A Systemic/Cybernetic Notion of Design

Nagib Callaos
The International Institute of Informatics and Systemics (IIIS)
n.callaos@callaos.com

Abstract

The purpose of writing this article is 1) to describe the notion[1] of "design" in order to show that there is almost no thought-based activity that does not, explicitly or implicitly, contains designing activities, including academic and scientific ones, professional practice, managerial action, and, even, everyday occupations; 2) to briefly describe the cybernetic relationships between research and design, and 3) to identify the relationships of design with intention and action. Since almost all what we have done, and do, in this life are caused by intentions that usually are followed by actions, then implicitly or explicitly, designing process support thinking and doing, especially in those related to academic, scientific and professional activities. Since 1) "design" is usually related to Engineering and professional activities and 2) this article is written for a special issue on "Research and Desing", we will be more frequently explicit with regards scientific/research activities and to the notion of Science, showing irrespective to Traditional Science or new approaches to Science based on the Copenhaguen Interpretation of Quantum Theory and Second Order Cybernetics and Second Order Systems Theory.

Keywords: *Design, Research, Desing Research, Research Design, End-Means Logic, Pragmatic-Teleological Truth, Action-Design, Action-Research, Action-Learning, Cybernetics, Systems Approach.*

1. Design and Research

Herbert Simon, a Nobel Laureate, affirms in (The Sciences of the Artificial (Third Edition), 1996) that "Engineers are not the only professional designers. Everyone designs who devises courses of action aimed at changing existing situations into preferred ones…Schools of engineering, as well as schools of architecture, business, education, law, and medicine, are all centrally concerned with the process of design." (p. 111) Furthermore, several scientific activities are, implicitly (e.g., theory construction) or explicitly (e.g., experiment design), based on design. This is why, we can affirm, along with Richard Buchanan (Wicked Problems in Design Thinking, 1995) that "*There is no area in contemporary life where design…is not significant factor in shaping human experience*." (p. 6)

[1] Elsewhere (Callaos N. , 2013) we analyzed with details the "notion of notion". Suffice it here to refer to our general conclusion. A notion is cognition, an idea which can be, and usually is, represented by the description of a set of related, or relatable, concepts along with their respective definitions. This set is frequently a fuzzy set.

[Italics added]. With regards to research and design, Ranulph Glanville, in (Re-searching Design and Designing Research, 1999) affirms that "Design is key to research. Research has to be designed … ***Research is a variety of design. So, do research as design***" [Italics and emphasis added].

Frayling (Research in Art and Design, 1993) asserts that "doing science is much more like doing design."[2] Pieter Jan Stappers affirms that "Both Design and Research are characterized by *iterative cycles* of generating ideas and confronting them with the world." (Stappers, 2007, p. 82) italics added.] Both Science and Design use generative and evaluative thinking, but Science stresses the *evaluative* one (by logic, deduction, strict and mostly explicit definitions, verbal notations, etc.), while Design focuses on the *generative* one (which is usually associative, analogical, and inductive thinking, using loose definitions, and supported by visual representation as doodling, sketching, diagramming, prototyping, etc.) (Stappers, 2007, p. 83)

An increasing number of authors, especially in the last decade, are stressing the relationships between Design and Research. Design is, implicitly or explicitly, an essential activity of *Natural* Science research, and an explicit backbone of the *Artificial* Sciences (Engineering, Architecture, etc.). In turn, Design, implicitly or explicitly, includes research activities. In Natural Sciences, design activities (hypothesis construction, experiment design, etc.) are means used in research, with *the purpose of generating knowledge to be evaluated* (validated and/or verified). In Artificial Sciences research is one of the means used to generate the knowledge required for design effectiveness. In other words, *Design is a mean for Research, and Research is a mean for Design*. Design and research are related via cybernetic loops in the context of means-ends logic. A visual schematization of the most fundamental relationships between Design and Research is shown below, in the next section.

Design is key to research: research has to be (implicitly and/or explicitly) designed. Design is a necessary condition for Engineering and Meta-Engineering activities (Callaos N. , The Essence of Engineering and Meta-Engineering: A Work in Progress, 2013a). Herbert Simon (1996) adds that "*The proper study of mankind is the science of design, not only as the professional component of a technical education but as a core discipline for every liberally educated man.*" (p. 138) [Italics added]

The ubiquitousness and (implicit or explicit) omnipresence of design in human thinking and acting enriches the meaning of the associated term and hinders a general definition of the related concept. Richard Buchanan (1995) affirms that "design and design thinking continue to expand their meanings and connections in contemporary culture." (pág. 6) But, the more ubiquitous and omnipresent designing activities are, the more integrative design thinking might be, and the more it might be used for interdisciplinaryy communications and as trans-disciplinary conceptual framework. Design Science requires and provides *an integrative thinking*. "The significance of seeking a scientific basis for design does not lie in the likelihood of reducing design in one or another of the sciences—an extension of the neo-positivist project and still presented in this terms by design theorists. Rather, it lies in a concern to connect and integrate useful knowledge

[2] Referenced by (Stappers, 2007, p. 82)

from the arts and the sciences alike, but in ways that are suited to the problems and purposes of the present." (Buchanan, 1995, p. 6)

2. Cybernetic Relationships between Research and Design

While many articles and several books have been written on 1) "Research", 2) "Design", 3) "Research Design", 2) and "Design Research", almost none has been written on the relationships among them. We suggest that it is important to foster the explicit analysis of these relationships as well as the meta-relationships among them. We will briefly describe them here in order to provide context for a more analytical thinking on this issue.

A quick Google search shows that there are 12,700,000 results on "Design Research"; 5,130,000 results on "Research Design", i.e. number of articles on, or mentioning the phrase; while just 8 results for " Design Research and Research Design" and only ONE result for "Research Design and Design Research". This means that *just 0.00005% of the searched web pages, on these two important topics, mention explicitly any relationships among them. This lack of written communications regarding the significant relationships between these two important fields is what is really perplexing. Consequently, a main purpose of this section is to try to alert more academics, researchers and designers with regard to this issue, hopping that some will take some action to address this situation.* We really hope that this article may foster *reflections* and *reflexions*[3] on the actual and/or potential relationships between these two important knowledge fields in order to start a process of written communications on both fields as related to each other.

Let us now provide a little bit of more details regarding the relationships between "Research and Design". Both activities relate to each other, via Systemic (not necessarily systematic relationships), and potentially via cybernetics loops, by means of co-regulatory loops (negative feedback and feed-forward) and co-reinforcing ones (additive or multiplicative positive feedback). Figure 1 shows a diagram relating to the notions (understood as set of concepts) of Research and Design.

Figure 2 provides more details of figure 1 and shows the *external relationships* that Research and Design have (implicitly and/or explicitly) with its environment. Research nurtures disciplinary knowledge and Design is usually nurtured by several scientific disciplines, especially in the case of Engineering, Architectural, etc. designs. Consequently, to explicitly relate Research and Design may help in inter-disciplinary research, education and/or communication as well as in integrating academic activities, i.e. Research, Educations and real life problem solving.

[3] We are using the term "reflexion" as a process and product of "reflection, plus self-reflection." O'Leary, for example, in *The Essential Guide to Doing Research* (O'leary, 2004) affirms that "Reflexivity in research refers to the ability of the researcher to stand outside the research process and critically reflect on that process. Research, as a 'reflexive' thinking process, "involves constant consideration of the researcher, the researched, and the integrity of the process." (p. 11) Reflexive Research is to reflect on the received data and to make a reflexion on these data as well as ***self-reflexion***, i.e., to observe both the object observed and the observer. This is a fundamental concept, a required notion, and a necessary act on the Second-Order Cybernetics, which, in turn, is based on the Copenhagen Interpretation of Quantum Theory.

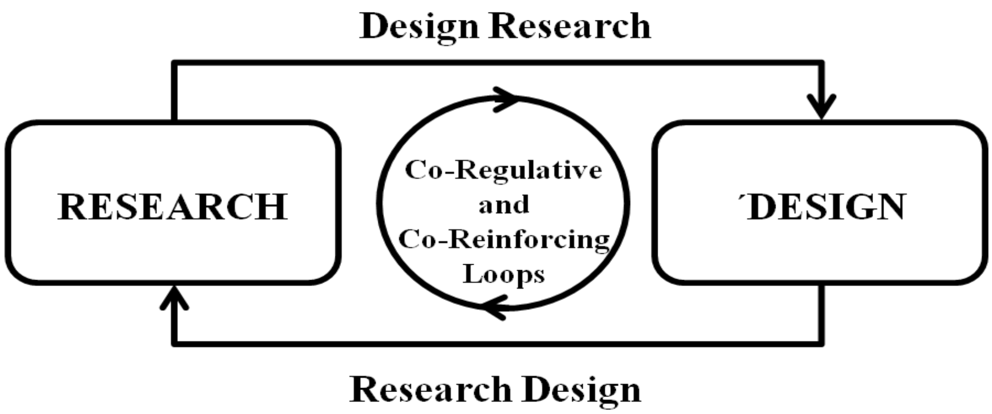

Figure 1: Cybernetic relationships between the research and design activities. Both regulates each other via negative feedback and feed-forward and reinforce each other via positive feedback which may generate emergent properties. Co-regulations and Co-reinfocement generates synergies to be shared by both activities.

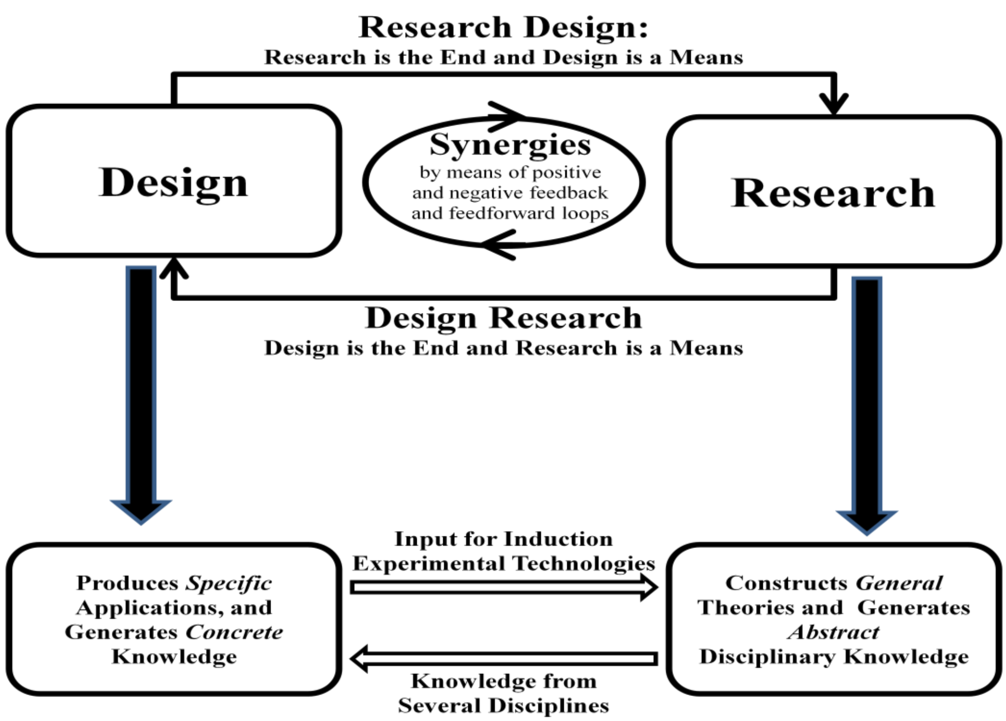

Figure 2: Design (implicitly or explicitly) is a necessary for Research and vice versa. Both activities 1) relate *internally* with each other and *externally* with their environment and 2) allow the generation of external cybernetic loops between the specific and the general and between the concrete and abstract.

According to Richard Buchanan (Wicked Problems in Design Thinking, 1995), one of the four designing areas is the design of *complex systems or environments for living, working, playing and learning*. Relating, explicitly, research and design represent also, as a whole, a complex system which, in turn is the subject of designing activities. To insert the complex whole research/design into its context generates a more complex whole; which, in turn, require desing and research at a higher level of complexity, as it is schematically shown in figure 2. These different levels of system complexity include an increasing number of cybernetic loops with different activities and at different levels of complex wholes or systems. This is why, in our opinion, an increasing number of authors are associating design concepts and notion to those of *Cybernetics*[4]. On the other hand, as it can also be noticed from Figure 1, Design and research relate, via cybernetic loops,, concrete and abstract knowledge, as well as implicit and explicit knowledge. It also relates, via cybernetic loops, disciplinarity with multi- and inter-disciplinarity.

All these cybernetic loops are sources of reciprocal 1) co-regulation, via negative feedback and feed-forward and 2) co-amplification, via positive feedback. The combination of these two kind of cybernetic loops, undoubtedly, generates a *whole larger than the sum its pa*rts, with emergent properties which are the necessary conditions for the production of synergies that, by definition, benefit both: designing and research activities.

Furthermore, since any research plans or activities include, at least implicitly, designing activities and vice versa, a more representative figure of their relationships and processes and activities is given in figure 3

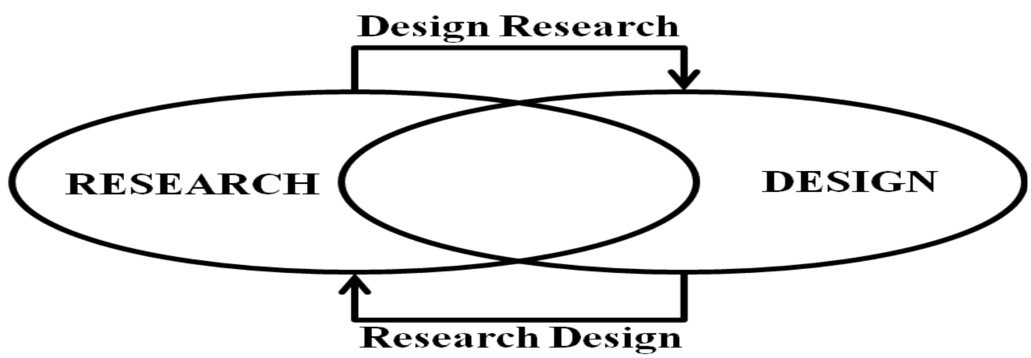

Figure 3: The intersection between the activities or processes of research and design intersect each other generate a common zone that support their communication for the generations of adequate co-regulative and co-enforcing loops via Design Research and Research Design.

If we increase a little bit the abstraction with regard to the conceptual and notional issues as well as to their respective activities and processes, we can hypothesize about the actual implicit and the potentially explicit relationships between “Research Design” and “Design Research” as succinctly and schematically represented in Figure 4. As it may be noticed in the figure and, as a consequence of what we briefly described above, research includes implicit or explicit design activities and, reciprocally, design includes research or search activities. Consequently, what we actually have is Design Research and Research Design activities, which intersect each other in a *common* area, which *commun*icate both activities. The cybernetic loops we referred to above are

[4] See, for example, Glanville (Re-searching Design and Designing Research, 1999), (Keeping Faith with the Design in Design Research, 2010) as well as Wolfing Jonas (Design Research and its Meaning to the Methodological Development of the Discipline, 2007)

actually or potentially present in the common area as well as between the non-common ones. Consequently, Design Research and Research Design communicate with and relate to each other, as schematically shown in figure 4. The later is mostly based on reciprocal means-ends relationships, i.e. Design Research is a means for Research Design and vice versa. This means that ends and means are related via cybernetic loops of negative and positive feedback as well as feed-forward. Consequently, non-linear thinking is required in most cases. From another perspective, any design or research activities require an initial *objective*, a '*telos*.' This objective is not necessarily a static one, on the contrary, it is usually a very dynamic one depending on the changes that might happen during the designing process and the learning process generated by the interplay between Research and Design. Figure 5, schematically shows the cybernetic relations between ends and means which may be applied to the specific case of the nonlinear dynamics, actually or potentially, implicitly or explicitly, present between Research and Desing as well as between Research Design and Design Research.

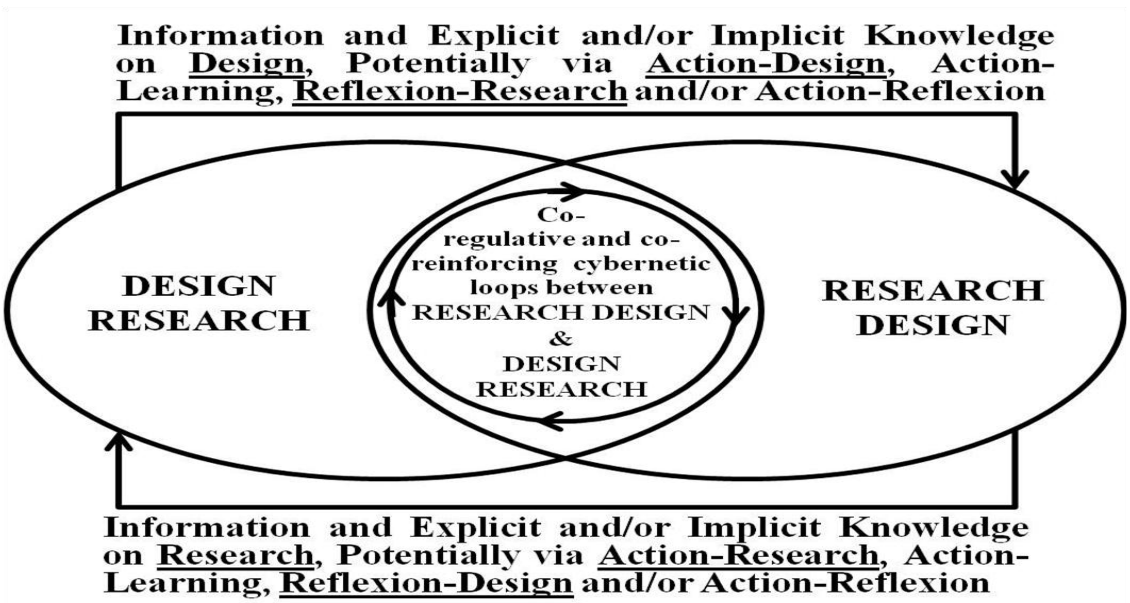

Figure 4: Since any research includes, implicitly or explicitly, designing activities, and any Design includes, implicitly or explicitly, research or search activities then what we really have are Design Research and Research Design activities; which intersects each other and have cybernetic loops in the common activities as well as between them

Explicitly differentiating end (purpose, goals) and means helps significantly in increasing the effectiveness of our thinking and practice, as well as our research and design activities. Differentiating *the why, the what and the how* should be well and explicitly made in order to help for an adequate and effective way of relating them, especially regarding cybernetic loops of co-regulation and co-amplification.

Figure 5 provides a schematic summary of the relationships that ends and means should have. The ***thinking*** process (including both research and design thinking processes) should go from the end (the why) to its means (the goals) and from the goals to the how. The ***action*** should proceed from the means to the end, i.e. from the "how" to the "what" and from the "what" to the "why". Design-centered professionals (e.g., engineers) relate thinking and action with, implicit or explicit, reciprocal, or potentially cybernetic, relationships. A combination of Action-Research, Actions-Design, and Action-Learning is usually (implicitly or explicitly) used. A similar situation happens in research-centered activities, though possibly in a more implicit form.

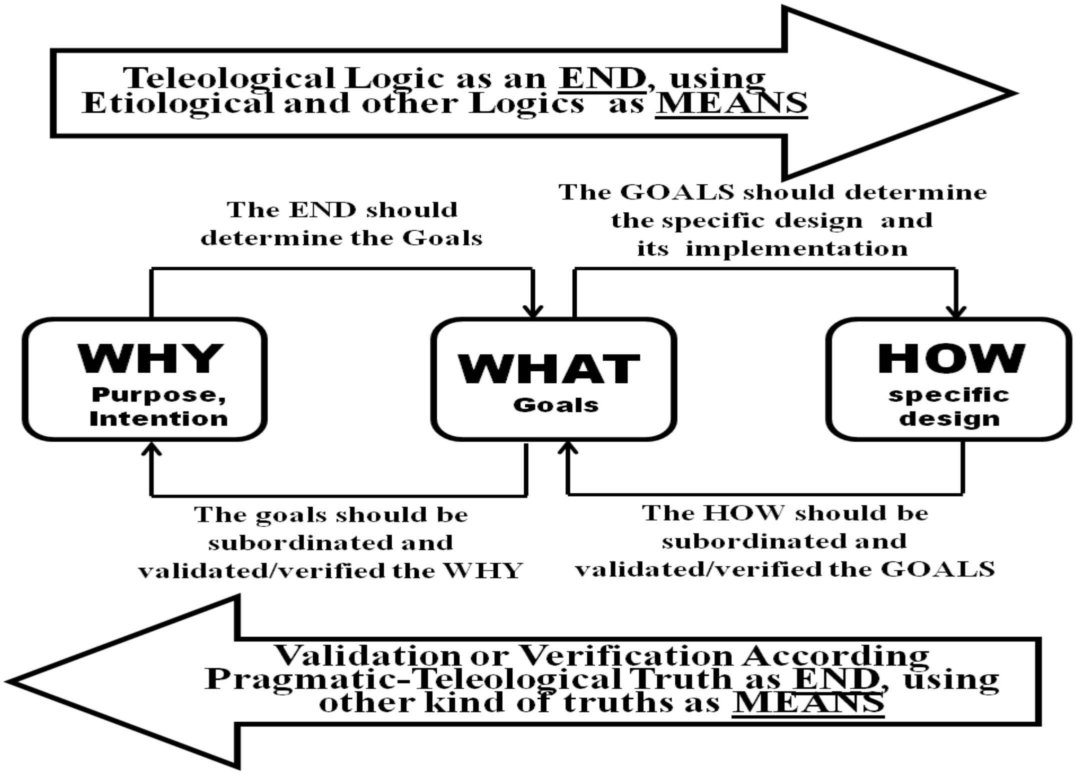

Figure 5: Thinking/Action processes for designed centered Research and Development, where Etiological and other scientific logics (based on identifying causes providing causal explanations) the identification of causes is not an end in themselves (as it is the case of scientific activities) but MEANS used for achieving the teleological logic. Similarly scientific truths are means used in thinking/action processes oriented to the pragmatic-teleological Truth, required in design-centered activities.

Now, let us go into a more analytical perspective with regards to the meaning of the term Design, its connotatin and denotation as well as the different, but related, concepts it comprehends.

3. Senses of the word "Design"

Elsewhere (Callaos & Callaos, 2008)[5] we identified three dual senses in which the word "design" has been used: 1) process/product (temporal/atemporal), 2) Mental/Physical, and 3) objective/plan-to-achieve-it. Accordingly, a semantic/conceptual framework, with 2x2x2 = 8 senses or sub-concepts, has been

[5] A section below will be based on this paper for more details on this issue, Suffice it here to anticipate some of the conclusions.

proposed, as a way of categorizing and integrating the increasingly rich meaning of the term and its expanding conceptual comprehension. In order to relate the concept "design" to other concepts and, hence, to integrate it into its conceptual context, we concluded that:

1. Design is a kind of "representation"[6], based on a combination of reproductive and productive perceptions oriented to a future existence, and directed by an intention. It is the imagination of what it is possible and desirable according to an intention. It is to imagine what it could exist by means of existing objects. It is a "poietic" (productive) imagination, intentionally directed, and action oriented. The notion of "design" refers to cognitive acts or contents, and/or their public cause or effect, all of which are future-oriented, representing non-existing physical objects, where the epistemological value of these private acts/contents and its public cause/effect depend on the feasibility and desirability of their physical existence and on the accompanied intention to make them come true. (Callaos & Callaos, 2008, p. 5)
2. The starting point and the essence of design processes are mental ones, and, as such, they are necessarily intentional**.** According to Brentano[7], mental (psychic) phenomena is -unlike the physical ones- an intentionality, i.e. they refer to an object, or objective. Mental phenomena, unlike physical ones, exist always in the mind. This is why the scholastics called them "in-existence" which should not be confused with "non-existence" or absence of existence. In its scholastic sense, "in-existence" means "existent-in" other thing[8]. Brentano emphasized in this scholastic sense: "this intentional existence -he wrote- is exclusively characteristic of mental phenomena. No physical phenomenon manifests anything similar. Consequently, we can define mental phenomena by saying that they are such phenomena as to "include an object intentionally within themselves" Quoted by (Aune, Intention, 1967). In this sense, design could be conceived as a **pre-existent intentional in-existence.**
3. Inherent to the notion of "intention" is the disposition to action. (Aune B. , 1967, pág. 198) Consequently, the notion of design also includes the disposition to action. Desires are potential influencers of actions; intentions are actual influences of actions. Consequently, a design is also a conduct-controlling pro-attitude. If a design generates no action it is not a real design, it is a virtual one; it is a desire which, when contrasted by other desires, refrained from action, it was an option not an intention; hence not a design. It might have been part of and iterative "essays and errors" cycle in the context of a designing process, but not a design; it might have been a means to achieve an end (a design as a process or as a product), but not an end in itself or a final end. To have an epistemological value, design should generate action that would produce the object designed; it should bring to existence the pre-existent, the "non-existent-yet" object of the design. (Callaos & Callaos, 2008, págs. 5-6)

[6] We are not taking any ontological stand by means of using the term "representation". Our ontological position in this article is an agnostic one. The notion of representation, in this article, might be an empirical or an ideal one, it might be taken in the context of realism or constructivism.
[7] *As interpreted and referenced by (Ferrater-Mora, 1969, p. 981)*
[8] *See, for example, (Ockham, 1958, pág. 121), quoted by (Ferrater-Mora, 1969, p. 944)*

4. But, since beliefs also implies disposition to action, intentions should also include "practical thought" or "practical reasoning" in order to be distinguished from mere beliefs. (Aune, 1967, pág. 200). If our actions were influenced by deliberation only at the time of action, the influence of such deliberation would be rather minimal, since deliberation requires time, effort and other limited resources, and there is obvious limits to the extent to which one could successfully deliberate at the very time of action. Consequently, we need some ways by which deliberation and rational reflection would be allowed to influence action and to take place before the action's time. Consequently, plans are a must for an opportune deliberating and rational reflection. (Callaos & Callaos, 2008, pág. 6)
5. Plans are also required for intrapersonal and/or interpersonal coordination. By constructing plans for the future, we facilitate coordination in both: our activities over time, and our activities with the activities of other. By setting plans, we enable our present deliberation and practical reasoning to influence our later conduct, extending the influence of our deliberation beyond the present moment besides ourselves. As a design gets complex requires us to go beyond the present and besides ourselves; consequently, it will require planning and plans. A plan (or various plans) is required for achieving the "pre-existent intentional inexistence", and a plan (or various plans) is (are) required for bringing to existence the mental and/or the physical representation of such "pre-existent intentional existence". (Callaos & Callaos, 2008, pág. 7)
6. Design is always intentional and action-oriented. The essence of design is to generate action in some direction and/or for some creation/production. It should not be isolated from action since it is strongly related to it. Both are parts of the same whole, both are members of the same organically dynamic system. Design gives direction and action gives propulsion to the whole. They complement and require each other. The design process and the implementing action are (or should be) interwoven, interacting with each other, with reciprocal loops of feedback and feedforward. When we are dealing with a complex system, design and action should be conducted concurrently, even though design will initially get off alone up till an initial design (of the first prototype, or archetype of the wanted system) is available. From there on, design and action should be interwoven, interacting with each other, by means of reciprocal loops of feedback and feedforward, in the context of an evolutionary process; which could be called action-design, that would be nurtured by the basic ingredients of action-research and action-learning. (Callaos & Callaos, 2008, pág. 8)
7. Herbert Simon (1996, pág. 3) contrasted the analytical orientation of Natural Science ("knowledge about natural objects and phenomena") with the synthetic orientation of Artificial Science ("knowledge about 'artificial' objects and phenomena"). "As soon as we introduce 'synthesis' as well as 'artifice,' – Simon affirms – we enter the realm of engineering. For 'synthetic' is often used in the broader sense of 'designed' and 'composed.' We speak of engineering as concerned with 'synthesis,' while science is concerned with 'analysis.' Synthetic or artificial objects—and more specifically prospective artificial objects having desired properties—are the central objective of engineering activity and skill. The engineer, and more generally the designer are concerned with how things ought to be—how they ought to be in order in order to attain goals, and to function." (Simon, 1996, págs. 3-4) [Italics added.

> This design characteristic is also to be found, according to Simon, in other professional activities, as it is the case in, for example, architecture, business, education, law, and medicine. While professional or, more generally, designing thinking is oriented, according to Simon, by how things ought to be, in natural science things are described as they are. This is why natural science is based on standard systems of logic, as it is the case of standard propositional and predicate calculi. Since standard logic is concerned with declarative statements, it is well suited for making assertions about the world (as the world actually is) and for inferences from those assertions (Simon, 1996, pág. 114). But declarative statements about how things actually are, do not adequately suit statement about how things ought to be in order to attain goals. Consequently, imperative and other modal logics were thought to suit better the designing logic. But, Simon thinks that modal logics are unnecessary. He says that modal logics exist, but they are not needed and they are even not useful for design (Simon, 1996, pág. 114), He also describes some paradoxes related to imperative logic and, consequently, he proposes to reduce design logic to a declarative one (Simon, 1996, pág. 115) . To do so, he proposes a perspective by means of which the designing process is seen as an application of "optimization methods" developed in statistical decision theory and management science. We may add Operations Research (including mathematical optimization and heuristic programming or procedures). When optimization is not feasible, or costly, Simon proposes his notion of a satisfactory solutions and actions. In any case, the design problem is reduced to mathematical models in the context of decisions to be, or should be, taken.

In our opinion, Simon is proposing a reduction of the notion of "desing". We think that what he is proposing is acceptable for some kind of design, i.e. for species in the genre of design. What Simon is proposing can be, and actually is included in the notion of design, but the concept of design should not be reduced to what he is proposing because designing activities and the uses of the word "design" shows more comprehensive connotations and denotations of this term.

The end/means logic, which implicitly and necessarily supports Simon's approach in reducing design logic to declarative logic, might be taken as the basic Logic of Design. End/means logic might include declarative logic, but this inclusion is not a necessary condition, let alone a sufficient one. Most actual designers' activities show that they are not, necessarily, done with just a declarative logic. Different logics have supported designing mental activities and meta-design thinking and reflections. Some designers "remain intermediaries between consumers and producers, interpreters of specifications that have mainly been drawn up by other people." (Moles, 1989, pág. 77). Information Systems designers, for example, interpret the user specifications identified by the so called "systems analysts" through an iterative and interactive communications process with the respective system's users. With traditional software engineering methodologies, the so called "systems analysts" were different individuals than the "systems designers" and "documents" were used to communicate them. But, in general, "designers have become a 'Demiurge,' not only interpreting human values, but also giving them concrete form." (Moles, 1989, pág. 77). This can also be seen in general and in the specific case of Information Systems Development and Software Engineering.

The "optimization methods", Operations Research and Managements Science methodologies taken by Simon as models for his proposals are special cases of a more general ends/means logic, which should not be reduced to *quantitative* models because the users' language is a *qualitative* one. Adequate modeling should be a qualitative, or a hybrid one. Consequently, end/means (qualitative or hybrid) modeling might support better design activities and meta-design conceptualizations and reflections. A Pragmatic-Teleological approach, as that of Singer-Churchman's (Churchman, 1971), for example, might be a better approach to make reflections on Design and Meta-Design, which is coherent with, and would include, Simon's approach, as a special case.

Any design activities require an initial *objective*, a '*telos*.' This objective is not necessarily a static one, on the contrary, it is usually a very dynamic one, depending on the changes that might happen during the designing process. Designers and users learn during designing processes and this learning process might change the initial objective. Likewise, researchers learn from their research activities which trigger in their mind new hypothesis which requires new or modified (experimental and/or mental) designs; which, in turn, requires verification and validation actions, which, in turn again, require their implicit or explicit design, and so on. *What is really surprising is that, even the clear existence of strong relationships between "research and design", these relationships are not frequently shown in an explicit way.*

4. Toward Systemic Notion of Design[9]

A systemic notion of "design" would be, as expected, an integrated and an integral one. To be integrated, the notion of design should include its contextual relations, as those cybernetic ones with research, we briefly and schematically presented above. To be an integral notion, it should be *comprehensive* and with *conceptual relatedness*. In this section, we will present a comprehensive framework based on three dichotomies inferred from a semantic analysis.

Consequently, we will attempt to identify an initial comprehensive semantic structure, which will lead us to a hypothetical conceptual infrastructure, which, in turn, will give us the pointers to contextual relations and the other notions strongly related to the notion of design, beside the notion of research. It will also relate what is described in this section to what we described above regarding the cybernetic relationships between design and research, especially with regards to what we schematically described in figure 5, with regards to means-end logic and the pragmatic teleological perspective of the Systems Approach. This conceptual infrastructure will also relate this section to a following one oriented to identify the conceptual relatedness among different concepts identified in the context of the notion of "design ".

4.1. A Semantic Approach:

From a thesaurus we observe that there are seven groups of synonyms of "design". Three of these are verbs and four are nouns. So, we might think that there are two sub-sets of the senses in the meaning of "design": as a process and as

[9] This section is an updated adaptation of a the co-authored article (Callaos & Callaos, 2008)

a product**,** in a temporal existence and in an atemporal one, a chronological sense and a logical or a spatial one. It is to be noticed that these two subsets of senses represent a semantic dichotomy and, such provides precise limits that allows their definition and, consequently, they can be *defined* as concepts, or set of concepts. Notice that what can be defined is what is "definite, distinct, and clear." (Dictionay.com) Etymologically definition derives from "Old French definicion, [which, in turn, derive from] from Latin definitionem (nominative definitio) *'a bounding, a boundary; a limiting*, prescribing; a definition, explanation'." (Online Etymology Dictionary) [Italics added]. This is why *a semantic dichotomy allow us to define a concept or a set of concepts.*

A semantic dichotomy provides a clear and definite boundary and frontier which what is required for conceptual definitions and structures.

Design as a process, as a temporal existence, will be analyzed in section 5, where we will relate past, present and future representations (different senses of "presentation") in the context of a means-end logic.

Let us now go back to the notion of "design". etymologically, "design" derives from the Latin term *designare* (to mark out), and this word, in turn, derives from *signum* (sign). Peirce, the founder of semiotics: the science of signs, gives many definitions of "sign", the most referenced one is "a sign ... is something which stand to somebody for something in some respect or capacity." (Pierce, 1931–36) The notion of "sign" as ***"something standing for something"*** has been very used through history, and it could be associated, by analogical thinking, to the notion of "re-presentation". Hence, the notion of "design", as a process, could be thought as "marking out", "generating a sign", "producing a representation"; and as a product could be thought as the "representation" produced, the "sign" generated. It is not any kind of sign or representation; it is not a phantasy, or hallucination, for example. It is a special kind of representation.

Representation is the genus of design. We will try to find the specific characteristics that differentiate design from other species which also belong to the genus of representation. Right now, we only need to know that it is a representation and, as such, there could be two principal kinds: ***mental*** and ***physical*** representations. So, we have another two macro-senses of "design": as a mental and as a physical representation. Some groups of synonyms relate to the sense of mental representation, such as, for example, "intend", "aim", "contemplate", "purpose". These are examples of Walter's (1915) conception of subject-object, i.e. the object that exists in the mind of the subject, as for example, "objective." In Spanish, "*designio*" means purpose, goal, objective, intention, plan, which is the desing sense of mental representation,

Other group of synonyms is the related to the sense of physical representation as, for example, for example, "blueprint", "chart", "lay out", "map out", "set out". These are examples of "*ex-formation"*, forms exteriorized by a subject as means to communicate with him/her-self or with other subjects. These kind of physical representations are among the examples of Walter's (1915) conception of object-object, i.e., objects external to the subject.

An initial semantic/conceptual framework could be derived by crossing the two already identified, semantic dichotomies: 1) "design" as process and as product, and 2) "design" as mental and as physical representation. In this way we will have four senses (or sub-concepts, or sub-notions) of the term "design", as it is shown in table A, where synonyms are distributed in the four cells of a 2x2 matrix, which represents four concepts or sets of concepts.

4.2. Conceptual-Semantic Framework

The term "plan" appears in each one of the four cells. Hence, the notion of "plan" is completely included in the notion of "design" and has the same four senses given in table A. Consequently, it is adequate to differentiate in the notion of "design" between "plan" (the ***"how")*** and the "object" planned the purpose sought, the aim quested, the intention wrought, the intention to be achieved (the ***"what"***), by mental effort and/or physical labor.

Therefore, we will have a semantic/conceptual framework of 2x2x2 matrix, based on three dichotomies, i.e. 1) process/product, 2) mental/physical representation, and 3) object sought/plan to achieve the object (what/how). This 2x2x2 matrix represents a set of eight concepts that are included in the notion[10] of "Design".

	Process (temporal)	**Product (atemporal)**
Mental Representation (Subject-objects or objects related to the observer)	To intend, to aim, to propose, to purpose, to contemplate, to plan	Intention, animus, intendment, intent, plan, purpose *Composition, construction, formation, constitution*
Physical Representation (Object-objects or objects related to the observed)	To chart, to arrange, to blueprint, to project, to devise, to lay out, to map-out, to set out, to arrange, to share a plan	Blueprint, scheme, game plan, project plan, figure, device, pattern

Table A: Classification of synonyms of the term "design" in a 2x2 matrix according to the dichotomies 1) process/product (temporal/a-temporal) and 2) mental/physical (subject-objects/object-objects, or object related to the observer/objects related to the observed

Therefore, eight sub-concepts (or sub-notions) form the conceptual infra-structure that supports the concept of design and relate (potentially integrate) the different denotations and connotations of the term "design". In this case, this conceptual infra-structure provides what would be needed as input for a systemic notion of "design", because it would be a comprehensively integrative conceptual structure. But, a systemic notion should also include the relations that integrate it to other important concepts or notions, so the notion would be integrative and integrated. In order to do so, we will briefly analyze the concepts of representation, intention and plan. The first two concepts have been largely treated in the philosophical literature. Hence, we will explore below the relation between "Design" and

[10] Reminder from a footnote above: A notion is cognition, an idea which can be, and usually is, represented by the description of a set of related, or relatable, concepts along with their respective definitions. This set is frequently a fuzzy set. But, using semantic dichotomies the set of eight concepts is not a fuzzy set.

“representation”, “intention”, and “plan”, all of which also relate subject with object, observer with observed, knower and known.

5. Design as Representation:

In terms of traditional logic, we identified, so far, the genus of the notion of “design’ and the sub-species of this notion. “Representation” is the genus of “design”, thus, to define “design” we should analyze its genus’ comprehension (Port-Royalist) or connotation (Mill), and its differentia as specie. We have already identified the eight sub-species of “design” and their respective differentia as such. Thus, the next step is to identify the predicates of “representation“, since what it is predicable from the genus (representation), it is also predicable from the specie (design).

As we wrote before, the notion of “representation” has been largely treated along the history of philosophy: so, all what we will do here is to present a very brief summary of the features that we think are relevant to our inquiry. It will be a very first step that could be followed in the future by a more detailed study.

The etymological meaning of “representation“ is to bring into presence, hence to make clear, demonstrate, symbolize, stand in place of (Weekley, 1967). It is good to notice Pierce’s definition of “sign” coincides with the etymological meaning of “representation”. A scientific theory might be conceived as a representation of observed non-variant aspects of reality (traditional science) and/or a design to answer a question by means of observing phenomena, which, according to The Copenhagen Interpretation of Quantum Theory and Second Order Cybernetics. The observed phenomenon is an inseparable combination of observer and observed, subject and object, knower and known. In any of both cases (Traditional Science and Copenhagen Interpretation of Quantum Theory) the observer, the researcher, represents with an implicit or explicit objective, i.e. ***designing an answer to a question***. *One of the means used in this kind of designs and designing is mental or physical experiments***.** Other means might be reflections, speculations, dialogue, etc.

Intuitions might be generated by implicit designing processes, made in order to answer a given question. It is a sudden design-as-product generated by explicit and/or implicit mental design processes; which include the observed and the observer, the object and the subject, the knower and the known.

Consequently, design is not just an activity of designers, architects, and engineers. It is also a necessary activity for any scientific inquiry and research, not just in designing physical experiments, as it could be believed. The objectives, the knowledge and the experience of the designer (observer, researcher) are necessarily part of the design, including experimental and non-experimental designs. This means that there is no way to separate the observer from the observed because the observed observes through a mental and/or physical design which, by nature and definition, have mental and non-mental, subject-objects and object-objects, parts related and integrated into a whole. This whole, in turn, might have very specific *emergent properties* (e.g., subjective intuitions) not necessarily generated by designs made by other observers, researchers or subjects.

Consequently, in my opinion, this approach may also support the Copenhagen Interpretation Quantum Theory or Second Order Cybernetics in order to include the observer in the observed. The General System Theory and Philosophy also show the intellectual evidence that, since scientific activities are based on implicit or explicit design, which, by nature, include mental and sense-based objects, then ***emergent properties*** of the integrated whole depends certainly on the perceiver, the observer and not just the perceived or the observed. This conceptual evidence is among the reasons with which we concluded in 1976[11] (Callaos N. , 1976, p. 127) that *"knowledge is relative to the observer",* knowledge "Depends on object [objective] and subject [subjective]", i.e. it is always a combination of subject and object.

Going back to the notion of "representation" which is the genre of "design", from a psychological perspective, Ferrater-Mora (1969, págs. 566-7), based on (Spencer, 1855) [Par.423], presented the following senses in the meaning of "presentation"

1. The apprehension of an object effectively present, as in perception; or in the *"presentative"* knowledge; where the related concepts or notions correspond to (represent) present, existing external objects. Consequently, "design" (relating the concepts or notions), is a mental representation, i.e. an apprehension of object-objects (external objects) and subject-objects (mental objects) effectively co-present, i.e. presently existing, simultaneously co-existing in the mind of a subject. Since a potential answer (not previously memorized) of a question is one kind of design, then answering a question (e.g., in scientific activities) requires simultaneously co-existing subject-objects (mental objects, e.g. objectives) and object-objects (external objects) in the mind of a scientist, an observer, a knower, a researcher. It is the same conclusion we had above, but this time from a psychological perspective.
2. The representation in the mind of past perceptions, i.e. memory representations, remembrances. If these past perceptions or memory representations did not happen at the same time when they were initially perceived, then the mind should *relate* them before making them to be co-present in the same presentation, then, again we are in presence of a design activity where the subject, the observer, the knower, is who is making the required *relationships*; which, in turn, depend on the subject (the reliability of his/her memory) as well as on a) the situations in which s/he had the respective initial perceptions before being memorized and even b) the kind of emotions in which the subject was immersed into when the related memories were memorized, or retrieved in the past. This kind of emotional and environmental situations may affect the reliability of the memory and, consequently, the mental object, the cognition generated by retrieval from memory.
3. The anticipation of future happenings by means of a combination of past perceptions regardless of whether they are reproductive or productive. In this sense, representation is frequently equated to imagination. *This is the characteristic of representation of what is more related to the notion of design*, which (as we explained above) is a species in the genre of "representation". Consequently, we could hypothetically affirm that "design" is a representation or presentation imagined as a ***possible and/or***

[11] This was one of the conclusions of a PhD dissertation presented at the University of Texas at Austin.

feasible anticipation of future happenings by means of a combination of past perceptions regardless of whether they are reproductive, productive, or a combination of both. A scientific experiment is production or reproduction of an anticipated result or behavior. If the anticipated result or behavior is observed after implementing the experiment, then the anticipated results or behavior would be confirmed and, then, what was previously anticipated get transformed into knowledge, i.e. a justified belief where the justification is the experimental method that has been applied. This is one of the ways in which scientific activities produce knowledge as long as the replications of the experiments confirm and validate the gained knowledge. This earned knowledge may be input to engineering designs which is based on knowledge (both: explicit science-based knowledge and implicit experience-based knowledge) in order to anticipate feasible artifacts, technologies and innovations. Consequently, we can affirm that designs in scientific domains produces one of the necessary inputs of contemporaneous engineering domains and engineering activities produce both mental and physical designs and, as a consequence, artifacts, technologies and innovations. In the far past, engineering required, mostly, implicit knowledge to generate mental and physical designs. *Design is what is* ***common*** *to scientific and engineering activities. Consequently is what* ***comm****unicates them.* Details regarding the complementariness between science and Engineering could be found in (Callaos N. , The Essence of Engineering and Meta-Engineering: A Work in Progress, 2013a)

4. The mental union of several perceptions, that are neither present, nor past, nor anticipated. In this sense representation is paralleled with phantasy, daydream, delirium, fiction, delusion, chimera, hallucination, etc. This kind of representations is certainly not associated with any kind of design, because it does not reflect any reality and it is not anticipation to any possible or feasible future natural or artificial realities.

Consequently, we could conclude that there are at least three senses in the meaning of the term “design”, as mental representation:

A) An apprehension of object-objects (external objects) and subject-objects (mental objects) effectively ***co-present***, i.e. *presently* existing, simultaneously co-existing in the mind of a subject.
B) ***Past*** perceptions, i.e. memory representations, remembrances. This might have happened at different times and not necessarily in a simultaneous past existence.
C) Anticipation of ***future*** happenings by means of a combination of past and/or present perceptions regardless if they are reproductive or productive. In this sense, representation is frequently equated to imagination. But, for Kant, Imagination is the human *faculty* required for any kind of representation, be it productive or reproducitve. We will provide belwow, a littlebit of more details regarding this issue.

We will se in section 7, below, futher relationships between the term “design” and thre these senses we just recumed in A, B, and C. These relationships will be based on the etymological meaning of intention, which may means “design” as will as understanding and comprehension (senses A and B), while sense C will be presented as anticipated intentional pre-existence.

6. Integral Conceptual framework

From what we briefly described in the previous section, we suggest a conceptual framework, based on timing and the means-end logic. We concluded, above, that the notion of design may be based on *present, past, and future perceptions or any combination of them*. Having presented that, with some details, above, it is good to add that the notion of "design" is strongly related to the third kind of "representation", i.e. oriented toward the future. The first and the second senses might be *means* used to achieve the third sense. as an *end*, i.e. *past and present representation are among the means for achieving the final end of design, i.e. anticipating future mental or physical happening.*

Design is a combination of past and present perceptions and mental representations oriented to future happenings as well as a combination of *reproductive and productive perceptions oriented to a future existence, and directed by an intention, a purpose, an objective, a goal.* It is the imagination of what it is probable, possible, desirable, and/or feasible according to an intention. It is to imagine what it could exist by means of existing objects (object-objects and subject-objects, external objects and mental ones, e.g. objectives). *It is a "poietic" (productive) imagination, intentionally directed, and action oriented.*

From an epistemological perspective, "representation" has been conceived by the scholastics as "similitude". "To represent something—according Aquinas—is to contain a similitude of it." [Quoted by (Peter, 2011, p. 199)]. Accordingly, to know is to represent an existing object of knowing (subject-object and/or object/object) by a simile; it is to simulate an existing object by a resembling idea. In this sense, we could think of "design" as the *knowledge of a preexistence*, a pre-figurement; it is a "pre-knowledge", a pre-cognition, of something that it is to come. It is a *"pre-knowing" by means of what is known*. This definition fits well the notion of design in Science (e.g., hypothesis formulation), in Engineering (design of an artifact or a technology), and in Art (e.g., architectural design)

In the late scholastics, the senses of "images" and "meaning" were added to the significance of "representation". Descartes emphasized on its sense of image, but it is Kant, who generalized its meaning as to signify: (1) any cognitive act or content no matter if they are similitude of a knowing object or not; and (2) any non-private, public structure, frames, models or scheme that is cause or effect of such cognitive acts or contents. This is in complete agreement with our hypothetical conceptual structure shown in table A, which is based on the dichotomies process/product (act/content) and mental/physical representations (private/public). If we add to Kant 's notion of "representation" that it is oriented to the future, then we will have the description of "design" as future-oriented cognitive acts or contents and/or their public cause or effect objects. According to Singer-Churchman's pragmatic-teleological truth (Churchman, 1971), the epistemological value of these private acts/contents and their public cause/effect depend on the feasibility and desirability of their *future orientation* and on the accompanied *intention to make them come true.*

According to (Rastovic, 2013, p. 5) **"**Kant's epistemological theory is grounded in investigation of representation of a mind–independent object which is represented to us." This means that the notion of representation is at the center of Kant's epistemology. Furthermore, Kant affirms that the *imagination* "the faculty of representing an object even without its presence in intuition" (Kant, 1988) [B151][12]. So, representation is a necessary condition in Kant for any kind of knowledge and imagination is the faculty required for the act of representing. This means that the faculty of imagination is a necessary condition for any knowledge acquiring, i.e. imagination is the human faculty required in Kant's epistemology, because it is necessary for any kind of representation, including knowledge. In this context, it is highly relevant, to our topic, Kant's conception and distinction between *productive and reproductive imagination*, which generates productive and reproductive representation; both of which are required in any kind of design.

Furthermore, Kant affirms that "Synthesis in general is … the mere effect of the imagination, of a blind though indispensible function of the soul, without which we would have no cognition at all, but of which we are seldom even conscious". (Kant, 1988) [B 103][13]. This is coherent, in our opinion with what we called *implicit and esplicit design*. Since design is a synthetic act, though frequently based on precious analysis, then it required imagination, in its Kantian sense, for past, present and anticipatory representations. The latter requires imagination in its psychological sense, i.e., created, produced mental images, forms or structures, frequently oriented to meet a goal or an objective.

Using the conceptual differentiation made by Kant between reproductive and productive imagination, "design" could be conceived as a turnout of a productive imagination, oriented to a future existence of an object and, hence, accompanied by the **intention** to bring it to physical or material existence that might make the corresponding object's existence come true. It is a kind subject-object (e.g., mental representation, objectives) with the possibility or feasibility of being transformed in object-object (physical, material representations), and the intention to make this transformation (from mental to material forms, from forms-in to forms-out, from in-formation to ex-formation)[14]. Notice that to communicate via language (speaking or writing) require previously a necessary, though implicit, mental representation and the intention [subject-objects] to express it via verbal or written sentences grammatically, coherently, and logically related (i.e. object-objects). It is evident that exactly the same situation happens when scientists try to convey old, new, or original knowledge. Consequently, scientific activities and, hence, Science includes and relate 1) subject-subjects/subject-objects and 2) object-objects (mental and physical representation) in a complex whole with potential ***emergent properties***.

As we said, in designing activities our *productive imagination* generates mental images or anticipatory representations intended toward a "non-existing-yet" physical, material object. These mental representations might, in turn, be physically represented as drawings, diagrams, visual schemas, material models, maquettes, etc. These physical representations are done in order to communicate the mental image to other person(s) and even to the same designer.

In general, the physical representation is an *effect* of the original mental image, and a *cause* of other mental images. The designer may interact with his/her

[12] Quoted and referenced by (Rastovic, 2013, p. 7)
[13] Quoted and referenced by (Rastovic, 2013, p. 2)
[14] Details regarding the differences and strong relationships between in-formation and ex-formation, impressed forms via sense data and expressed forms via verbal or non-verbal signs are extensively analyzed in (Callaos & Callaos, 2011)

physical representation changing the mental representation which in turn could change the respective material representation and so on in cybernetics loops until a final design is achieved. These loops could generate synergies and emergent properties between the mental and the material design, especially when the design is being made collaboratively or being materially expressed to elicit comment form the future users of the implemented designs. This kind of collaborative design or interaction between mental representations with other (e.g. users) via material representation has been especially used in prototyping methodologies (e.g., tailored software-based information systems developments). In experimental sciences, hypotheses are tested via experiments, which need to be designed before being implemented in such a way that the observer can observe the results of the experiment and can control the respective variable of the experiments. This interaction with the experiment might suggest another experiment, which would require, in turn, a mental design for the material experiments, and so on via cybernetic loops.

We wrote above that "physical representations are done in order to communicate the mental image to other person(s) and *even to the same designer*". The later would support a "conversation" of the designer with him/her self[15], which may generate a cybernetic self-loops with self-regulation and self-amplification via self-learning and action-learning, action-design and/or action-research. This involves physical representation of mental content, mental re-representation of of the physical representation, and so on, into a self-learning loops with a high potential of self-synergy generation[16].

7. Design and Intention

The starting point of a design process is mental, and "intention" is essentially what triggers it. According to Brentano (1874/1935) [II, 1], mental (psychic) phenomena possess—unlike the physical ones—an intentionality, i.e. they refer to an object, an objective. A perception is always a "perception" of "something", a conscience—as Husserl (1900/2007) emphasized—is always a "conscience" of "something". Any scientific activity refers to an object 1) object-object (external object) and/or 2) subject-object (e.g., objective, mental representation). Consequently, any scientific, technological, artistic, everyday activities have intention(s)

Mental phenomena, unlike physical ones, ***exist*** always ***in*** the mind. This is why, as we mentioned above, the scholastics called them "**<u>in</u>**existence" which should not be confused with "non-existence" or absence of existence, or **in**-forms as we already called. In its scholastic sense, "inexistence" means "existent-in" other thing[17]. Brentano emphasized in this scholastic sense: "this intentional existence—he wrote—is exclusively characteristic of mental phenomena. No

[15] Ranulph Glanville used this notion of self-conversation in a plenary presentation at the one of the World Conferences on Systemics, Cybernetics and Systemics.

[16] Being synergy the cooperation among two or more parts in a whole which is more than the sum of its parts (emergent properties); self-synergy would be the cooperation of the designer with two different instances of him/her self: before and after making a physical design. This would support the interaction between his/her synthetical and analytical thinking.

[17] *See, for example, William of Ockham; "Inexistentia" in Leon Baudry:* Lexique Philosophique de Guillaume d'Ockham, *1958, p.121, (referenced by José Ferrater Mora (1969, pág. 945)*

physical phenomenon manifests anything similar. Consequently, we can define mental phenomena by saying that they are such phenomena as include an object intentionally within themselves.” (Brentano, 1874/1935) [Vol. I, Book II, Ch. I][18]. In this sense, explicit design (sense C among the three senses identified in section 5 above) could be conceived 1) as an ***anticipated intentional inexistence,*** future oriented intentional inexistence, intentional inexistence of a future mental or physical object (subject-object or object-object), or 2) as a **dynamic pre-existent intentional inexistence** (in the context of a dynamic imaging process where there is a sequence and images and designs oriented to a design according the potentially changing intention).

The term “intention” refers to the act and the effect of *tending* toward something. Etymologically ‘intend’, as a verb, derives from “Latin intendere, stretch out, extend, aim at, stretch toward, direct toward, turn to, purpose” (The Century Dictionary and Cyclopedia, 1889/1911, p. 3134).

According to the (Online Etymology Dictionary), “intention” means

> "to incline, to move in a certain direction," early 14c., from Old French tendre "stretch out, hold forth, hand over, offer" (11c.), from Latin tendere "to stretch, extend, make tense; aim, direct; direct oneself, hold a course" …from … tendere "to stretch," from PIE [Proto-Indo-European root] root *ten- "to stretch."

In English, among the senses with which the word ‘intend’ is used, as *transitive* verb are the following “To stretch forth the or out … fix in a course or tendency … To fix the mind upon, as something to be done brought about, have in mind or purpose … To ***design***, to signify.” (The Century Dictionary and Cyclopedia, 1889/1911, p. 3134) [Italics and emphasis added].. Similarly, among the senses that the English term ‘intention’, we find the following ones: “Direction of the mind; attention; hence uncommon exertion of the intellectual faculties … The act of intending or purposing … that for which a thing is made, ***designed*** …A mental effort or exertion; ***notion***; ***conception*** … Special end or purpose … the fixing of the mind on an act with the purpose **to do it**” (The Century Dictionary and Cyclopedia, 1889/1911, p. 3136) [Italics and emphasis added]. Is is evident in this text the three senses of the word “desing” we concluded and presented on section 5. It is important to also notice that in Spanish, “entender”, which means “to understand, to comprehend”, has the same Latin root of “intendere”. This is important because it shows more evident semantic ans conceptual links between “understaning and comprehending” and “design”, already mentiones in the senses A and B of desgn, mentioned in section 5, above.

Consequently, there are reiterated corroborationswith regards yo the notion of “intention” as strongly associated with “purpose”, “end”, “objective”, “pre-doing”, “design”, and in, one its senses, with “pre-design. Intention is “action-oriented” as well. And, as transitive verb is associated with “to stretch forth the (object) or out (toward the object); fix in a course or tendency; fix the mind upon, as something to be done, brought about, have in mind, or purpose of bringing about something. It is evident then that *“intention” is what relates “subject” and “object”*, a movement, a stretching out of the subject toward the object. *It is the subject stretching out toward the object*, be it by it a physical object, mental object, and/or objective; it is the observer toward the observed, the knower toward the what to be

[18] *Quoted and referenced by Bruce Aune (Intention, 1967)*

known, the designer toward what is to be designed, by ir a technology, a methodology, a hypothesis, a coceptual structure, or a theory.

Aquinas also defined the term or concept of ‘intentio’ (intention) as *relating* the knower with the known, the perceiver with the perceived, the subject with the object. Actually, intention is required for any phase of perceiving, informing, knowing, and/or designing processes. For example, Lonergan (Insight: A study of human understanding, 1992) affirms that all three cognitive operations of knowing (experiencing, understanding and judging) require “the intentionality of the subject, and a resulting relation and engagement of the knower with the known.” (Frezza & Nordquest, 2015, p. 2)

‘Intention’ is also a central notion in phenomenology, which opposes strongly any kind of reductionism, and any way of isolating the subject from the object. The perceiver/knower is always related to perceiving/knowing something. Hence, the designer is always related to the designed, in any of the three senses of designed identified in section 5. To be a perceiver, knower, or a designer is to be related to what is perceived, known, or designed. To be a subject is, necessarily, to be related to an object; and to be an object is, necessarily, to be related to a subject. There is neither isolated subject, as such, nor an isolated object as such. There is no designer without desing and vice versa.

The essential characteristic of “intention“, as to relating subject and object, generates ambiguities in the meaning of the term, which sometimes is used to refer to the subject’s mental potential, act, or content; and in other contexts is used to refer to the object.. This equivocalness of “intention” has been recognized since the scholastic[19], up to the present[20]. Being the notions of design and intention so conjoined, it is no surprise that the four (2x2) sets of senses identified in sub-section 4.2. are analogous to the senses which seem to have been identified for the notion of intention, i.e. 1) intention as act and content (process and product) and 2) intention as mental or material (subject and object-object)

8. Design, Intention, and Action:

As we showed above, important essentialities of the notion of intention are constitutive of the notion of design. The first of these essentialities is the inherent *disposition to action* (Aune B. , 1967). When a mental representation includes no disposition to action, there is no intention, or design. In such cases, the mental activity might be daydreaming, illusion, hallucination. A desire, for example, may conflict with another desire and not be followed by action, but if a decision is made between both desires, then there is an intention, which along with design, generates action. Intentions and desires are both pro-attitudes, but―as Bratman emphasized―just intentions are conduct-controlling pro-attitudes (Bratman, 1987, p. 16)

Desires are potential influencers of action; intentions are actual influencers of actions. Intention and, hence, design are ***conduct-controlling pro-attitudes***. If a design generates no action it is not a *real* design; it is a desire which, when contrasted by other desires, might be refrained from action. In such a case, it is an option not an intention; hence not a design. To have an epistemological value,

[19] As, for example, in St. Thomas Aquinas and St. Bonaventure (Ferrater-Mora J. , 1969, p. 980)
[20] As, for example, in (Aune, Intention, 1967)

design should generate action oriented to produce the object designed; it should bring to mental or physical existence the pre-existent, the “non-existent-yet” object of the design, me it mental (subject-object) and/or physical (object-object). Else, what is the use of design? What is its reason of being?

A) If the design is an abstract mental representation (subject-object), it should be translated to 1) physical representations or signs in order to be communicated and, hence, making an impacts in other minds or, 2) to act on other mental represtations, reflexively, to impact the mind of the same designer.
B) If the design is oriented to an external object (object-object), then it should generate concrete physical representation of it.

In any case, it should be the cause of a *transformation* between mental representations or between external objects. i.e... it should cause a transformation on what are called external and/or internal worlds. This means that intention and design should produce an action on the external or the internal world. Intending and designing physical objects represent an action of the external world (object-objects); while intending and designing mental objects (subject-objects) act on the subject (subject-subject). In both cases a transformation is generated 1) on the external and/or 2) on the internal worlds, i.e. there should be a material and/or intellectual transformation.

The *in*-formation[21] we gather from the external world provides us with the *mental forms* that are necessary for the mental (conceptual, notional, intellectual) constructs of the (implicit or explicit) knowledge required for the designs triggered by our intentions. These mental processes generate the new mental constructs required for internal or external *transformation*. *Ex-formation* is necessary condition for external transformations. Designs should be **ex-**pressed via external signs (e.g. language, mathematical representation, symbols, diagrams) or physical objects (e.g. prototypes, maquettes, mock ups, scale-models) in order achieve a *trans-formation* which is the purpose, the ‘*telos’* of any intended action. Scientific activities, mostly, produce external signs and the means used are in many situations objects physically designed by scientists (e.g., experimental situation, systems, or contexts) or by engineers (e.g., technologies, instruments). On the other side, engineers and technologists generate mostly generate physical design using implicit and explicit knowledge. The later is frequently produced by scientists. Intentions and design, along with their exteriorization, are what is **common** to scientists and engineers and, hence, **communi**cate them. Consequently, shouldn’t design be an essential ingredient of a systemic notion of Science as related to Engineering or to any kind of Expansion of Science, including that which based on the Coprnrghen Intermpratation of Wuantum Mechanics and, consequently, Second Order Cybernetics? If we need to also observe the observer and not just the observed, shouldn’t we also be knowledgeable about 1) the notion of design and 2) the intention, the purpose, the *telos* of the observer?

[21] It is good to remind the reader that what we make the identify the differences between in-formation and ex-formation in order to differentiate between information 1) as impressed forms via sense data and 2) as expressed forms via verbal or non-verbal signs. Details regarding these differences and the strong relationships among them are analyzed in (Callaos & Callaos, 2011)

Referring to Wheeler's (1975) (1977) notion of "Participatory universe" , Nesteruk (2013) arrives to similar conclusions from another perspective. He affirms that "It is not difficult to conjecture that the "real" law which drives physics is the 'law" that universe must be explicable … In this sense it is this explicability which becomes the ultimate telos of the whole human complex of human observer [who generate the known Science] … there is an implicit purposiveness in the closed circuit established between observers and physical reality which ultimately proceeds from the nature of the observers as human intelligent beings endowed with the purposiveness of any actions." (Nesteruk, 2013, p. 18). Intention (purpose) is transformed into effective action necessarily by design, including physicists' action or any other kind of other scientists. Scientific results and, hence, Science is the product of purposeful related actions, produced by intentions and designs. So, how we can leave intention and design out of a systemic notion of Science or a conception of Science based on Copenhagen interpretation of Quantum Theory or Second Order Cybernetics. Nesteruk continue affirming that "Purposiveness is a human aspect of existence and one can hardly believe that physics, being a purposive activity, can explain the emergence of this purposiveness out of itself" (Nesteruk, 2013, p. 18). Consequently, purpose, intentions and design should necessarily taken into account in the context of Science and not out of it. This conclusion can be acheieved from both the supra and the subatomic perspectives.

9. Intention, Design, and Practical Reasoning

We should not confuse the act generated by an intention with the act that generates the intention. The notion of "intention" has also a non-dispositional sense, as when we make a resolve or decision, i.e. we have the "intention" of voting for a candidate but we do not take the action of actually voting. In this kind of circumstances the "intention", understood as resolve, is an act but does not produce the action of actually voting. Practical Reasoning is also required for the intention in its sense of "disposition to action" Consequently, intention is associated to design in the sense of "disposition to act" and acting as a consequence or practical reasoning, i.e. *"intention" is associated to design via "practical reasoning"*

Aune explains this differentiation between the senses of intention in the following terms: apart from having an intention in the "disposition to action" sense, "it is also possible - writes Aune - to intend in an occurrent, nondispositional sense -that is, to engage in 'acts' of intending. This is possible because resolving is an 'act' that counts as a special case of intending- namely, intending as an immediate consequence of deliberation or choice". As mere disposition to action "intentions may form themselves as effortlessly and as unconsciously as beliefs, which they resemble; but sometimes, as in deliberation or choice, one forms an intention explicitly, consciously, and occurrently -in which case one's intending may have a character of a resolve... Here one's intending, as act, is a 'practical' thought, serving as the conclusion of a line of practical reasoning" (Aune, Intention, 1967, p. 200). Consequently, we are using here the word of "intent" as cause and effect of practical reasoning and not just as a mere non-dispositional resolve or decision.

If our actions were influenced by deliberation only at the time of action, the influence of such deliberation would be rather minimal. This is because deliberation requires time, effort and other limited resources, and there are obvious limits to the extent to which one could successfully deliberate at the very time of action. Consequently, we need some ways by which deliberation and rational reflection to be allowed to influence action and to take place before the action's time. Consequently, *plans* are a must for an opportune deliberating and reflecting, and plans require and are a form of design. Hence, intention (in its sense of real disposition to action) requires plan, i.e. one form design. Consequently, intention with no design is not an effective disposition to action and it might be just the result of the act of resolve. This means that *intention is generated by an act and it should generate an associated action orated to what is intended*.

Since we have already shown that design, implicitly or explicitly, is required in any observing, then a systemic notion of Science, whether it is based on it traditional conception, or in an expanded notion of it (that takes into account the consequences of the Copenhaguen interpretation of Wuantum Theory, e.g. Second Order Cybenetics), should also include include observer's intention, design and practical thinking. Likewise, "Science of Practical Reasoning" and "Practical reasoning in Science" should also be included in the notion of Science.

10. Intention, Design, and Planning:

Plans are not just necessary for transforming an intention in effective action; they are also required for intra-personal and/or inter-personal coordination. By constructing plans for the future, we facilitate coordination of both 1) our activities over time, and 2) our activities with those of others. By setting plans, we enable our present deliberation and practical reasoning to influence our consequent conduct, extending the influence of our deliberation beyond the present moment and beyond ourselves. As a design gets complex requires us to go beyond the present and ourselves, consequently, ii will require plans, which another form of design. We need a plan (or several plans) for meeting our purpose or intention, i.e. for bringing to existence the sought or intended mental and/or the physical representations.

But, as Bratman asserted, "we do not, of course, promote coordination and extend the influence of deliberation by means of plans that specify, once and for all, everything we are to do in the future. Rather, we typically settle on plans that are *partial* and then fill them in as need be and as time goes by. This characteristic incompleteness of our plans is of the first importance. It creates the need for a kind of reasoning characteristic of planning agents: reasoning that takes initial, partial plans as given and aims at filling them in with specifications of appropriate means, preliminary steps, or just relatively more specific courses of action" (Bratman, 1987, p. 3)]. [Italics added]. This means that the execution of a plan drequently (or always) requires dynamic meta-planning (in re-planning the planning process) as the execution process proceed generating a learning-process and meeting changes in the planning environments.

There are several 'whys' supporting Bratman's assertion about the inherent partiality and incompleteness of plans, especially those related to complex designs. Let's enumerate briefly some fundamental whys:

1. Experiments had shown that people have perception processes which can handle between 5 and 9 things at once. (Miller, 1956). Consequently, complex situations should be handled by means of different levels of abstraction, where details are not shown in the higher leveles of abstraction. Consequently, the most abstract, or general plan would not contain the details that will be filled in at lower levels of abstraction or in more advanced staged of the plan execution. The general plan will not have the specificities of the special plans forming parts of the general one. Consequently, the general plan will necessarily be partial and incomplete, as related to the specific ones.
2. Plans need time to be executed. The larger and the more complex the plan is, the larger the time required for its execution. And, the larger the execution time, the larger the probability of modifications in the initial conditions, and the larger the amount of new relevant information that will emerge. Consequently, the larger and more complex the plan is, the larger the probability that such a plan will be inadequate at some time in its execution process. Thereupon, as the plan reaches further in the future, the probability of change and new information will increase (potentially in an exponential form), and, hence, the details may change and would be less relevant. Consequently, the plan will be more partial and more incomplete, as it will protract in the future.
3. In an empirical research, Braybrooke and Lindblom (A Strategy of Decision, 1970) found that executives and policy makers, when facing complex problems, try to clarify and plan with details, just for the next step, i.e. up to the next planning increment, leaving the succeeding steps, or increments not so clear and so detailed, i.e. leaving the following planning increments partial, incomplete and even purposefully ambiguous or obscure. We suggest that similar situations happen in any kind of effective practice, including scientific and Engineering practice; especially when scientists or engineer are facing complex problems and/or uncertain situations or environments.. Shouldn't similar empirical studies be done regarding effective scientists? This question increases its validity with any re-conception of Science according The Copenhagen Interpretation of Quantum Theory and Second Order Cybernetics. Isn't that a way to include the observers in what is being observed in order to support more effective processes of observing?
4. Our experience in designing and implementing complex systems (educational, organizational and informational) evidenced the verisimilitude and the applicability of Braybrooke and Lindblom's conclusions, as well as the appropriateness and the relevance of Bratman's arguments. In fact, we have been developing, for 40 years, ans still developing, a Methodology for Systems Analysis and Synthesis, using Braybrooke and Lindblom's conclusions and Bratman's philosophical perspective among the foundational bases in our praxis and methodological theory construction. We have already done a general description of such a methodology[22], which has been applied to many and different kinds of

[22] See, for example, (Callaos & Callaos, A Systemic Definition of Methodology, 1991), (Callaos N. , A Systemic 'Systems Methodology', 1992a) and (Callaos N. , Metodología Sistémica de Sistemas [A Systemic Systems Methodology], 1995)

systems, as for example, in the areas of educational systems design and implementations, (e.g., design of the Latin-American School of Statesmen and Executives: LSSE[23]); design and implementation of more than 130 information systems[24]; the design and experimental implementation of Total Quality Designing Systems[25], etc. Consequently, the referred systemic methodology has been applied to a high diversity of different systems, situations and problems. We see no reasons why it cannot be adapted for re-designing an Science and Engineering Methodologies, especially Science, as re-conceived according Copenhagen Interpretation of Quantum Theory and, consequently, according to Second Order Cybentics or, in general, the a Systems Apporach, in the end Science is related set of conteptual systems, social systems, methodological systems, semiotic systems (including disciplinary, inter- and trans-disiplinary semiotic systems) with their respective levels of syntaxis, semantics and pragmatics. This is why, in our opinion, Science can be conceivend as a meta-system in each of several dimesion, i.e. a highly complex system, meta-system, supra- or super-system. In our opinion, Systems Engineering, specifically a General Systems Methodology (e.g., (Callaos N. , 1995) can effectively be applied to any re-conception of Science and, consequently, the notion of Design would be. not just part of scientific activities but what would be required for any re-conception of the notion of Science as well of the notion of Engineering and Meta-Engineering (Callaos N. , The Essence of Engineering and Meta-Engineering: A Work in Progress, 2013a).

11. Action-Design:

We can conclude without any hesitation that when the designing process is not simple, plain and facile, 1) it should be done with successive partial and incomplete plans to be filled in along with the design activities, as the process progress toward an accepted existent intentional inexistence, which could be physically be represented as a verbal model and/or a visual diagrammatic maquette, prototype, etc; 2) the design should be an evolutionary one; 3) and the designing process should be accompanied from the earliest possible stage with implementation actions, which should be conducted, in turn, with successive partial and incomplete plans. The design and action/implementation should be done in parallel according an incremental approach to planning as, for example, the findings of Braybrooke & Lindblom (A Strategy of Decision, 1970) on how executives make decisions. In this way, *the design process and the "implementing action" will be interwoven, interacting with each other, with reciprocal loops of feedback and feed-forward* (figure 6).

As we concluded above, design is always intentional and, hence, action-oriented. The essence of design is to generate action, according the intention, in some direction and/or for some feasible creation/production. It should not be isolated from action since it is strongly related to it. Both are parts of the same

[23] (Callaos N. , Designing an Latinamerican School for Statesmen and Executives, 1992b)
[24] (Callaos, Callaos, & Belkis, A Systemic Methodology for Information Systems, Analysis and Synthesis, 1992c)
[25] (Callaos & Callaos, Designing with a Systemic Total Quality, 1992d) and (Callaos & Callaos, Designing With A Systemic Total Quality, 1994)

whole, both are members of the same organically dynamic system. **Design gives direction and action gives propulsion to the whole, generated by the intention**. Design and Action are. In a sense, polar opposites and, as such, they complement and require each other. So, there is no way in separating them without deteriorating their essence. Usually, design comes before and is input to material action. But when we are dealing with a complex system, design and action should be conducted concurrently, even though design will initially get off alone up until an initial design of the first prototype, or archetype, of the intended system is available. From there on, design and action are (and should explicitly) be interwoven, interacting with each other, by means of reciprocal loops of feedback and feed-forward, in an evolutionary process that could be called *action-design*, which is would be nurtured by implicit or explicit methodologies of *action-research* and *action-learning.*

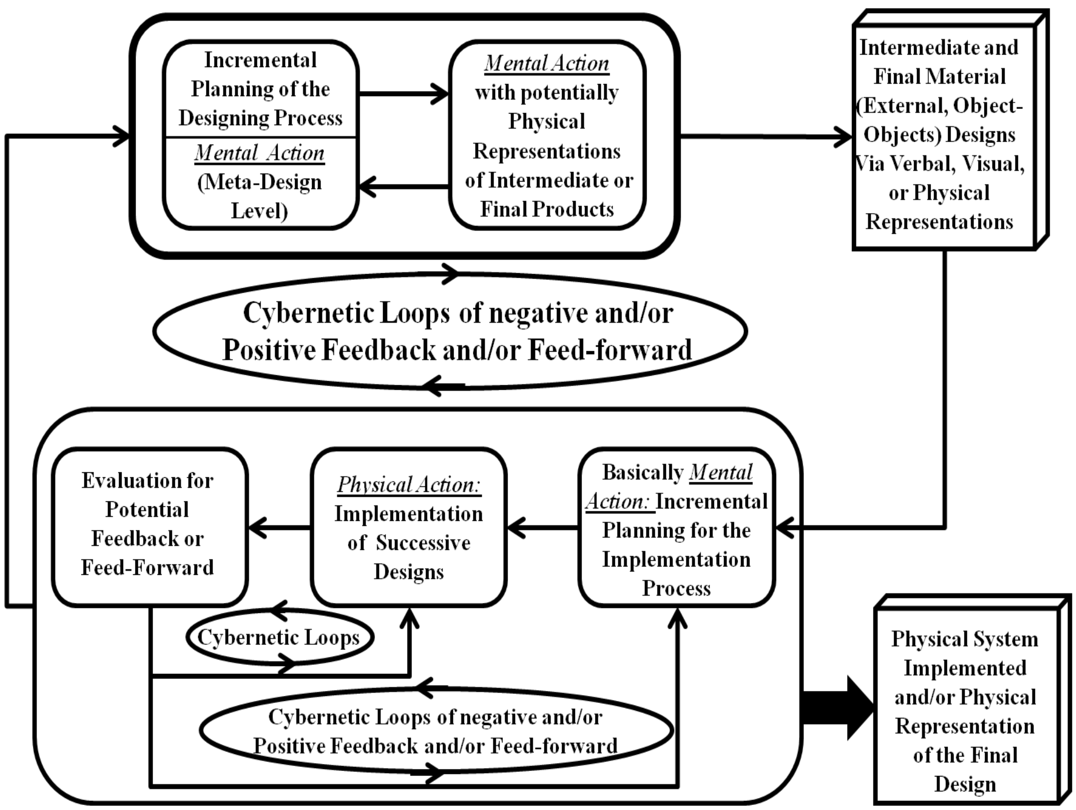

Figure 6: Action-Design and its potential main cybernetic loops. Parallelizing design and implementation is important, even necessary, in the design of complex systems or in finding solutions to complex problems especially in the context of uncertain and/or dynamic situations and environment. A design of a systemic methodology for describing a systemic notion of Science or in identifying a consensual meaning or conception of what should be Umpleby's Expansion of Science should combine processes of action-research, action-learning, and action-design. This processes are expected to be related via cybernetic loops in the context of an integrated meta-process of an incremental-evolutionary methodology in the context of an unending logarithmic spiral which continually would be approaching more consensual understanding.

References

Aune, B. (1967). Intention. In *The Encyclopedia of Philosophy* (Vol. 4, pp. 198-201). New York: Macmillan Pub. Co. and The Free Press.

Aune, B. (1967). Intention. In *The Encyclopedia of Philosophy* (Vol. 4, pp. 198-201). New York: Macmillan Pub. Co. and The Free Press.

Bratman, M. E. (1987). *Intention, Plans and Practical Reason.* Cambridge, Massachussetts, EUA: Harvard University Press.

Braybrooke, D., & Lindblom, C. E. (1970). *A Strategy of Decision.* New York: The Free Press.

Brentano, F. (1874/1935). *Psicología desde un punto de vista empírico (Psychlogie Vom Empirischen Standpunkt) II, 1 (Translated to Spanish by J. Gaos).* (J. Gaos, Trans.) Madrid, Spain: Revista de Occidente.

Buchanan, R. (1995). Wicked Problems in Design Thinking. In T. I. Design, & M. a. Buchanan (Ed.). Cambridge, Massachusetts, USA: The MIT Press.

Buchanan, R. (1995). Wicked Problems in Design Thinking. In T. I. Design, & M. a. Buchanan (Ed.). Cambridge, Massachusetts, USA: The MIT Press.

Buchanan, R. (1995). Wicked Problems in Design Thinking. In V. M. Buchanan (Ed.), *The Idea of Design* (pp. 3-20). Cambridge, Massachusetts, WUA: The MIT Press.

Callaos, N. (1976). *A Conceptual Development of Sociopolitical Information System.* Austin, Texas, USA: Non-published dissertation presented at the Faculty of the Graduate School of The university of Texas at Austin).

Callaos, N. (1992b). Designing an Latinamerican School for Statesmen and Executives. In L. P. Peeno (Ed.), *36th Annual Meeting of the ISSS; General Systems Approaches to Economics and Values; July 12-17, 1*, pp. 565-574. Denver, Colorado, USA.

Callaos, N. (1995). *Metodología Sistémica de Sistemas: Conceptos y Aplicaciones (Systemic Systems Methodology: Concepts and Applications.* Caracas, Venezuela: Universidad Simón Bolívar (Work presented for the academic rank of Titular Professor at Universidad Simón Bolivar)

Callaos, N. (2013a). *The Essence of Engineering and Meta-Engineering: A Work in Progress.*

Callaos, N., & Callaos, B. (2008). *Design, Intention, and Action.* Orlando: International Institute of Informatics and Cybernetics.

Callaos, N., & Callaos, B. (2011). *Toward a Systemic Notion of Information: Practical Consequences (Extended Version).* Academia.edu.

Churchman, C. W. (1971). *The Design of Enquiring Systems: Basic Concepts of Systems and Organization.* New York: Basic Books, Inc. Pub.

Ferrater-Mora, J. (1969). *Diccionario de Filosofía (Vol.1)* (Vol. 1). Buenos Aires: Editorial Sudamericana.

Frayling, C. (1993). Research in Art and Design. *Royal college of Art Research Papers , 1* (1), 1-5.

Frezza, S., & Nordquest, D. A. (2015, June). Engineering Insight: The Philosophy of Bernard Lonergan Applied to Engineering. (J. Heywood, Ed.) *Philosophical and Educational Perspectives on Engineering and Technological Literacy* , , 17-28.

Glaville, R. (1999). Re-searching Design and Designing Research. *Desing Issues , 13* (2), 80-91.

Harper, D. (n.d.). Retrieved 4 22, 2017, from Online Etymology Dictionary: http://www.etymonline.com/

Hursserl, E. (1900/2007). *Investigaciones Lógicas (Logische Untersuchungen) (Spanish Edition)* (Spanish ed.). (García-Morente, & G. J, Trans.) Alianza Editorial.

Kant, I. (1988). *Critique of Pure Reason Translated and edited.* (P. Gye, W. W. Wood, Eds., P. Gye, & W. W. Wood, Trans.) New York, New York, USA: Cambridge University Press.

Lonergan, B. J. (1992). *Insight: A study of human understanding.* University of Toronto Press.

Miller, G. (1956). The Magical Number Seven Plus or Minus Two. *Psychological Review , 63*.

Moles, A. A. (1989). The Comprehensive Guarantee: A New Consumer Value. In V. Margolin (Ed.), *Design Discourse: History, Theory, Criticism* (pp. 77-88). Chicago: The University of Chicago Press.

Nesteruk, A. V. (2013). A “Participatory Universe” of J. A. Wheeler as an Intentional Correlate of Embodied Subjects and an Example of Purposiveness in Physics. *Journal of Siberian Federal University. Humanities & Social Sciences , 6* (3), 415-437.

Peter, D. (2011). (A. a. Intentionality, Ed.) Brill Academic Publishers.

Pierce, C. S. (1931–36). *The Collected Papers* (Vols. 2, Par. 228). (C. Hartshorne, & P. Weiss, Eds.) Cambridge, MA, EUA: Harvar University Press.

Rastovic, M. (2013, 11). Kant's Understanding of the Imagination in Critique of Pure Reason. *E-LOGOS Electronic Journal for Philosophy, University of Economics Prague* , 1-13.

Simon, H. A. (1996). *The Sciences of the Artificial (Third Edition).* Massachusetts: The MIT Press.
Simon, H. A. (1996). *The Sciences of the Artificial (Third Edition).* Massachusetts: The MIT Press.
Spencer, H. (1855). *Principles of Psychology* .

Stappers, P. J. (2007). Doing Design as part of Doing Research. In R. Michel (Ed.), *Design Research Now: essays and Selected Projects.* Basel, Switzerland: Birkhäuser Verlag AG, Part of Springer Science.

The Century Co. (1889/1911). *The Century Dictionary and Cyclopedia* (Vol. 9). (D. W. Whitney, Ed.) New York: The Century Co.

Walter, J. E. (1915). *Subject and Object.* West Newton, PA.: Johnston and Penney.

Weekley, E. (1967). *An Etymological Dictionary of Modern English.* New York: Dover Publications, Inc.

Wheeler, J. A. (1977). Foundational problems in the special sciences . In R. E. Butt, & J. Hintikka (Ed.), *Proceedings of the Fifth International Congress of logic, Methodology, and Philosophy of Science, London, Ontario, Canada. 2.* Dodrecht-Holland/Boston-USA: D. Reidel Pub. Co.

Wheeler, J. A. (1975). The Nature of Scientific Discovery: A Symposium Commemorating the 500th Anniversary of the Birth of Nicolaus Copernicus. In O. Gingerich (Ed.). (pp. 261-96; 575-87). Washington, DC: Smithsonian international symposia series.