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When I examine myself and my methods of thought,
I come to the conclusion that the gift of fantasy has meant
more to me than any talent for abstract, positive thinking.

Albert Einstein, 1921, Nobel Prize in Physics

Chapter 2
Science, Art and Design: A Methodological Comparison

1 2.1 The Method of Scientific Inquiry

Scientific inquiry aims to establish objective truth regarding the world around us. Science is not only interested in a mere description of reality or in a quantifiable order of facts and data, but aims explicitly at understanding and explaining the phenomena that constitute our world. Science is constantly in search of the underlying principles and the connection between different sets of phenomena in order to be able to predict and control future behavior and effects. The scientific method tries to structure those findings into logically coherent and universal systems, called scientific theories. In the Classical tradition, this method is grounded in empiricism and the Cartesian principle of universal doubt. It has led to the well-known empirical cycle based upon five stages enumerated by Adriaan De Groot in *Methodologie* (1972)[23]:

- Observation, where empirical facts are gathered and organized;
- Induction, where hypotheses are formulated;
- Deduction, where special consequences from these hypotheses are deduced in the form of testable predictions;
- Testing, where the predictions are verified to be true or false;
- Evaluation, where the results of the tests confirm or refute the hypotheses.

The distinction between observational recordings and the formulation of a hypothesis is in many cases unclear — and often difficult to maintain. The scientist usually has already formed a certain point of view regarding the problem under investigation. Thus, empirical data is collected according to

23 De Groot, A.D., 1972, *Methodologie*, Mouton & Co, The Hague, The Netherlands.

criteria derived from that viewpoint. Therefore it is inevitable that during the observation stage hypotheses have already been introduced, however implicitly.

According to Karl Popper's *The Logic of Scientific Discovery* (1959)[24], pure facts are never available. All observation is theory-laden and is a function of both purely subjective factors, such as interests, expectations, wishes, and values and of what is objectively real. This assessment seriously questions the traditional empirical method: how to distinguish between facts and assumptions, between facts and ideas, and determine the point at which an assumption becomes a testable hypothesis. The scientist can work inductively or deductively. He can either try to systematically gather relevant data in order to formulate testable predictions, or he can try to formulate a hypothetical theory, which he can then try to verify by observational findings. The history of science gives examples of each: the systematic measurements by Newton, using Kepler's and Tycho Brahe's observations; the systematic descriptions and classifications by Darwin, leading to the Theory of Evolution; and the Theory of Relativity put forward by Einstein as a consistent theoretical system, explaining certain phenomena, which only later was validated by experiments and observations.

Einstein's approach starts from a problem to be solved rather than a series of observations, which require explanation.

In Popper's terms, this means that the scientist makes selective observations to test the extent to which a given theory can function as a satisfactory answer to an occurring problem. In that sense, Popper rejects the inductive method as the characteristic method of scientific inquiry. This leads to his Theory of Falsification: a theory is scientific if and only if it is refutable by a conceivable event. Every genuine test of a scientific theory is an attempt to refute or to falsify that theory, and one genuine contra-fact falsifies the whole theory, as Popper states in *Conjectures and Refutations: The Growth of Scientific Knowledge* (1963)[25]. This is based on the paradox that stems from the relationship between verification and falsification: while it is logically impossible to conclusively verify a universal proposition by mere reference to experience, one single contra-fact weakens the corresponding universal theory to the level of rejection and completely discredits it. In other words, the exception does not prove the rule; it refutes it. In those terms "all knowledge is provisional, conjectural and hypothetical." We can never *prove* our scientific theories, we can only confirm or refute them. Confronted with this dilemma, we can only eliminate those theories that are obviously false and accept the theories that remain unfalsified. This stresses the importance of critical thinking to science. It is only by thinking critically that we can eliminate false theories and trust that the best of those remaining have the highest explanatory capacity and predictive power.

24 Popper, K.R., 1959, *The Logic of Scientific Discovery*, Hutchinson, London.

25 Popper, K.R., 1963, *Conjectures and Refutations: The Growth of Scientific Knowledge*. Routledge, London.

Popper's theory on scientific inquiry is associated with the positivist approach to science and is still based on the pre-assumption that critical testing is possible at all — that there exist critical tests, which can either falsify a hypothesis or give it a strong measure of corroboration, given that the hypothesis is true until falsified by new facts. In that sense, science can be seen as an ongoing process, where definite results are never obtained, but our knowledge about the world nonetheless increases permanently through a constant process of conjectures, refutations, and verifications. Important here is the fact that the testing should be repeatable and universal, in other words, context-independent. It is only under those circumstances that a well-defined hypothesis can acquire the status of scientific theory. The engine of this process is the scientist: through his research, he seeks to constantly turn theories into more robust and consistent explanatory models of reality.

1 2.2 The Method of Artistic Inquiry

Where science aims at finding the truth, art is said to aim for beauty. In that sense, it is considered neither measurable nor able to be described in objective terms, but instead is tasked with generating an aesthetic experience. It should appeal to the different human senses, stimulate them while engaging them in a mind-expanding dialogue.

The definitions of art in the specialized literature are numerous and often contradictory. But rather than trying to define art as a concept, it seems more relevant to try to answer the question of what art brings to the world, what is its meaning, and what is its purpose. At first glance, art seems to be contraindicative of one of the basic laws of nature: the desire for survival. Art seems to be in essence indifferent to the primary functional needs of the human being, and from that perspective it could even be characterized as afunctional. Nonetheless, examples of artistic expression have been found dating from the emergence of man, the wall paintings in the caves of Lascaux in the south of France dating back between 15,000 and 20,000 B.C. being good examples. They demonstrate a most significant aspect of human behavior, the need to express perception of the surrounding world and to communicate it with others. It distinguishes man from other species.

The translation of experiences through communication media is an essential feature of art. Each art form uses the appropriate language of expression: drawing, painting, and sculpture in the fine arts; dance, music, and acting in the performing arts; and photography, cinematography, television, and animation in the visual arts. This dialogue between perception, self-expression, and communication is the essential cornerstone of artistic inquiry.

Unlike the scientist, the artist does not try to answer the question of how the world is the way it is, but rather reflects upon reality and, through that reflection, questions it. Art does not provide answers; it poses questions. It holds up a mirror and solicits reaction.

In *The Philosophy of No: A Philosophy of the New Scientific Mind* (1968)[26], Gaston Bachelard describes the development of scientific thinking as the progression of scientific thought from animism through realism, positivism, rationalism, and complex rationalism to dialectic rationalism. This is, in his view, the closed orbit of scientific thought: “The philosophical evolution of a special piece of scientific knowledge is a movement through all these doctrines in the order indicated”. Juhani Pallasmaa, in his “The Space of Time – Mental Time in Architecture” (2007)[27], rightly points out that artistic thinking aspires to develop in the opposite direction: “An artistic image works its way from the realist, rational, and analytical understanding back towards a mythical and animistic grasp of the world.” Therefore, Pallasmaa concludes, science and art move past each other in opposite directions along the same continuum:

> Whereas scientific thought progresses and differentiates, artistic thought seeks to return to a de-differentiated and experientially encompassing understanding of the world. Artistic imagination seeks expressions that are capable of mediating the entire complexity of human existential experience through singular images.

Artistic inquiry deals with immeasurable parameters and intuitively-made decisions and by its own nature cannot be subject to verification or falsification. This is not because art does not produce hypotheses about the world. In fact, each work of art is a hypothesis *per se*, but because these hypotheses can never be true or false, right or wrong, they have to keep their status of hypothesis forever. This is the true meaning and only purpose of art. The artist makes a statement, takes a position, and by doing so puts it to the individual appreciation of the other. The work of art is the message conveyed to the spectator by a chosen medium. The receiver can accept or reject that message, go into a dialogue, or neglect it, but can never refute it on the basis of its being not true. Artistic hypotheses *per se* can never be true or false, right or wrong, as they are not guesses as to how the world works, but instead suggestions from the artist to the viewer of how the world might be perceived. In that sense the terms “right” or “wrong” are meaningless.

By definition, the method of artistic inquiry transcends boundaries between disciplines. It sees the world as a whole of interrelated facts, ideas,

26 Bachelard, G., 1968, *The Philosophy of No: A Philosophy of the New Scientific Mind*, Orion Press, New York.

27 Pallasmaa, J., 2007, “The Space of Time – Mental Time in Architecture” in *The Antwerp Design Sciences Cahiers*, Nr. 17, Henry Van de Velde College of Design Sciences, Antwerp.

and processes. The real artist juxtaposes these facts and ideas, interprets them and confronts them with his personal values and beliefs in an act of enlightened and liberating insight. In that sense, art belongs to the metaphysical, trying to produce "clarity" about the world by questioning reality and answering those questions with a synergetic hypothesis.

This metaphysical dimension of art may explain why true art is also visionary. In *Art & Physics* (1991)[28], Leonard Shlain argued extensively that although the artist usually may not be well versed in scientific knowledge, images, metaphors, symbols and icons used in art have been found to presage thought patterns of a future scientific age not yet born. Shlain quoted the art critic Robert Hughes: "The truly significant work of art is the one that prepares the future. The essence of the avant-garde myth is that the artist is a precursor". In the same sense, Marshall McLuhan in *Understanding Media, The Extensions of Man* (1967)[29], defined art as "advanced knowledge," indicating its function of preparing the future.

The fine arts — especially the development of painting in Western culture — provide ample evidence for this statement (but equally interesting examples can be found in music, literature, drama, and dance).

Hieronymus Bosch painted a chaotic and pessimistic world, where all belief in human rationality had vanished. He was reacting against a world constantly at war, where the Medieval value system was disrupted and subject to an emerging humanism, but at the same time he demonstrated a deep insight into the human character. With a new kind of symbolism and the introduction of abstract concepts derived from a vocabulary of dreams and nightmares, he not only paved the way for the Surrealist movement in the 20th century, but also can be seen as a forerunner of psychoanalysis and Freud's theory of the subconscious.

Jan Vermeer and Rembrandt, the unsurpassed masters of light and shadow — the chiaroscuro, influenced by the work and technique of Caravaggio — brought painting almost as close to 20th century photographic techniques as possible, where the shadow of one color darkens another, and light and shadow demonstrate the personality of the portrayed character.

In the late 18th and early 19th centuries, Turner, arguably one of the England's most creative painters, spent his life searching for a way to transmit light on a piece of canvas. By doing so, he broke ground for the Pointillist movement, a style of painting in which small distinct points of primary colors create the illusion of a wide range of secondary colors. The technique relies on the ability of the human eye and mind to mix and combine the primary color dots into an almost infinite range of secondary

28 Shlain, L., 1991, *Art & Physics*, Harper Perennial, New York.

29 McLuhan, M., 1967, *Understanding Media*, Sphere Books Ltd., London; also 1994, *Understanding Media, The Extensions of Man*, MIT Press, Cambridge, Massachusetts.

colors. Seurat and Signac, both living in the second half of the 19th century and the main protagonists of this technique, were in fact the forerunners of a technology nowadays commonly used in color television technology, in CRT and LCD screen technology and in inkjet-printers.

At the beginning of the 20th century, Braque and Picasso, the founders of the Cubist movement, started to conceptually break down their objects, analyzing them by identifying the constituent elements and reassembling them in an abstract way. At the same time they were experimenting with recombining different sections and viewpoints of an object, producing not only an original and strange image, but also a new insight into reality. The same idea is behind today's 3-D scanning technology.

As a result, we can argue that the value of artistic inquiry is defined by the extent that it not only comments on the past and present, but that it predicts a possible future.

It re-establishes the dichotomy between art and science and the role creativity plays in both.

1 2.3 Creative Thinking

Despite the fact that the scientific method tries to be rigorous and exact, the criteria for what is a true fact are not always clear or evident, and the criteria for beauty are even more indistinct. The borderlines between art and science are in fact less well-defined than the contemporary scientist may be comfortable with. So the mathematician speaks about an "elegant" solution, the surgeon about an "aesthetic" operation, the theatre critic about "two-dimensional" characters, the computer artist about bits, pixels, gray-scales. Music, in fact, is the transformation of a mathematical equation into an aesthetic experience.

In fact, as Arthur Koestler argued in *The Act of Creation* (1964)[30], there is a continuous gradient between science and art: from objective to subjective, from verifiable truth to aesthetic experience. This continuum leads from the hard sciences through medicine to the social sciences, from engineering through architecture and design to the performing and fine arts. The Renaissance recognized no boundary between art and science; they could only be conceived as one big continuum. The separation of science and art is a historically recent phenomenon, as we have argued above. This has led to the relegation of intuition and creativity to the arts, rational thinking and discovery to the sciences. It has led to the perceived

30 Koestler, A., 1964, *The Act of Creation*, Hutchinson, London.

incompatibility between function and form, utility and experience, necessity and luxury.

The positivist approach to scientific thinking in relation to innovation and new discoveries has in the end confined creative thinking to the service of perfect decision-making on rational grounds, strictly following the rules and paradigms of scientific inquiry. But new discoveries in quantum physics and the construction of "virtual environments" in information technology have called this dualistic thinking into doubt.

In *The Hidden Order of Art* (1970)[31], Anton Ehrenzweig rightly pointed out that in creative work there are no limiting rules. Creative work creates its own rules, which may only be known after the work is finished. This means that creative thinking always involves parameters unknown to the thinker; nonetheless he must be able to handle these parameters in order to achieve some precise outcome. Action painting, where, as the term indicates, the artist wishes to act rather than think about the underlying meaning of his painting, is a good example of this. At first glance, this seems to be a completely random process where, apart from the characteristics of the paint and the canvas involved, all parameters are unknown, and there are indeed no limiting rules. However, there are in fact moments of reflection throughout, as revealed by Jackson Pollock, commenting on his own method of working: namely, that after every series of actions he took, he stopped to reflect on these actions, which in turn led to new actions. The Constructivist movement, although at the other end of the modern art spectrum, uses in its turn unusual rules of geometry and calculus. Here too the artist submits himself to a partly unknown world of interrelated parameters, which seems to have no relation with the reality he wants to produce and the form he wants to give to it. Only in and during the progression of his work is the hidden structure revealed as a whole.

Edward De Bono, among others, noted in *Lateral Thinking: Creativity Step by Step* (1970)[32], that a creative process is directly related to the mechanisms of the thinking brain. He introduced the term "lateral thinking": activity concerned with the choice of the most appropriate steps out of a multitude of possibilities. The search is not for a definite solution, but for a policy of behavior that is more effective than others. In their *Creative Synthesis in Design* (1964)[33], John Alger and Carl Hays defined creativity as the ability to choose the right series of actions from a number of alternatives, which cannot be evaluated beforehand but are original and effective.

These observations lead us to a first conclusion: a creative process is not based on intuition alone, but can only exist when intuitive action is supported and complemented by reflective thinking. I will call this "the creative moment" — the moment where the walls between rational and intuitive thinking disappear and give way to new insight. Through this

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Ehrenzweig, A., 1970, *The Hidden Order of Art*, Paladin, London.

32
De Bono, E., 1970, *Lateral Thinking: Creativity Step by Step*, Harper & Row, London.

33
Alger, J. and Hays C., 1964, *Creative Synthesis in Design*, Prentice Hall, New York.

process, new discoveries are made and novelty is created, in both art and in science. Gutenberg invented the printing press by intuitively combining his rational observations of the signet ring, the process of coin minting, and the winepress. In the same way, Keppler combined astronomy and physics.

In all these processes, intelligence and creativity complement each other: the first by stating the problem on an abstract level, the latter by collecting evidence from personal experience and applying it to the first. During the creative process, there is a constant confrontation between the abstract and the concrete, between the known and the unknown, between the familiar and the alien. During the creative process, the left side of the brain (primarily tasked with aspects of problem-solving) works together with the right side of the brain (considered the locus of innovation, discovery, and art), hence aspects of problem solving are more related to the left side and innovation, discovery and art more to the right part. The process is aimed at *finding* and is therefore a cornerstone of heuristics.

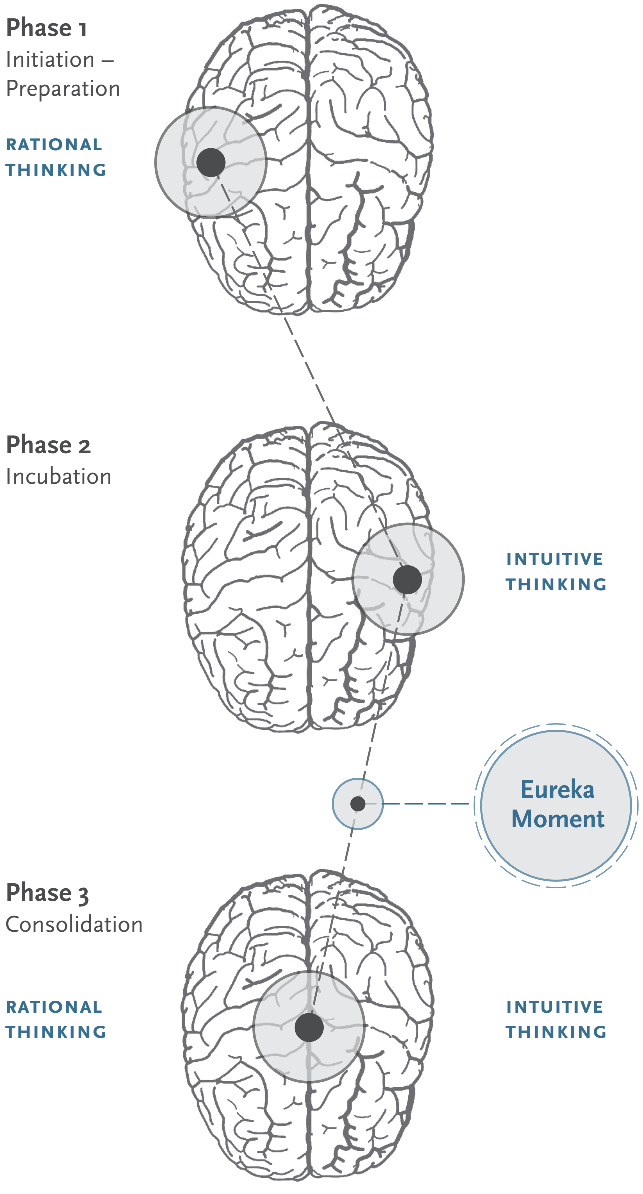
Crucial in that process is the discovery of the secret analogy or the connecting switch, which bridges the gap between the two parts, creating a new neurological pattern. I will call these new patterns mind-networks, systems of neurological interconnections, which emerge suddenly without any rational evidence or explanation, but which are able to produce novelty in one or another form, from scientific breakthroughs to innovative technological applications, from a virtuoso performance to the creation of a revolutionary work of art. The process of incubation, which keeps the problem under investigation permanently on the subconscious agenda even when the mind is occupied by totally other ones, seems crucial for building these mind-networks. Within this context, intuition can be seen as a thinking activity, which happens at a relatively low level of explicitly conscious reasoning, where rational thinking would refer to the other extreme of the scale. They are two aspects of the same creative process, the two poles between which that process can evolve. A creative person, according to Donald McKinnon, in "Creativity, a Multi-faceted Phenomenon", (1970)[34], is the one who reconciles in his intellectual endeavors the opposites of expert knowledge and the childlike wonder of naïve and fresh perception.

34 McKinnon, D.W., 1970, "Creativity, a Multi-faceted Phenomenon", in *Creativity, a Discussion at the Nobel Conference*, (Ed. Roslansky), Stockholm-Amsterdam.

Fig. 1.2.1 illustrates how the creative process proceeds between these dual polarities. Three phases can be distinguished, and each is characterized by its typical fluctuation on the rational-intuitive scale.

> Phase 1: Initiation and Preparation. The aim is to familiarize oneself with the problem under investigation. It is thoroughly studied, and serious and systematic work is done on searching for a solution, supposing it will be easily found; but not much

The Creative Process in Time



> progress is made. Thinking here takes place on a strong and increasing rational level. The left side of the brain is fully activated.
>
> Phase 2: Incubation. The problem is off the conscious agenda. The right side of the brain takes over and thinking becomes strongly intuitive; creative mind-networks are being constructed. The end of this phase is characterized by a moment of recognition of the solution: with reference to Aristotle in his bathtub, we will call it the "Eureka point".
>
> Phase 3: Consolidation. The solution is elaborated, verified, tested and applied. Right and left sides of the brain work together along an established mind-network. During this phase equilibrium is reached on the rational-intuitive scale, and the mind completes the creative process.

35 Florida, R., 2002, *The Rise of the Creative Class*, Basic Books, Cambridge, Massachusetts.

Most scholars in the field agree that a creative mind works in a multidimensional and experiential way. A wide spread of experiences and the ability to look at situations from diverse perspectives is recognized as the trigger for creative solutions. Richard Florida points out in *The Rise of the Creative Class* (2002)[35], that "the varied forms of creativity that we typically see as different from one another — technical creativity (or invention), economic creativity (or entrepreneurship) and artistic and cultural creativity, among others — are in fact deeply interrelated". This is clearly not coincidental, and history proves that periods of technological innovation go hand in hand with breakthroughs in art and a rich cultural life, embedded within a prosperous and stable political climate. Moreover scholars, scientists, and artists seem to be attracted to certain centers of creativity: Rome in antiquity, Bruges in the Middle Ages, Florence during the Renaissance, Antwerp in the 16th century, Amsterdam in the 17th, Paris in the 18th, Vienna in the 19th century, the U.S. during the second half of the 20th century, along with new centers in Asia, the Middle East, and South America emerging today. More than ever in recent history, we see that architecture and design, recognized as the creative professions *par excellence*, are shaping everyday life. They are no longer exclusive to the wealthy class but recognized by the man in the street as important and enriching, and thus have gained economic value and status. This development points to a major shift in human evolution, comparable to the transition from a nomadic culture to a sedentary one, from an agricultural and craft society to an industrial one, and from the Industrial to the Information Age. Florida calls it the rise of the creative class in his book of the same name: the emergence of the creative economy, where knowledge and information are the tools and materials of creativity.

1 2.4

The Method of Design Inquiry

More than ever before, we live in a man-made world, at a point in history where that man-made world challenges the natural world and comes into conflict with it. This puts great responsibility on mankind. Although science's primary mission is to investigate the hidden mechanisms of the natural world, trying to understand their workings and behavior, at the same time it aims to control nature to improve the prospects of mankind's survival. Here technology comes in, or what are commonly referred to as the applied or engineering sciences. Applied scientific research starts where the fundamental scientific inquiry ends. Using an established scientific theory, possible applications are developed. These are the engines of technological innovation through which the man-made world emerges. Starting from a technological hypothesis, based on a scientific theory, prototypes are developed and tested — not in the sense of true or false but on the level of rational applicability. Does it work? Can it be used and in which way? What are the effects? Can it be made or produced and at what cost? Are there ethical concerns? These are the kinds of questions underlying applied sciences. Engineers call it the verification process. If the answers prove positive, the technological hypothesis may be realized and becomes part of the man-made world. At first glance, there seems to be a great analogy between applied research and the research activity within a design context, but a closer look uncovers some fundamental differences.

Design thinking is *per se* innovative, heuristic, and experimental, driven by empathy and focused on problem-solving. It essentially deals with problems with multiple stakeholders and fuzzy boundaries, and where the solution is found between disciplines. Therefore designers should bring to the table a broad, multi-disciplinary spectrum of ideas from which to draw inspiration.

Definitions of design are numerous, varied, many-sided, and divergent. But they all agree that designing has to do with a course of actions and decision-making that aims to solve an acknowledged problem. From a methodological standpoint, I will use the definition put forward by Herbert Simon in *The Sciences of the Artificial*, (1996)[36], where he defined design as every course of action aimed at changing existing situations into preferred ones and conceiving artifacts to enable such changes. Therefore, Simon argued, every designer should ask: "Which of the worlds that can be designed is the best one?" This seemingly empirical question, governed by the laws of scientific inquiry, raises fundamental issues related to the underlying

36 Simon, H., 1996, *The Sciences of the Artificial*, 3rd Ed., MIT Press, Cambridge, Massachusetts.

societal value system in which the designer operates, along with his own ethical beliefs. It also points to methodological differences: if the essence of designing is the search itself for a "best" solution, it obeys not only the laws of scientific inquiry but also the logic of heuristic thinking.

As we have seen, scientific research is based on the testing of a hypothesis put forward in the form of an explanatory model. In art, testing a so-called hypothesis is senseless, as argued above. The essence of the design inquiry, on the other hand, aims to develop in parallel as many hypotheses as possible, not on the basis of exploratory models but of exploring ones, models with probing capacity. Testing seeks to identify the most desirable result. It is at the same time an optimizing, judging, and subjective activity. In scientific inquiry, testing is based on verification. The results should be objective, repeatable, and universal. In design inquiry, testing is based on both verification and appreciation. It is subjective, essentially contextual, and therefore not repeatable.

It is essential in the process of design inquiry that the hidden theoretical and ideological framework of assumptions and premises, on which decisions are based, is made explicit. This is not to say that it should be a general metaphysical analysis, but it should make transparent how the specific design beliefs are determining the normative knowledge about the physical world and how this physical world should be organized. As a process, it refers to the process of pragmatic thinking put forward by John Dewey in his *Democracy and Education* (1923)[37], and later by Hilary Putnam in his *Pragmatism: an Open Question* (1995)[38]. Pragmatic thinking reflects a unity of the process of learning and experience, of conceptual thought and situational consciousness. It is based on a backward and forward connection between what we do to things and what we enjoy or suffer in consequence. Under such conditions, doing becomes trying: a kind of experiment to find out what the world is like and what it should be. It is per se heuristic, as the purpose is to discover at the same time the existing connection between things and the possibilities of connection.

Such an approach involves the use of argumentative and rhetorical means as a necessary precondition, analogous to global governance, as maintained by René Foqué in "Global Governance and the Rule of Law" (1998)[39]. Within this context, rhetoric and argumentation are not to be seen as mere skills or techniques of persuasion but as necessary components of a pragmatic approach to looking for the best design solution. Testing design hypotheses is therefore inextricably bound up with the ethical normative framework of society and with its epistemological principles. As a consequence, design

37 Dewey, J., 1923, *Democracy and Education*, The Macmillan Company, New York.

38 Putnam, H., 1995, *Pragmatism: an Open Question*, Blackwell Publishers, Oxford, England, and Cambridge, Massachusetts.

39 Foqué, R.G.M.E., 1998, "Global Governance and the Rule of Law" in *International Law, Theory and Practice*, (Ed. K. Wellens), Kluwer Law International, Amsterdam.

relies on the methodologies of both science and art. Understanding how they interact within a design process is crucial for understanding its role in solving socio-economic problems and issues in an innovative way.

Moreover, as I have argued in "On the True Meaning of Research by Design" (2001)[40], an instance of testing is necessarily conducted within a strongly determined context, consisting of physical and non-physical elements: non-physical due to the formal, legal, and historical elements surrounding the test and physical because every design inquiry is related to the constraints and characteristics of a physical environment, be they real, virtual, or imaginary. For the test to be replicable, all of these elements must be held constant. The temporal nature and the uniqueness of the test itself make this impossible. Moreover, putting the design hypothesis to the test in itself changes the context. Therefore the test will never be repeatable. A striking analogy can be found in developments within quantum physics, where the results of a scientific experiment directly depend on the way the experiment is designed and the research methods that are used.

In his revolutionary work on chaos theory Ilya Prigogine (1985)[41], introduced the concept of coincidence. His chaos theory assumes that dissipative systems — systems that remain in a high state of unbalance as energy is constantly added — will themselves structure this condition of chaos. According to Prigogine, this process aimed at reaching a certain level of organization is entirely based on coincidence and is irreversible. As we will argue in the next chapter, design can be defined as an attempt to structure the environment, following the law of dissipative systems. In this sense, design inquiry consists of determining which elements constitute the design context and which structural patterns determine its cohesion. Therefore it will always fluctuate between the analysis of objectively perceptible facts and the weighing of subjective value judgments.

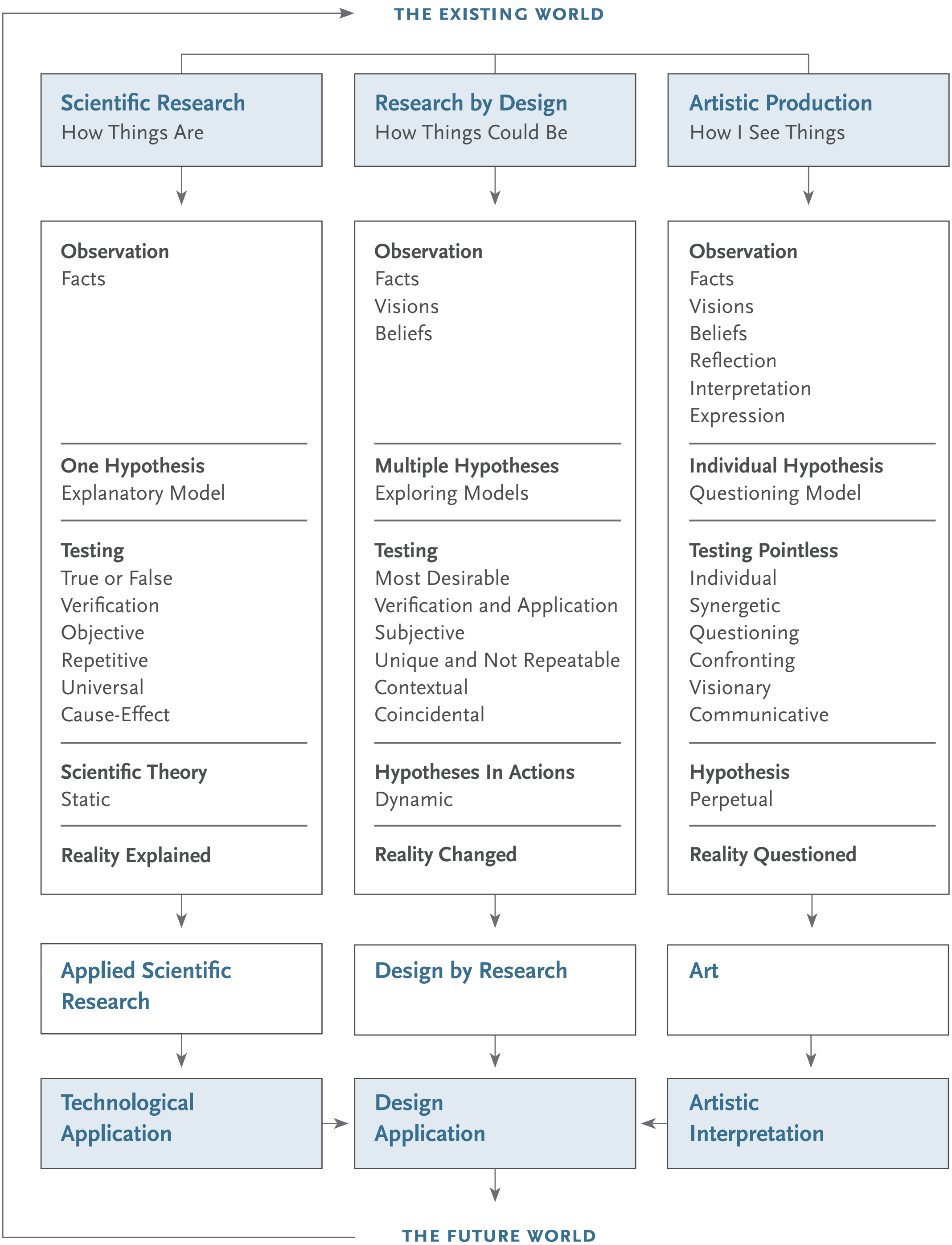
This is where the notion of creativity comes in. The analysis of creative processes makes it clear that they occur in the zone between unconscious intuition and rational thinking, allowing the designer to propose original solutions to a given problem.

40 Foqué, R.K.V., 2001a, "On the True Meaning of Research by Design" in *Proceedings of the International Conference on Research by Design*, Delft University Press, Delft, The Netherlands.

41 Prigogine, I. and Stengers, I. 1985. *Orde uit Chaos*, Bert Bakker, Amsterdam.

1.2.2

Scientific Research, Research by Design, and Artistic Production Compared and Applied



1 2.5 Research by Design

The creation of novelty and, combined with it, the ordering of the environment in Prigoginian terms are the keys to understanding the process of design inquiry and the grounding for what I will call "research by design," opposed as it is to traditional scientific research, which is mainly based on empiricism, analysis, and deduction.

Therefore, research by design constitutes a heuristic activity *par excellence*. Heuristics deals precisely with the discovery of something new by means of a methodological system. The heuristic method is based on hypotheses in action. This means that a design hypothesis can be adapted, converted, adjusted, and replaced during the testing without being deemed true or false. This is the reason why several hypotheses can exist next to each other at the same time.

While scientific inquiry tries to answer the question how things are, design inquiry tries to answer the question how things could be. Both challenge the physical world. Art, on the contrary, transforms reality by giving it new meaning, raising the physical to the metaphysical.

A close comparison between pure scientific research, research by design, and the method of artistic inquiry, what we will analogously call "research by art," shows that the concepts of contextuality, coincidence, and pragmatic thinking are essential in a world that does not merely exist, but is at the same time in a continuous process of being created. In this process, research by design is an essential cornerstone, as it conceives possible realities, investigates their desirability, changes the existing reality by implementing a new one, and evaluates the resultant reality. This implies that the design activity is equally subject to the method of artistic inquiry. Design indeed relies on the methods of both science and art, and from there derives its own methodology.

While science tries to explain the world, art questions reality and tries to answer the very personal question, "How do I see and perceive that world?" Art-based research is based on observation, vision, values, beliefs, reflection, interpretation, experience, and expression, all at the same time. It leads to an individual hypothesis about the world, based on a questioning model and impervious to testing. It is a "forever" hypothesis — questioning, synergetic, confronting, visionary, and communicative.

Research by design tries to explore and change the world, and by doing so, tries to gain knowledge about how man analyzes and explores the world and brings it into culture: how we create a man-made world. It does so by creating design applications, relying on technological knowledge and artistic interpretation (Fig. 1.2.2).

1 2.6

A New University Model

The above analysis gives rise to rethinking the classical university model.

In *Understanding Media*[42], McLuhan wrote that Gutenberg had been the father of all assembly lines, meaning that at the moment the printing press was invented, the Industrial Revolution emerged. From that moment, mass products began to conquer the world, leading to a centralized and globalized world. Repetition, homogeneity and the succession of cause and effect have since become the keys to understand a world that is essentially mechanistic, as we have outlined above.

42 McLuhan, M., 1967, *Understanding Media*, Sphere Books Ltd., London; also 1994, *Understanding Media, The Extensions of Man*, MIT Press, Cambridge, Massachusetts.

Our current educational models are indebted to that world and deeply rooted in it. That mechanistic world has led to specialization and standardization, with increasingly competitive behavior as a consequence. As a matter of fact, competition is still the driving and motivating force in education. Evaluation and grading systems, the admissions process to higher education, and the awarding of grants, for example, are based on it.

As in the old mechanical production methods, where materials were pressed in designed molds, students are considered as objects that can be molded and trained in preconceived educational programs. In the traditional sense, education and training mean unilateral information transfer. It is evident that this model is no longer tenable in a world based on information technology and creative thinking. Division, specialization, and uniformity will be replaced by totality, diversity, and extreme engagement. A society and an environment are being created that become information itself. This means that emphasis will no longer be on training, but on discovering. The teacher of the future will be less occupied with information transfer and more on creating the best possible study environments. Therefore, the responsibility for the effectiveness of education will shift from the students to the faculty.

Information technology will bring about a new type of student: the "shopping student", who is constantly seeking individualized packages of information in a global university supermarket. Packages will be tailored to the aims and goals set by the individual student to benefit a professional future and possible career. Ultimately, this may lead to the disappearance of the traditional diplomas, degrees, and educational structures in general. Students will move freely throughout the educational landscape. Motivation will come from the learning experience itself, and the classical boundaries between subjects and disciplines may become nonexistent. Education, training, and work will become elements of the same process.

As a result, the role of universities will change drastically. Gradually, they will become research centers, instead of educational institutions, and university students will become research assistants. As a result, the gap between professional education and academic education will become not only wider but also fundamentally different. The former will reproduce the knowledge that the latter will be producing: universities as actors of innovation and discovery, engines of change.

Change will become the steady state of society, instant and global. Basic concepts of right or wrong, real or fiction, true or false, will lose their meaning. Society, on its way to lose its own history as the collective memory, will be permanently rewritten in an almost perverse manner. We are touching the paradox of a world based on global information technology. Uniformity and integration of macro systems on a meta-level will lead toward what McLuhan called "tribalization of the culture; discontinuous kaleidoscopic, parallel and instant." The film *oeuvre* of David Lynch is an example of this. There is no story line: he is creating worlds of simultaneous happenings, of everything at the same time in parallel universes: worlds ruled by chance, without any logical relations between events, worlds in a permanent state of coming into being.

This analysis confronts us with one of the major challenges for coming generations: to build an intellectual culture based on reevaluating the existence of a consistent ethical value system. Investing in intellectual capital will be absolutely necessary to provide the coming decades with a sustainable and affluent community.

To date, the focus has been placed on science and technology as the primary agents for change. We have seen that we are moving toward a new creativity-based socio-economic model. Such a model can only be put into practice when it values critical thinking. Emphasis should be placed on the development of creative and design industries. Design in the next decade will move beyond the product, beyond the workflow; it will deal with total processes, entire environments, and global experiences, creating added value and synergy.

In such a context, architects and designers can play an important role, as they are trained to analyze and understand the present and, from there, formulate possible futures.