Working paper

A novel Holistic Risk Assessment Concept: The Epistemological Positioning and the Methodology

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Abstract
Risk is an intrinsic part of our lives. In the future, the development and growth of the Internet of things allows getting a huge amount of data. Considering this evolution, our research focuses on developing a novel concept, namely Holistic Risk Assessment (HRA), that takes into consideration elements outside the direct influence of the individual to provide a highly personalized risk assessment. The HRA implies developing a methodology and a model.
This paper is related to the epistemological positioning of this research. We consider this research as an artificial science under the constructivism paradigm. We also introduce the positioning of this research in the complexity science paradigm. We end this paper by presenting a methodology based on an adapted Design Thinking Model.

***Keywords*—**Epistemological positioning, Holistic Risk Assessment, Constructivism, Complexity paradigm, Design Thinking Model.

I. Introduction

We aim to develop a Holistic Risk Assessment (HRA) defined as follows:

"HRA is based on all aspects and events related to a person's life. The underlying idea is that all actions, events and states of the environment have an impact on the risk level, on every aspect of the person's life and environment. How things are correlated and what is the impact, are the central questions of holistic risk assessment.".

To provide a personalized risk assessment, the HRA concept seeks to develop a methodology and a model that will consider elements outside the individual's direct influence.

This research is interdisciplinary, and its position is on the intersection of management sciences and information systems sciences with a focus on data sciences, in a highly technological constellation. The objective of this research is a Holistic Risk Framework elaboration in a highly ubiquitous context known as the internet of everything.

Research relies not only on a methodology but also on identifying epistemological questioning in order to maintain consistency in the various stages of research development (Weick, 1989). In order to provide a suitable research design for this study, we refer to the fundamental philosophical aspects of the research.

We start with an epistemology definition and a brief description of two major contemporary scientific models as well as the three major reasoning types. We proceed with the overview of the major epistemological paradigms in social and human sciences and the research approach for big data analytics. We then outline our positioning, which will guide our research design.

II. Introduction to Epistemology

If society evolves, so do the sciences. The rise of new sciences, such as computational sciences or management sciences, has led to a reconsideration of the well-established epistemological framework allowing the appearance of new concepts, notably the appearance of the Artificial Sciences model or a re-interpretation of the constructivist epistemological approach. Before describing them, we start by defining the term "epistemology".

The meaning given by Jean Piaget (1967) to Epistemology is "*the study of the constitution of valid knowledge"*.

From a philosophical perspective, epistemology is related to these three questions (Gavard-Perret et al., 2012):

"*What is knowledge?*
How is it elaborated?
How do we justify the validity of knowledge?"

The relevance of drawing on an epistemological frame is highlighted by Avenier and Thomas (2012) in order to be consistent between the vision of knowledge and the justification of the validity of a research project. The epistemological approach is based on four main dimensions: ontological (the nature of reality), epistemological (the nature of the produced knowledge), methodological (how knowledge is developed), and the axiological (the values conveyed by knowledge) (Allard-Poesi & Perret, 2014).

Several schools of thought have emerged over time. We focus only on empiricism and rationalism introduced hereafter referring to Gavard-Perret et al. (2012).

Rationalism assumes that scientific reasoning derives from reason. The reasoning starts from abstract, ideas, concepts (the general) to go towards concrete conclusions (the particular) by referring to deductive reasoning. The main rationalists are Plato, Socrates, Descartes or Spinoza. **Empiricism** is founded essentially on hypothesis testing by means of sensitive experience, or most of the time by means of experimentation. As opposed to rationalism, reasoning follows a different path by moving from particular cases to a general rule using inductive reasoning. Philosophical empiricists are mainly Bacon, Locke, Boyle or Hume. More anciently, Aristotle already refers to it.

Reasoning process refers to methods to deploy results, make predictions or explanations based on knowledge. The three major reasoning methods are the deductive, inductive and abductive reasoning approaches.

Deductive reasoning is based on a logical necessity. This reasoning starts from asserted assumptions, from which the inferred consequences are certain (Grawitz,1972). It moves from general rules to a specific result. Mathematic is mainly based on deductive reasoning. **Inductive reasoning** proceeds to a generalized conclusion based on evidences obtained with observations. Inductive results are not logical necessities. The inductive arguments are cogent because the evidence convince and is relevant. Therefore, the result is probably true. Philosophy distinguishes between *rigorous induction*, which acknowledges characteristics to observed phenomena, then generalizes and summarizes them in a law, and amplifying or *experimental induction*, which generalizes to an infinite number of possible facts, a determined number of observed facts (Grawitz,1972). **Abductive reasoning** (called as well abduction, abductive inference or retroduction) was conceptualized initially at the end of the 19th century by Charles Sanders Peirce.
As per Locke (2010) "*Abduction is the process of forming a possible explanation involving an imaginative effort to understand on the part of beings acting and learning in a world"*. From a set of observations, abduction approach seeks to find the most probable result or conclusion. Therefore, the conclusions retain a certain degree of uncertainty.

III. MAJOR CONTEMPORARY SCIENTIFIC MODELS

Two major contemporary scientific models are described hereafter, the natural sciences and the sciences of the artificial. Simon (1996) highlights the artificial sciences include the social and design sciences.

A. The Natural Sciences

The natural sciences are related to natural phenomena, such as physical and biological sciences. They have become dominant for more than three centuries in physics.

As described by Simon (1996), *"a natural science is a body of knowledge about some class of things objects or phenomena in the world: about the characteristics and properties that they have; about how they behave and interact with each other. »*

The postulate behind this model is the verification of scientific knowledge using the experimental method. From the empirical observation of the relationships revealed by this model, the researcher establishes general laws (Gavard et al., 2012). The choice of observation method is related to the deterministic consideration of the world which operate by general laws. Essentially subordinated to positivism (Comte, 1844), the ontological character is based on a unique, knowable and objective reality using methods consisting in quantification, experimentation and empirical validation of statements (Allard-Poesi & Perret, 2014). Metaphysic or intuitive knowledge are not considered in positivism paradigm. The objective nature of reality is based on the independence of the subject in relation to the object. Indeed, the observation of the object by a subject must not modify the nature of this object (Popper, 1972).
The attributes of the Natural Sciences model are not easily applicable to many of the humanities and social sciences as well as information systems or computational sciences. Indeed, these sciences are mostly focused on social phenomena for which experimental methods are not well suited. This paved the way to other models.

B. The Sciences of the Artificial

"I am confident that man will, as he has in the past, find a new way of describing his place in the universe—a way that will satisfy his needs for dignity and for purpose. But it will be a way as different from the present one as was the Copernican from the Ptolemaic."
Herbert A. Simon (1965)

Herbert Simon describes nowadays world in term of human and social artifacts as follow: "*The world we live in today is much more a man-made, or artificial, world than it is a natural world. Almost every element in our environment shows evidence of human artifice."* (Simon, 1996). Therefore, he conceptualized a new way of thinking about scientific research, called the sciences of artificial. This is a general term designing that all what is not natural sciences, is artificial sciences which refer to developing knowledge about artifacts studies. Unlike the science of nature, which studies natural phenomena, the science of the artificial, focuses on the study of artifacts, such as human-made phenomena, like systems or organizations for instance.
Engineers conceive artifacts, therefore Simon (1996) considers the science of artificial closely linked to the science of engineering. But these conceptions of the artificial do not only involve engineers. Simon extends it as follow "*engineering, medicine, business, architecture, and painting are concerned not with the necessary but with the contingent not with how things are but with how they might be in short, with design*."

This leads to another model of artificial sciences, the science of design.

The analysis stance of the classical natural sciences differs from the artificial sciences, which adds to the analysis, the design/synthesis stance. Design sciences develop knowledge for the design and implementation of artifacts (Gavard-Perret et al., 2012).

As the world is major based on human artifacts, Simon (1996) argues that artificial sciences should be fundamental sciences. He adds that "*artificiality is interesting principally when it concerns complex systems that live in complex environments. The topics of artificiality and complexity are inextricably interwoven*."

IV. Main Contemporary Epistemology Paradigms

The word "paradigm" is outlined by Kuhn (2012) as "*the entire constellation of beliefs, values, techniques and so on, shared by the members of a given community*". *Epistemological paradigms* are the beliefs, values, techniques used to build a scientific process of thought.

There are multiple paradigms, however we focus on the main paradigms of the management and social sciences. While the logical positivist paradigm is clearly established, other epistemological paradigms, such as the paradigm of post-positivism, are not supported by consensus, some nuances remain. We propose to consider in our overview, logical positivism, as well as two post-positivism paradigms, namely the scientific realism and the critical realism. Constructivism is also differentiated with pragmatic constructivism and constructivism in the meaning of Guba and Lincoln. We present the pragmatic constructivism in our overview. The interpretivism is not included.

In the early 19th century, Auguste Comte described the **positivism** epistemological perspectives in his "*Courses in positive philosophy*" (Comte, 1830), this concern several texts. He also wrote a "General view of positivism" (Comte, 1844). The main thought movement is the logical positivism (or neo-positivism, empirical positivism) constituted by the Circle of Vienna. The ontological hypothesis prevails an independent reality of the researcher's interest and attention. Science is reduced to the measurable and quantifiable facts of a reality governed by its own laws. (Allard-Poesi & Perret, 2014). Positivists consider an objective, unique and knowable reality that must be studied and known in a neutral attitude. Empirical realist ontology assumes an observable reality (Gavard-Perret et al, 2012).

In order to establish general laws, positivism prioritizes inductive reasoning based on observation. The two methodological principles are, on the one hand, the Cartesian principle of analytical division and, on the other hand, the principle of sufficient reason (Leibniz, 1710) which states that a cause exists for any event (Gavard-Perret et al., 2012).

Post-positivism followed positivism, some of whose criteria do not satisfy, such as the difficulty of capturing reality. Scientific realism and critical realism are in the movement of post-positivism.

According to the work of Hunt (1991, 1992, 1994) and also cited by Gavard-Perret et al, (2012), there are four fundamental principles of **scientific realism**.

The first meets classical realism by considering the independence of the real with respect to perception and representations made. The second principle refers to the uncertainty of knowledge generated by science and at this point, this principle is in contradiction with direct realism. The third principle considers that the mechanisms involved to test the truth of some knowledge are fallible and therefore can be questioned. This refers to a critical vision of realism. The last principle refers to the theories whose intention is to explain observable phenomena based on unobservable concepts, described by Hunt as inductive realism. Positivists are oriented in an empirical realism that applies only to observable entities, the rest being metaphysical, thus rejected by positivist science. Scientific realists, on the contrary, include unobservable entities in their way of thinking, thus giving it a substantial position in science.

In the 1980s, Roy Bhaskar developed the *transcendental realism* (Bhaskar, 2013), a general philosophy of science. He, then, extended it to a philosophy of human sciences, called the *critical naturalism* (Bhaskar, 2014). Both combined are called **critical realism**. Critical realism differs from positivism essentially on the ontological dimension. The fundamental ontological hypothesis is that Reality is stratified. The three levels are, first, the *empirical reality*, the domain of experience and impressions, then the *actual reality*, the domain of events, facts and the *deep reality*, the domain of forces, structures and mechanisms. All together form the reality (Bhaskar, 2013; cited by Allard-Poesi & Perret, 2014) (table 1).

	Domain of Real	*Domain of Actual*	*Domain of Empirical*
Mechanisms	✓		
Events	✓	✓	
Experiences	✓	✓	✓

Table 1: Stratified ontology (Bhaskar, 2013)

Critical realism assumes that researchers have no access to the deepest reality, but only to the domain of actual reality. He may reach an actual reality through which the deep real reveals its rules and its structure, called generating mechanisms (Allard-Poesi & Perret, 2014). The researcher could reveal these mechanisms through regularities.

Two properties designated *Intransitivity* and *Transfactuality* are postulated about the generating mechanisms. *Intransitivity* postulates that the generating mechanisms exist and operate independently of human identification. *Transfactuality* postulates that the generating mechanisms exist even without being apparent in empirical reality (Gavard-Perret et al., 2012). The other fundamental epistemological hypothesis postulates

Philosophy	Logical Positivism	Post-Positivism (scientific realism)	Post-Positivism (critical realism)	Pragmatic Constructivism
Ontology (nature of reality)	The reality exists in itself, and is independent of researcher's interest and attention	The real is independent of researcher's perceptions and representations	The reality exists in itself and is independent of researcher. The reality is stratified in 3 levels, deep, actual and empirical levels	The real is relative. There are multiple socially constructed realities not governed by natural or causal laws.
Epistemology (nature of the produced knowledge)	The reality is objective, unique and knowable	The real is not clearly identifiable (potential fallibility of the measuring devices)	The deep level is not accessible to researcher	Interdependence between the subject and the object
Purpose of the research	Establish general laws (inductive reasoning)	Representational design of knowledge: Explain observable phenomena using unobservable concepts	Generating mechanisms could be revealed through upper levels	Understand how the reality works expressed in the form of representations or modeling

Figure 1: Synthesis : Major epistemological paradigms

that the human set of perceptions of events that occur in the actualized reality is knowable in the empirical reality (Gavard-Perret et al., 2012). Unlike the laboratory experiments considered as closed systems, the reality in Critical realism is an open system (Bhaskar *et al.*, 1998). Social phenomena are difficult to measure and can only be understood (Bhaskar, 2013, 2014). Critical realism aims to explain as to predict or understand phenomena (Wynn & Williams, 2012).

Continuing Piaget's pioneering work, von Glaserfeld (1988, 2001) developed the theoretical framework of the **pragmatic constructivist** epistemological paradigm. Le Moigne pursued this theoretical approach under the name radical or teleological constructivist epistemological paradigm. The term *radical* having been the source of misinterpretation, was replaced by *pragmatic*. Based on Gavard-Perret et al. (2012), we present hereafter the hypothesis.

The first foundational hypothesis postulates that what is known is the human experience of relationships of perceived resistance to actions. In other words, each human knows his or her own experience of a reality, which manifests itself through the resistance perceived by the human to the actions he or she conducts. The real being subjective, the veracity of any fundamental hypothesis on the existence and nature of a real in itself can never be proven. This paradigm only postulates the existence of flows of human experiences, however without denying the existence of a reality in itself.

The second foundational hypothesis is the interdependence between the subject and the object of study. The elaboration of knowledge depends on the researcher and his knowledge, his history, his project. The third foundational hypothesis is the teleological hypothesis. It postulates the project of knowing a certain reality influences the way in which one experiences it and therefore the knowledge that one develops of it. The knowledge developed aims to acquire intelligibility in the flow of human experiences, and not to describe how the real may work. The way in which the researcher understands how the reality works are thus expressed in the form of representations or modeling. Any research method is allowed in order to elaborate knowledge.

Based on Gavard-Perret et al. (2012) and Allard-Poesi & Perret (2014), we provide an overview and a **synthesis** of the main epistemological paradigms (Figure 1) considering three dimensions of the epistemological approach, the ontology, the epistemic and the methodology.

V. Epistemological Paradigms and Big Data

After a presentation of different contemporary epistemological approaches for management and social sciences, our attention focuses on the data sciences and big data analytics using artificial intelligence. Without benefiting from a long-established tradition, these researches raise epistemological research challenges.

We have observed throughout history that epistemologies have evolved to respond to new scientific needs, particularly in those of the social sciences and humanities.

Nowadays, the progress of technology and in particular of IoTs has led us to consider a large amount of available data in various fields. The quantified-self movement is representative since it involves a large number of people who take care to quantify some body parameters in order to extract data from their body sensors or mobile to improve their health or to monitor their activities in real-time. A large amount of data comes from other types of sensors, particularly coming from smart cities where measurements are very heterogeneous (house temperature, mobility data, etc.). Data also comes from the internet, such as social networks or is generated by companies, the business data. Data is continuously generating exponential growth. In an ultra-connected world, such as smart society and internet of everything, this data is becoming massive.

The characteristics of big data are the large volume of data, the high velocity, and the variety. The processing of these data requires more sophisticated techniques than before. These techniques allowing a high power of computation are nowadays available. Artificial intelligence is one of the means to process data as well as Machine learning is commonly used in data analytics to mine and process data to find patterns using algorithms to get predictive models. Big data analytics is used in many disciplines, and society's evolution continues toward an increased growth of available data. This is a new way of handling data and will be pursued in the future.

These revolutionary changes in our society through big data open the way to consider a new epistemological paradigm. The way epidemiologic research is done is influenced by big data, which "*will become the dominant scientific paradigm.*" (Mayer-Schönberger & Cukier, 2013).

Kitchin suggests that this new approach to data is leading to a new epistemological paradigm. The use of data to test a theory is replaced by an understanding of the world through data, namely "*insights born from the data*". (Kitchin, 2014).

> *"I wanted to point out that almost everything about science is changing because of the impact of information technology. Experimental, theoretical, and computational science are all being affected by the data deluge, and a fourth, "data-intensive" science paradigm is emerging." Jim Gray on eScience* (Hey, *at al.*, 2009*)*

Jim Gray suggests adding the fourth science paradigm. The first born a thousand years ago, science was empirical, followed by the last few hundred years with theoretical science, and finally, the last few decades have seen the computational branch (Hey et al., 2009; cited by Kitchin, 2014). Nowadays, the data-intensive science paradigm is suggested by Jim Gray.

A fourth science paradigm is not the only proposal, a new empirical approach to knowledge is also suggested (Kitchin, 2014). Let data give the insights, without theory is the basic foundation of a new empiric science paradigm.

Natural sciences or economics sciences, such as finance, already use lots of data in research. Being part of the positivist epistemological paradigm, Big Data is for these sciences a way to have a better and fine analysis. On the other hand, the use of big data in the humanities and social sciences is a significant transformation in their approach to epistemological paradigms mostly based on qualitative technics.

VI. HRA Epistemological Positioning

We observe through this analysis several facets to explore for epistemological positioning for our research, such as the consideration of the complexity level, as well as the context. Nowadays, a risk assessment is an Epistemological positioning that will define not only the design of the research but in a more fundamental way how the object of research is approached. Studies using big data and data analytics in a specific context, which may be social and/or economic, are developed using a fine analysis of the data in order to extract an understanding of causality.

The research can thus be considered from two angles. On the one hand, a positivist and empirical positioning offer a more limited view of a complex reality, focusing on the data processing aspect and the results. On the other hand, a post-positivist positioning, such as *critical realism*, offers a more nuanced view of reality by looking for an explanation of the object. The first positioning is more technical and statistics-oriented, the second is focused on the core problematic understanding.

Within the framework of this research, epistemological positioning appeared to be a difficult exercise. Indeed, we are in the situation of a risk assessment which, under certain conditions, such as those using a mathematical model, is based on positivism and empirical paradigm. However, the analysis within the context of big data raises another epistemological debate because it offers a more nuanced, finer, and more subtle analysis and insights. The ontological positioning remains objective, and the researcher is in a position of exteriority in relation to the object of the study. The reality exists in itself and is independent of researcher's representations. Our positioning changes if more data is available looking at causal inferences to understand the reality, and not only based on prediction. This brings us to a similar ontological approach as post-positivism paradigms, such as critical realism, where real is defined through three dimensions. The question remains relevant if we consider the massive data of the internet of everything. Are we still in a positivist approach? May the General Mechanisms be better understood and detected?

The positivist approach ignores notions of metaphysics. However, if we consider the massive data in a context of ubiquity in reference to the scenario, technology is serving humans, and, in this case, it is a human-centric society that is being built. Risk assessment becomes intrinsically linked to sociological considerations. Our epistemological positioning is to consider the fundamental research topic on the sociological and economic dimensions of the concept of risk in society. As the complexity is at the highest level in a ubiquitous environment, we then need to consider reality in a constructivist epistemological paradigm.

Mathematical consideration specific to this field, but in a context of ubiquity, using other methods and with massive data, in an interconnected world, risk assessment is intrinsically linked to metaphysical elements and social, ethical or moral phenomena.

To conceive a risk assessment model in the internet of everything, where technology is omnipresent, such as a human and social artifacts world, means to consider research as an artificial science in a constructivist paradigm where the real is relative.
The more the real becomes complex, the more it becomes relative.

VII. Complexity and Philosophy

The HRA study is based under the light of the paradigm of complexity as described by Edgar Morin (1992, 2015). Morin (1992) explains that "*Complexity is not merely the phenomenal froth of reality; it is in the principles themselves*".

Based on the theory of information, systems theory, and organization and self-organization theory, the paradigm of complexity is built on three principles, the *dialogic* principle, the *recursion* principle, and the *hologrammatic* principle.

The dialogic principle associates complementary but antagonistic elements. Keeping this duality is essential in understanding of the same reality.

The principle of *recursion* is a self-generating loop process where *"products and effects are at the same time causes and producers of what produces them"*. It is a non-linear view of the elements of causality. The example of Morin (2015) is *"society is produced by interactions between individuals, but society, once produced, retroacts on individuals and produces them"*.

The *hologrammatic* principle is related to the quotation of Pascal *"I cannot conceive the whole without conceiving the parts and cannot conceive the parts without conceiving the whole"*. The part comprises the totality of the information of the whole, and each part is an essential component of the whole.

VIII. Methodology

The development of a new risk concept in a complex environment requires technical knowledge and creativity. An agile method is preferred.

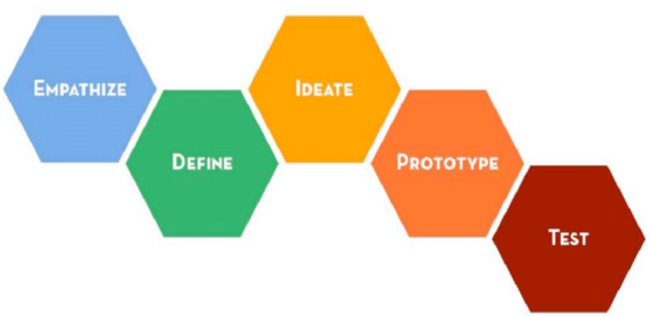

Figure 2: d.School Design Thinking Model (Image source: https://dschool.stanford.edu/)

The Design Thinking approach is adapted to this type of innovative research. To reach our objective, we chose the d.School Design Thinking model developed by the Institute of Design at Stanford. This model was ideated by the Institute of Design at Stanford. It uses abductive reasoning. The problem is reinterpreted and reframed.

Steps are explained by Stanford Institute of Design as follows:

> ***EMPATHIZE***
> *Empathy is the foundation of human-centered design. The problems to solve are rarely your own, they are those of particular users. Build empathy for your users by learning their values.*
>
> ***DEFINE***
> *The define mode is when you unpack your empathy findings into needs and insights and scope a meaningful challenge. Based on your understanding of users and their environments, come up with an actionable problem statement: your Point of View. Your point of view is your unique design vision that is framed by your specific users.*
>
> ***IDEATE***
> *Ideate it the mode in which you generate radical design alternatives. Ideation is a process of "going wide" in terms of concepts and outcomes-a mode of "flaring" instead of "focus". The goal of ideation is to explore a wide solution space – both a large quantity and broad diversity of ideas.*
>
> ***PROTOTYPE***
> *Prototyping gets ideas out of your head and into the world. A prototype can be anything that takes a physical form—a wall of post-its, a role-playing activity, an object. In early stages, keep prototypes inexpensive and low resolution to learn.*
> *Quickly and explore possibilities.*
>
> ***TEST***
> *Testing is your chance to gather feedback, refine solutions, and continue to learn about your users. The test mode is an iterative mode in which you place low-resolution prototypes in the appropriate context of your user's life. Prototype as if you know you're right, but test as if you know you're wrong.*

We have adapted the d.School model to our research by proposing 7 steps (fig. 3). We replace the Prototype step with the Conceptualize, Study, and Model steps, redefining the Test.

The 7 steps are: Empathize, Define, Ideate, Conceptualize, Study, Model, and Test, are deployed in a circular mode.

> ***CONCEPTUALIZE***
> *This step is the application in a concrete mode of the idea. This is a primary analysis of the idea, and a basic concept is developed.*

STUDY
The study is an in-depth analysis of the concept. All the elements of the concepts are exposed and deeply analyzed.

MODEL
The generation of a model is the result of the last two steps allowing to implement it in a real case study or a simulation as per the last step, called TEST to prove that the model works well.

All these steps are deployed in a circular mode.

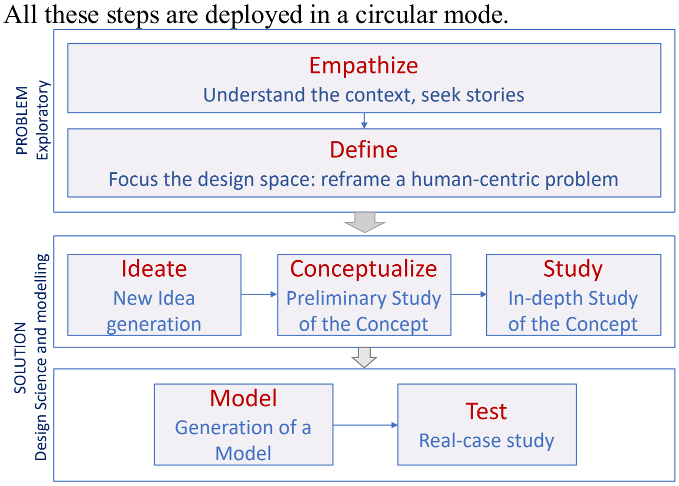

Figure 3: Adapted d.school Design Thinking Model

These steps are distinguished into two main phases, the Problem, and the Solution. The Problem (empathize, define) is focused on the understanding of the problem and the Solution (Ideate, Conceptualize, Study, Model, Test) is related to the development of an idea which will then be developed in a preliminary study of the concept. The latter step is followed by in-depth studies of the elements of the concept, finalized by a model and a real-case study.

IX. Conclusion

As this research is founded on complex systems using a massive amount of data in an ubiquitous world, we consider the real as relative and position it under the constructivism paradigm in an artificial science. This research is conducted in the light of the science of complexity of which we have introduced some concepts.

The methodology required to deploy this study is based on the Design Thinking Model developed by the Institute of Design at Stanford, that we have adapted to better fit to this research.

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