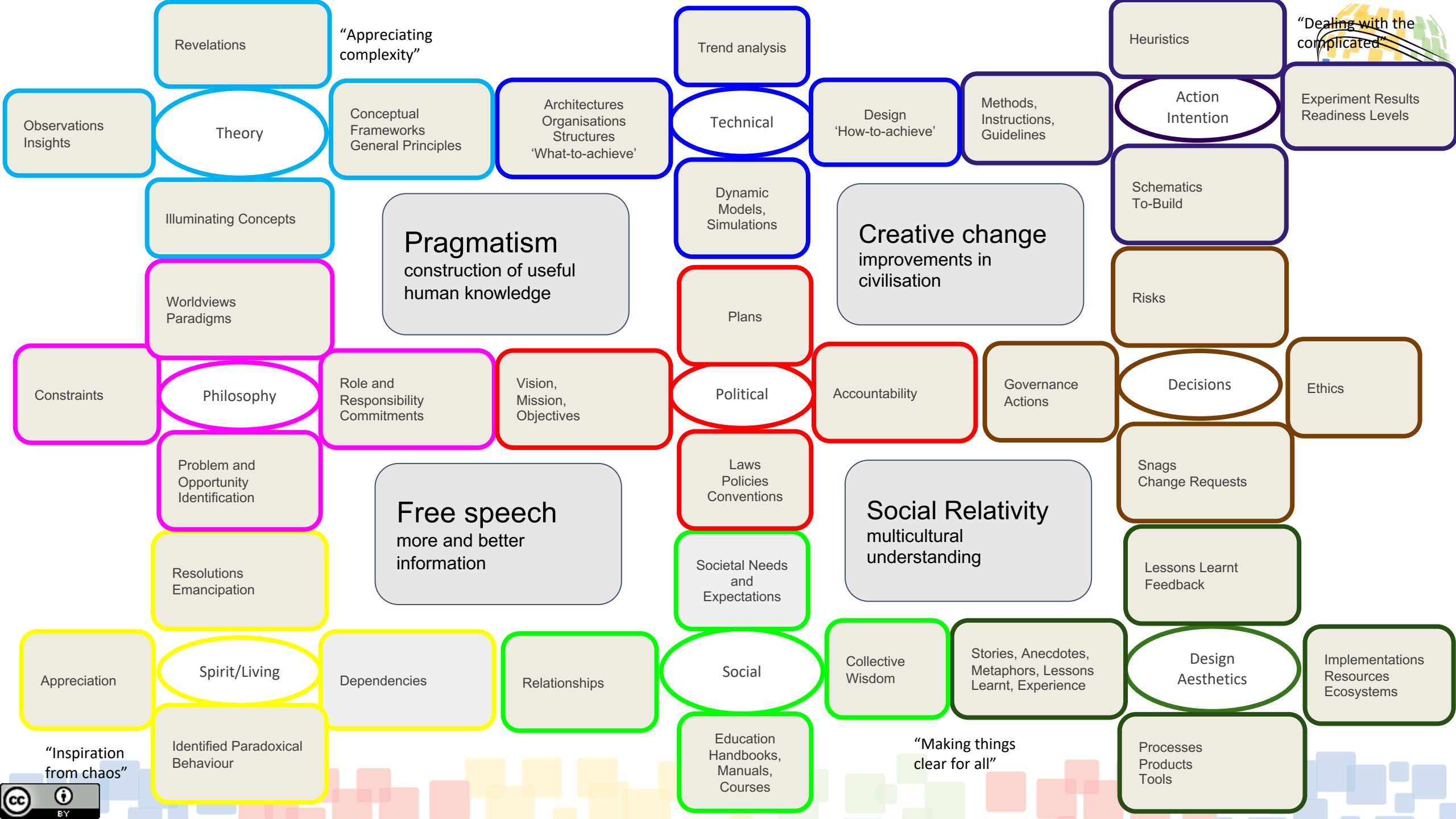


Engaging with Systems

		Ideas - Concepts (for meaning and observation)	General Theories - Frameworks (for orientation)	Big Ideas - Principles (for deciding)	Enablers - Assets (for acting on)	The whole-Context (to realise)
Categories						
FORM	**Identity of wholes (togetherness of things)**	Structure, Components, Boundary, Boundedness, Holarchy, Topology, Wholeness, Integrity, Network,	Theories of Identity and Togetherness	Simpler things combine into more complex things #1 have systemness #3 are networks	Taxonomy of togetherness (eg Volk)	Taxonomy of system types (eg Boulding)
	Behaviour of wholes (processes of things)	Activity, Dynamic, Influence, Interaction, Dependency, Feedback, Source, Sink, Stock, Flow, Effect	Theories of Behaviour and Processes	Very different things do many things in the same fashion #2 are processes #4 are dynamic	Taxonomy of processes (eg Troncale)	Taxonomy of behaviours (Troncale?)
FUNCTION	**Cycles of wholes (phases of things)**	State, Phase, Transition, Event, Tipping point	Theories of Cycles and Phases	Everything follows a lifecycle, even the universe #11 can be understood #12 can be improved	Taxonomy of phases (eg Troncale)	Taxonomy of cycles (Troncale?)
	Capability of wholes (purpose of things)	Stakeholder, Responsibility, Role, Hierarchy, Autonomy, Environment	Theories of Capability and Purpose	Emergent Properties when things combine #5 are complex #8 have regulatory subsystems	Taxonomies of purposeful subsystems (eg Miller)	Taxonomy of capabilities (Mobus/Beer?)
	Value of wholes (qualities of things)	Perspective, Use, Judgement, Condition, Circumstances, Benefit, Selection	Theories of Value and Qualities	Value increases when stakeholders are engaged #9 models of others #10 models of themselves	Taxonomies of qualities (eg Virtues - Rousseau et al)	Taxonomy of values (Swartz)
FIT	**Consciousness of wholes (experience of things)**	Awareness, Understanding, Empathy, Comprehension, Learning, History, Memory, Evolution, Adaptation, Anticipation	Theories of Consciousness and Experience	The more complex something is, the richer is its experience #6 are evolving #7 encode knowledge and exchange information	Taxonomies of experiences (eg Bloom)	Taxonomy of Consciousness (eg Jonkisz)


Theory
Generate Hypotheses
Confusion in Complexity
Explore potential
Technical
Develop technologies
Limited Choices
Extend what is possible
Action Intention
Change your mind
Perspective Gap
Open your mind
Embracing new Perspectives and Knowledge
Make dynamics explicit
Not seeing connection/ flow of causality
Plan ahead
New know-how, implementation potentials
Seeking efficiency
Resource and Energy Gap
Seek effective use
Philosophy
Find your place and purpose
No Vision of Future Situation
Give voice to future possibilities
Political
Take ownership of issues
Wrong Direction
Steer the way (right time, right way)
Decisions
Change your attitude
Isolation, Pain, Sadness
Redirect your energy
New signals, emergent events and Relationships
Engage stake-holders
Lack of information, knowledge, Appreciation
Develop system knowledge
Experiencing Systems, Parts and Wholes
Learn from mistakes
Unintended Consequences
Adapt and improve
Spirit/Living
See yourself as part of nature
No Sense of belonging
Connect with others
Social
Be wise to systemness
Not seeing the big picture
Seek elegance
Design Aesthetics


Theory
Losing objectivity
Perspective Gap
Fear of the unknown
Philosophy
Belief in a separate "I"
Isolation, Pain, Sadness
Lacking authenticity and empathy (poisoning relationships)
Spirit/Living
Manipulation of research by funders
Confusion in Complexity
Jumping to technological conclusions
Theoreticians lose real world perspective
Being blinkered to possibilities (acceptance of status quo)
No Vision of Future Situation
Reluctance to change (retain establishment)
Curmudgeons fail to build relationships
Competition over collaboration
No Sense of belonging
Belief in unrestrained growth
Technical
Getting lost in data
Not seeing connection/ flow of causality
Manipulation of information (hide / downplay the consequences)
Political
Manipulation of relationships (eg. blame the "other", a subgroup/alien)
Lack of information, knowledge, Appreciation
Complacency (accepting falsehoods, not seeking truth)
Social
Lack of innovation
Limited Choices
Firefighting
Populists promote "the" single way of doing things
Benefits for the parts and not the whole
Wrong Direction
Leaders escaping accountability
Gurus understand everything about just one thing
Tribal behaviour
Not seeing the big picture
Scope too narrow
Action Intention
Not doing your part for the whole
Resource and Energy Gap
Wasting time and energy
Decisions
Not enough understanding
Unintended Consequences
Don't Learn from mistakes
Design Aesthetics


Revelations
"Appreciating complexity"
Trend analysis
Heuristics
"Dealing with the complicated"
Observations
Insights
Theory
Conceptual
Frameworks
General Principles
Architectures
Organisations
Structures
'What-to-achieve'
Technical
Design
'How-to-achieve'
Methods,
Instructions,
Guidelines
Action
Intention
Experiment Results
Readiness Levels
Illuminating Concepts
Dynamic
Models,
Simulations
Schematics
To-Build
Pragmatism
construction of useful human knowledge
Creative change
improvements in civilisation
Worldviews
Paradigms
Plans
Risks
Constraints
Philosophy
Role and
Responsibility
Commitments
Vision,
Mission,
Objectives
Political
Accountability
Governance
Actions
Decisions
Ethics
Problem and
Opportunity
Identification
Laws
Policies
Conventions
Snags
Change Requests
Free speech
more and better information
Social Relativity
multicultural understanding
Resolutions
Emancipation
Societal Needs
and
Expectations
Lessons Learnt
Feedback
Appreciation
Spirit/Living
Dependencies
Relationships
Social
Collective
Wisdom
Stories, Anecdotes,
Metaphors, Lessons
Learnt, Experience
Design
Aesthetics
Implementations
Resources
Ecosystems
"Inspiration from chaos"
Identified Paradoxical
Behaviour
Education
Handbooks,
Manuals,
Courses
"Making things clear for all"
Processes
Products
Tools

An action space (1 of 24)

Negative pathway inspired by https://managementisajourney.com/organizational-change-8-reasons-why-people-resist-change/

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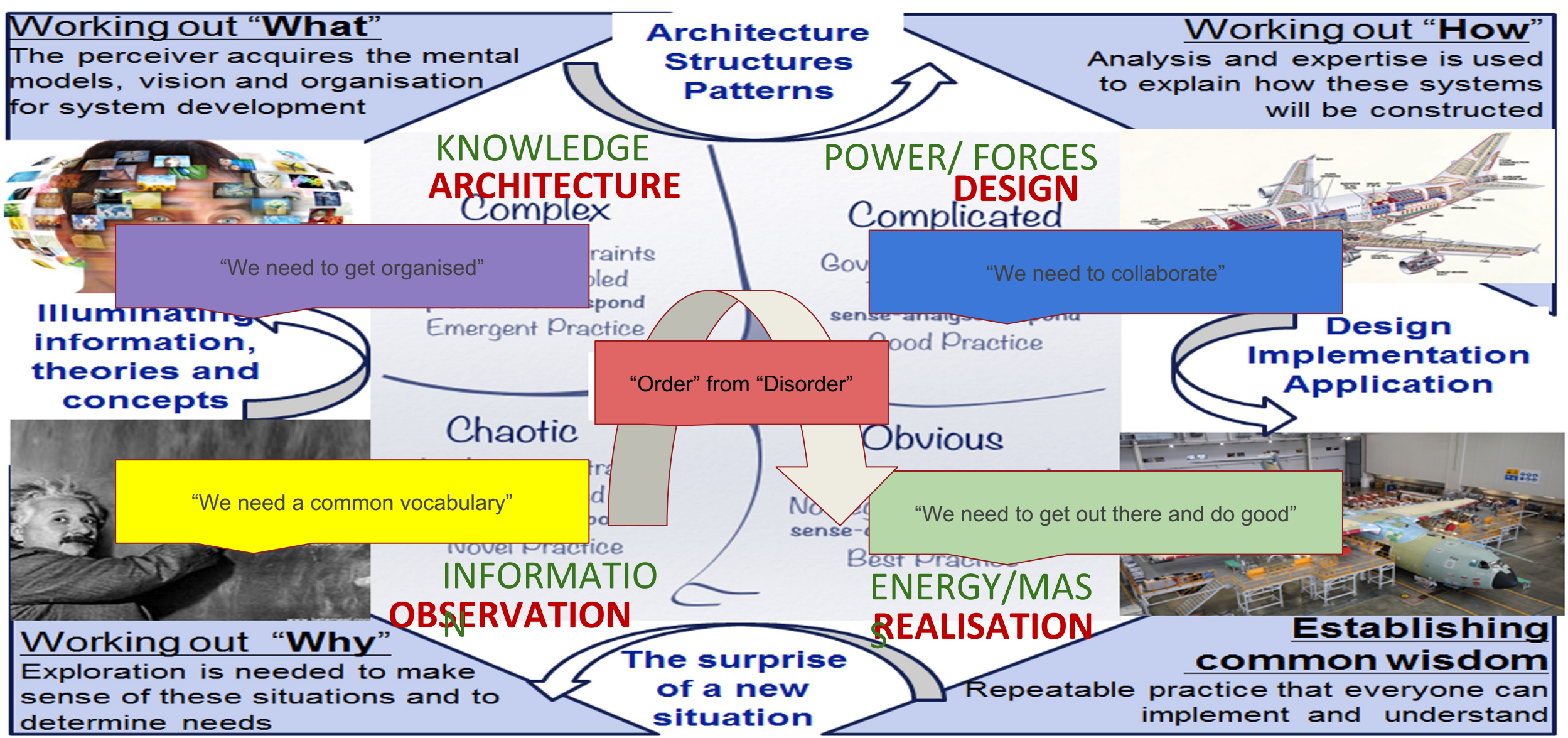
Reflections on Cynefin and collaboration



Discussion