

Article

Concerning the Epistemology of Design: The Role of the Eco-Cognitive Model of Abduction in Pragmatism

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Abstract: Design has usually been linked to art and applied in scenarios related to everyday life. Even when design has, on occasion, made its way into the world of academia, it has always been closely linked to art and scenarios related everyday life. At last, however, the idea of design has reached the field of epistemology: an area within the very heart of philosophy that has always focused, in theory, on the foundations of knowledge. Consequently, design is being studied from different approaches interested in the foundation of knowledge, theoretical and practical. This is one of the reasons why abduction and pragmatism have been considered relevant from a design perspective. This paper first shows the main features of abduction and pragmatism, describes their evolution and considers their mutual implications. Second, the epistemology of design is analysed considering its most relevant characteristics. Third, the connection between abduction and, on the one hand, pragmatism and, on the other, design epistemology is addressed. Finally, the role of abductive inference in grounding a real epistemology for design theory from the naturalised cognitive perspective of abduction is outlined. The central proposition is that this approach is essential as a methodological innovation, as it allows us to analyse both the inquiry process and the design process as interdependent when dealing with practical problems of a social and cultural nature. This approach allows us to analyse how human actions determine changes in the theoretical framework from which we make our inquiry. In short, the world is an open-ended project that humans design through our daily inquiry.



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1. Introduction

It is no straightforward matter determining exactly when the turning point occurred that led to the rise of the question of design for knowledge and scientific inquiry, but there is a range of factors that has culminated in the concept of design being introduced into many different fields of knowledge. On the one hand, there are the practical issues that science has faced since the industrial revolution, the expansion of products reaching broad layers of the population, the phenomenon of mass production, etc.; and on the other, the shift from a priori ideas of epistemology to a naturalised epistemology, in the sense that the empirical results of science cannot be ignored when we come to configure its own methodological models. Moreover, the philosophy of science has expanded its analysis beyond pure science, and this has meant that it has become necessary to reconsider the epistemology of applied science. There are many ways in which the idea of design has penetrated the different spheres of knowledge, eventually offering a new way of understanding the problematic relationship between theory and praxis. The rise of pragmatist theories and their theoretical tools, such as abduction, is an example of this new turn in the different disciplines of the philosophy of science and cognitive science. Alvin Goldman is a referent of this perspective in the field of epistemology [1]. Similarly, Ronald N. Giere is a reference in the field of

philosophy of science. Both authors form part of the cognitive turn in epistemology and philosophy of science [2].

The consequences of this turn go beyond a mere methodological question, since theoretical elements have been involved that have enriched and, therefore, modified the theoretical framework from which these disciplines started. Modification of the theoretical framework occurs when new elements are introduced into the models of reality to which the different methodologies are applied. When introducing a new element into the theoretical framework on which the discipline is based, it can modify the perspective on reality and lead to changes in the methodologies used to represent it. A case in point is that of the planet Neptune, which was suggested by Urbain Le Verrier's theoretical consideration of its existence before its discovery [3] (p. 124–1n), [4].

Our aim in this work is to analyse how far theories such as pragmatism offer a new conceptual framework from which to revitalise questions that historically had been neglected by the more scientific branches of philosophy. Therefore, when this article propounds abductive reasoning as a logical and cognitive mechanism with which to constitute the basis of what we can consider as "design epistemology", we are also offering a new theoretical horizon that invites us to consider the present case from a new perspective that allows for a review of epistemic development throughout history. This work proposes an epistemology that assumes that the actions of human beings are determinant in the realisation or unfolding of reality. In this sense, design is presented as a cognitive resource with which to modify the environment for different purposes by reviewing past and projecting future solutions.

This objective requires two factors to be properly articulated: one is a detailed characterisation of abductive inference and pragmatism, while the other involves framing design epistemology as a methodological innovation stemming from classical epistemology. The hypothesis that we support is that abduction and pragmatism together with design epistemology constitute a specific line of thought within the framework of the programme for the naturalisation of philosophy.¹

So, first of all, we are going to set out the principal characteristics of abduction and pragmatism, describe their evolution, consider their mutual implications and introduce the most representative authors in these fields. Secondly, we will analyse design epistemology and related concepts such as design thinking, design theory and designerly ways of knowing, considering their most relevant characteristics. Thirdly, we will address the connection between abduction and, on the one hand, pragmatism, and on the other, design epistemology. Finally, from the naturalised eco-cognitive perspective of abduction, we will sketch the role of abductive inference in grounding a real epistemology for design theory.

We will argue that this approach is important as a methodological innovation since it allows us to analyse both the research process and the design process as being interdependent when dealing with practical problems of a social and cultural nature. We consider that the main novelty of this approach is the link established between several concepts such as epistemology, design, abduction, and pragmatism that, even though analysed individually, had not been integrally examined. The vital question is how each one can obtain benefits from this connection. The introduction of design has had consequences in the evolution of epistemology in the sense that it passes from an analytical-descriptive framework to a synthetic-applied one, which implies changes in its methodology. This change has led to design being considered as epistemology, called epistemology of design, science of design, and theory of design [6] (p. 2).

Perhaps this cannot be considered a revolution in the Kuhnian sense, but it is consistent with epistemic progress in Larry Laudan's model [7] in which changes in methodology can lead to changes in the research tradition as a whole. The design framework also represents the evolution from theory to practice. That is, an epistemology that addresses applied science, emphasising design values such as usability and problem-solving capacity is also conducive to changes in the inquiry tradition, and more deeply to the change in methodological tradition highlighted by Laudan. Design is mainly based on introducing

novelties into the world, which entails a constant revision of history to project the future on the present. In other words, design assumes different scenarios when it hypothetically adds or removes elements from the theoretical framework. Typical cases are the design of instruments that reveal and enhance reality, such as the microscope and the telescope. Philosophers have analysed the role and relevance of tools in scientific revolutions via the historical approach, especially Thomas S. Kuhn [8], Feyerabend [9], Hanson [10] and Lakatos [11], among others.

2. Abduction and Pragmatism: The Bases for Scientific Praxis

As is well known, abductive inference is a reinterpretation drawn by Peirce [12] (CP 5.14–40)² of the Aristotelian *apagōgē* (ἀπαγωγή, reduction) [13] (An. Pr. II 25, 69a20–35) which is a construct resulting from pragmatist logic [12] (CP 5.180–212). The factor that Peirce wishes to capture through abduction is the fact that inquiry is largely based on the processes of continuous adaptation to the constant flow of information from our surroundings. Therefore, the shift that Peirce introduces which allows us to see the value of abduction is to situate the hypothesis as the basis of perception [1] (CP 2.619–644). We must bear in mind that Peirce’s main motivation was to respond to Kant’s denouncement of the idea that the existence of external things should be assumed as a mere act of faith [14] (B, Preface, xxxix), through more general analysis of the bases of experimentation [12] (CP 5.348). Estany [15] considers the debate on the relationship between theory and experiment in light of the contrast between pure vision [16] and interactive vision [17] noting that:

The debate concerning the role of theory versus the role of experiment is an old one in the philosophy of science, and it has crystallized in the comparison between Theoretical Traditions (TT) and Experimental Traditions (ET). From the perspective of TT, the philosophy of science has fundamentally focused on theoretical models, on established laws and principles, and ultimately on the reconstruction of scientific theories, leaving experimentation to play a secondary role. [15] (pp. 3–4)

Additionally, she concludes that:

The conception that is emerging in the philosophy of science in ET is supported by the cognitive models that address motor cognition, and that we could see as one of the consequences of the interactive and dynamic vision proposed by Churchland, Ramachandran and Sejnowski in 1994. [15] (p. 11)

One of the earliest characterisations of abduction is a syllogism and it is intended to complete the inferential triad of deduction and induction [12] (cf., CP 2.623). See Table 1.

Table 1. Syllogistic characterisation of abduction, deduction, and induction.

Deduction	Induction	Abduction
Rule: All the beans from this bag are white. Case: These beans are from this bag. therefore Result: These beans are white.	Case: These beans are from this bag. Result: These beans are white. therefore Rule: All the beans from this bag are white.	Rule: All the beans from this bag are white. Result: These beans are white. therefore Case: These beans are from this bag.

There is no need for those readers who have noted the fallacy of affirming the consequent in the syllogistic formalisation of abduction to worry. Although the conclusions of an abduction are problematic or conjectural, they are also assertive (they are not necessarily in the weakest degree of conjecture), which is precisely why they are problematic judgments of a high degree of expectation [12] (CP 5.192). This is important because the abducted product has no inferential power or, more precisely, it is not inferred from its premises. This warning that Peirce issues is extremely important and, in our opinion, defines the basis of the contemporary characterisation of abduction. However, taking into account the difficulties of working with the different characterisations of abduction that Peirce offered over approximately fifty

years [18], here we will start with an interpretation of the consensus reconstruction generally accepted by the academic community made by Kapitan [19]³:

1. *Thesis of autonomy*: Abduction is a type of inference different from deduction and induction.
2. *Thesis of inference*: Abduction infers hypotheses that do not follow from its premises. Following the argumentation in this section, it may seem strange to affirm this Thesis 2: that abduction is an inference. However, it is important to see that the rejection of its inferential power is in relation to its premises and not as a genuine process. In this sense, abduction has the power to infer novel hypotheses.
3. *Thesis of purpose*: The principal objective of an abduction is to generate and select new hypotheses. This implies, in turn, that the subsequent steps of implementation, testing, etc., of a hypothesis are not part of abduction.
4. *Thesis of comprehension*: Taking a maximal point of view, abduction encompasses most of the operations through which knowledge is acquired.

Applied to scientific research, abduction makes theoretical knowledge possible because, “all the ideas of science come to it by the way of abduction. [Then,] abduction consists in studying facts and devising a theory to explain them” [12] (CP 5.170). For Peirce, the fact that we constantly adapt to new circumstances must be reflected in science. This conception starts from the evidence that it is impossible to adapt through reason using a rigid and closed idea of the world—in other words, knowing the world is an open project in which we participate actively, completing it to the extent that we experience it and then grasp it. This is an idea totally consonant with thinking by design. So, scientific research cannot be fully understood without abduction [20]. This conclusion follows, as has been said, from conceiving this form of inference as the basis of perception [12] (CP 2.619-644). On the one hand, Peirce maintains the revisionist tendency of Kant’s knowledge, from which he draws the perspective of critical realism, and, on the other hand, he revises the Hegelian teleology, in the sense that the most real is, at the same time, the most cognisable:

Peirce’s rejection of incognisable things-in-themselves (5.452), owing to just this very critical restriction, leads him to the possibility—in fact the unavoidability—of a realist metaphysics, a metaphysics whose hypothetical postulates must all be fallible, but whose general concepts must be able to prove their objective validity “in the long”. This is because we cannot conceive the “real” to be anything other than that which is “cognizable” (5.275). By starting with a critique of meaning, Peirce makes room for a sweeping evolutionary metaphysics in the vein of Hegel and Schelling. [21] (p. 11)⁴

One of the direct consequences of assuming the pragmatist principles subsumed in perception through abduction has been the incorporation of praxis as part of research within debates in the philosophy of science. For this reason, there is at the basis of Peirce’s formal inquiry a concern with practical and moral issues [22]. In this regard, Peirce warns against surrendering ethics to the aims and methods of science [21] (p. 28). Following Apel’s thesis, it can be stated that pragmatism is a philosophy that assumes that reality is unfinished, just as Marxism and Existentialism do. From this perspective, praxis has to be understood as the link between the actual world and theory, in an attempt to account for the future [21] (p. 11). This raises uncertainties, not only because the future is always an enigma, but because part of the research project involves deciding on paths of action that will determine how the future unfolds. The world is an open-ended project that we humans design and realise through our actions. In the face of these uncertainties, historical, social and cultural factors influence the effort to fulfil the model of the world on which work will be done today so that it will be possible tomorrow. Therefore, accepting a pragmatist epistemology also implies taking on board its ontology:

- (1) The world of pure experience—the experience that configures reality is structured from a continuous flow of information;

- (2) Fallibilism—continuous experience means that knowledge is always provisional to a certain degree, which forces us to review and adapt our beliefs in accordance with the changes we experience [23].

2.1. *The Epistemological Taxonomy of Abductive Reasoning*

Abduction can be defined as an inferential process of hypothesis formulation by which meaning is made of phenomena by inferring a plausible solution endowed with non-classical epistemic virtues. There are inferences whose validity is not related to the standard virtues of deduction but remain crucial in determining the direction of inquiry. In this sense, the commitment to the truth of abduction is related to “the non-arbitrary transition from reliable truths to interesting and new truths” [24] (p. 90). In this direction, Lorenzo Magnani refers to what has been called material validity (an inference that, although semantically valid, instantiates an invalid syntactic form, [24] (p. 90), [25], occasionally achieved by all fallacious and rhetorical schemes (i.e., enthymemes) of reasoning as “arche-validity”, whose epistemic virtues are non-classical because they stabilise the proposed hypotheses precisely because of the possible epistemic benefits that can be extracted from them, and in which the validity/preservation of the truth of the inference at stake is sporadic. Concerning design thinking as a reference, it is important to keep in mind other forms of inference whose epistemic validity is arche-validity, such as explorative reasoning, which cooperates with creative processes to design a solution to a problem [26].

Within this understanding, Magnani calls some cases of creative abduction “knowledge-enhancing”: inferences that generate hypotheses capable of acquiring force to the extent that they are shared and accepted for reasons that often escape epistemic ones, such as their goodness or duration [24] (p. 90) and that, consequently, are capable of offering new truths. This definition allows us to characterise the main function of abduction as that of managing different novel experiences through the process of generating and selecting hypotheses [27] that indicate alternative paths of action allowing us to make sense of surprising or disconcerting situations [28]. This conception of abduction is the result of Peirce’s efforts to capture logically the epistemological bases of research from the point of view of pragmatism [12] (CP 5.348).

The inclusion of epistemological bases for hypothesising and conjecture has made it possible to redefine key questions in the philosophy of science concerning the value of processes such as discovery. The most common sense of the term “discovery” in historical and philosophical studies is that of providing substantive new knowledge [29] (p. 42). However, recent changes in both pure and applied science mean that there are new terms, such as invention and innovation, which are more in line with technological and pragmatic changes. In fact, the convergence of theory and practice in most of the phenomena that science faces has the consequence of confirming the relevance of concepts such as invention and innovation, besides discovery. These bases, which were already established with Kapitan’s four theses, are situated in the process of generation (fill-up) and selection (cut-down) of hypotheses in the light of surprising facts ([30] (ch. 6); [28] (ch. 2); [27] (pp. 81–82)). Examples that we can only briefly mention here include the extrapolation of the orbit of Mars to the rest of the Solar System [10] (pp. 72–85), the discovery of the planet Neptune by Le Verrier [31] or Darwin’s theory of evolution [32]. These were only possible thanks to highly abductive (hypothetical) processes. Similarly, the fact that psychological factors are incorporated into the process, the triggers of the abductive process (for example, that the planet Uranus behaves “as if there were” a planet next to it), reveals the cognitive approach adopted within the philosophy of science; consider, for example, the thought processes that are involved in epistemological processes [33].

The two approaches that have most successfully examined the epistemic dimension of abduction are the AKM (explanatory) and the GW (non-explanatory) schemata.⁵ It is interesting to note that the issue of whether or not an approach is explanatory in abduction is an echo of the debate on the fundamental role of scientific hypotheses. Although this is not the place to analyse this debate, it may be useful to highlight the advances in epis-

temological conceptualisation that have stemmed from it. As is well known, explanation usually requires some type of verification, refutation, etc. However, this requirement does not fit in with the functions of abduction because the factors that operate in the generation and selection of hypotheses are different from those that are at work in classical epistemic processes, which usually focus on strong epistemic acquisition. These “divergent” factors are divided between triggers and constraints. Both types are logical and cognitive mechanisms that represent the operational bivalence of morphological and cultural aspects when defining the limits of our reality (constraints) and in the process of change (triggers) [39].

One of the main problems when characterising the epistemological dimension of abduction is the role of the abducted hypothesis in classical methodology (i.e., a system that does not on the face of it contemplate the epistemological dimension that is involved in abduction). If we reconsider Kapitan’s thesis, we can see that there is a problem reconciling the first thesis (autonomy) with the fourth (comprehension): it is not clear how an abducted result can have epistemic value for a general system without ceasing to be an abductive type of hypothesis. For example, the AKM schema puts forward a special form of abductive explanation which is called “tentative” [28] (pp. 36–37). The main purpose behind this manoeuvre is to allow abduction to play an explanatory role in a classical system without the requirement for it to be tested: it is a provisional explanation that meets Peirce’s requirement of a weak or conjectural argument. Nevertheless, provisional or not, the tentative explanation does seem to imply some kind of knowledge. This does not appear to be a serious setback for this scheme because, since it addresses logical applications, the problem that is actually resolved is that of monotonicity (the dependence between premises and conclusions): tentativeness seems to allow one to infer “as if” the monotonicity was maintained, without losing the provisional autonomy of the abduction (tentativeness).

From a cognitive perspective, however, the implication of tentative explanationism that there is (weak) knowledge does indeed present a theoretical problem. The GW schema defends the idea that an increase in epistemic strength always tends towards a conclusion in a classical system. This means that, although previously it had been merely provisional, the implementation (testing) of the product abducted in a classical epistemic system transforms it into a conjectured hypothesis [27] (p. 47). The main problem with this perspective is that it establishes a division that is too rigid between, on the one hand, the processes of generation and selection of hypotheses, and, on the other, classical epistemic systems. The motivation behind characterising a process in this way is to maintain the property of the preservation of ignorance: abduction does not provide genuine knowledge because its results do not eliminate the state of ignorance, they only mitigate it [27] (pp. 42–44). Therefore, this process should not be confused with those of classical hypothesising.⁶ However, there is an additional complication as abduction then seems to become something that is epistemically trivial because it does not participate in a classical epistemic process (it only does so once the hypothesis is conjectured) [41,42].

A novel perspective from which to redefine the situation of this debate is that offered by the eco-cognitive model of abduction (or the EC model): a so-called enactive cognitive proposal based on the contextualisation and anthropomorphisation of the knowing agents when they interact with their surroundings. One of the first proposals that stems from application of this model is to conceive issues such as the preservation of ignorance or tentative explanationism as circumstantial factors. In this way, the conditions that are declared intrinsic to each of these debates are situated in the context within which they are developed and they define each of the different practices. This means that abduction, as a form of reasoning, has a component which adapts to the circumstances that triggered it and, in the same way, is subjected to the defined form of the local constraints. This emphasises, on the one hand, the anthropomorphisation of cognition, which is based on a naturalisation of the logic of hypothesis generation and selection. As shown in what follows, the key point to highlight when assessing the value of the EC model of abduction is that it allows us to analyse initial design processes from a perspective that contemplates the biconditional interaction between agent and environment. On the other hand, the EC

model highlights the role of agents' actions as a link between the history that has defined them and the present, as well as their transformative power in projecting desired futures.

The Eco-Cognitive Model of Abduction

The starting point for our proposal is precisely this EC model of abduction: a contextualised interpretation of classical pragmatism stemming from the naturalisation of cognitive processes [24]. From this perspective, the processes of generation and selection of hypotheses can be considered to be present in all the different degrees of human experience: from natural adaptive processes with a purely biological base, to the most complex of processes that occur within a cosmovision⁷ that is socially and culturally shared and which defines the morphological bases of hypothesisation [39]. It is interesting to note that this model allows us to expand the set of factors that influence the generation of an abductive process, such as emotions, feelings, and narratives (collective and individual). From this perspective, situations such as determining that a person is a rock star because of the way they dress [33] (pp. 54–56) or not considering the possibility that the argument you see in the distance on a train between two men is an argument between a couple [20] can be explained using abduction: they are triggered hypotheses that indicate a course of action when we are faced by surprising situations to which we cannot give a habitual response. Abduction can similarly be understood as a mechanism through which to manage one's experiences of novel or strange facts, etc., that pose a challenge which agents begin to resolve starting with the hypothesis.

As we mentioned in the previous section, the main idea that the EC model puts forward is that agents modify their surroundings to the extent that those surroundings modify the agents [42] (p. 292). So, this model allows us to accept the Pragmatic Maxim of considering that the definition of knowledge to be based on the practical effects that the objects of our perception have [12] (CP 5.402) from a cognitive perspective that allows us to naturalise the logic of reasoning. In this sense, abductive reasoning is also a mechanism for integrating the different interactive predispositions that agents maintain towards their surroundings. In other words, the logical principle (way of knowing) contained in the Pragmatic Maxim can be implemented from a cognitive perspective to explain the various strategies that are at work to accommodate the variations in experience that exist within perception [44]. Therefore, to the extent that the ways agents interact with facts is related to the definition of the context, the possibility of transforming one's surroundings is also determined by the different ways agents have of managing and resolving situations.

The realisation of the EC model is based on a multimodal (which relates different cognitive strategies) non-monotonic (which does not maintain a static relationship between premises and conclusions) system of hypothesisation which manages novel information generated from the modes in which the information is presented and the means available to the agents to experience and understand it [24,45]. In technical and specific terms, for this realisation to be viable, it is necessary that this model of abduction takes the following factors into consideration. Following Magnani's thesis, that means:

- (1) Optimisation of the situation (contextualisation of cognitive processes).
- (2) Maximisation of the mutability between the different roles that the elements which constitute the context acquire.
- (3) Condition 1 is met because abduction meets the requirement of being a sensitive mechanism of constant absorption of information.
- (4) Contemplation of the inferential richness available to the human cognitive apparatus (multimodality) [24] (pp. 138–139).

This characterisation of abductive reasoning and of the conditions for its realisation to be possible allows us to establish a pragmatic holistic relationship between the truth and the hypothesised product [24] (p. 15): the interactions of all agents with their surroundings are influenced by factors that stem from the worldview of the community to which they belongs. Putnam schematises pragmatic holism as follows:

1. Knowledge of particularities (facts) presupposes knowledge of theories,

2. Knowledge of theories presupposes knowledge of facts (particularities),
3. Knowledge of facts presupposes knowledge of values,
4. Knowledge of values presupposes knowledge of facts,
5. Knowledge of facts presupposes knowledge of interpretations, and
6. Knowledge of interpretations presupposes knowledge of facts.

(Points 1 to 4 [46] (pp. 136–137); points 5 to 6 [47] (p. 33).)

Perception of facts is built on theories, values and interpretations. In order not to fall into “bad” relativism,⁸ it is important to highlight the epistemic value of the “presupposition”, which can be characterised as abduction. If the EC model of abduction is applied to this characterisation of pragmatist holism, we see that the various ways of investigating are based on the reasoning effort of each of the agents. Likewise, it allows for the incorporation of other types of factors that make it possible to realise other ways of interacting with one’s surroundings and which in this work we conceive as essential for an epistemological theory of design that contemplates the cognitive strategies of designers. According to this, in the next section, we analyse the main ideas of what is called “design epistemology”; and in Section 4, we will see how the EC model establishes an optimal base from which to manage the constituents of a theory of design that contemplates the first sketches that are initially made in a project.

3. Design Epistemology

The idea of design epistemology is essential for the objective of this work. This is why Nigel Cross [48] proposed in *Designerly Ways of Knowing* (DWK) his design perspective that is related to a way of knowing. According to Cross, design can be considered a third culture besides the scientific and humanistic cultures. Comparing the three cultures, we see they have some different characteristics, especially regarding the object of study, the method, and the values.

Other questions are specific to design that are important in the theoretical framework of Cross, for example, the relevance of the material representation, the relationship between action and thought, and the role of images in cognitive processes [48] (p. 11). Cross’s project to solve problems, even the ones that are complex, constitutes one of the main objectives. For this, it is vital to consider other ways to cope with the problems using strategies not necessarily dependent on linguistic expressions. In this sense, graphic representations acquire much relevance [48] (p. 20).

The perspective of the epistemology of design raises various issues that in turn constitute perspectives on how to understand this epistemology. On the one hand, we have the epistemology of design as an alternative to classical epistemology, which is usually described as analytic rather than synthetic, and which would apply to design and include applied sciences. Talking of ‘classical or analytic epistemology’ identifies the epistemology arising from the tradition of the Vienna Circle and logical empiricism, in the sense of an epistemology designed for basic pure science [46] (ch. 1). In contrast, synthetics aims to collect the necessary changes for an applied science that, in Herbert Simon’s words, would constitute the sciences of design [49]. In the philosophy of science, Ilkka Niiniluoto takes Simon’s ideas to reconsider the methodology of applied science [50]. On the other hand, there are a series of crucial characteristics, among which we can highlight interdisciplinarity, as the relevant dimension for addressing complex and dynamic problems, and social concern expressed through design thinking that hinges on the idea of human-scale design. A series of proposals and considerations arises from these different dimensions which we are going to recap in what follows.

Guillermo Bengoa [51] makes a series of points regarding the scope of the practical applications of science. According to him, the idea that epistemology is the doctrine of the foundations and methods of scientific knowledge does not fit in with the fact that a wide variety of objects populates our field of knowledge, so there cannot be one single epistemology. In fact, Bengoa refers to constructed objects or artefacts and wonders whether an epistemology of these objects could not be constructed based on parameters other than

those traditionally considered. To this end, he makes a distinction between epistemology “for” design and epistemology “of” design. Regarding the former, he says that it has to do with “science of knowledge that helps the designer”, while the latter has to do with “epistemology to be used as a tool to reveal the reality of design itself”. We could say that his views with regard to the former type of design epistemology fit in with epistemology of applied science. When it comes to his views on the latter type, the definition seems unclear unless we interpret it as “epistemology that is to use design itself as a tool to reveal reality”. It could be understood, then, in the sense that the design theories that we use to build objects can be a model for epistemology, both in its function of grounding pure sciences, in the sense of revealing and explaining reality, and as epistemology/methodology of applied sciences. One may object that this approach constitutes a vicious circle; let us concede that it may be said to be a circle, but not a vicious one, rather a pragmatic holistic circle: it implies feedback between knowledge, artefacts and design.

Darius Mahdjoubi [6] in his paper, “Epistemology of design” classifies design as an activity, as planning and as epistemology. The activity refers to the conceptualisation of the product; planning, to the organisation of the actions for the realisation of the product; and epistemology, to the relationship with the synthetic methodologies necessary for any change in the applied sciences and different from the analytic methodologies that are vital for the development of scientific initiatives. As mentioned in the introduction, Mahdjoubi points out that analytic methodology has been shown to have deficiencies or shortcomings when dealing with applied science, which is why synthetic methodology has flourished. He considers design epistemology to be an alternative that can alleviate those deficiencies, especially in fields such as engineering. In other words, design theory contemplates praxis. Therefore, this project needs tools that make it possible to represent the role of design as hypotheses that propose a line of action which, once carried out, implies a substantial change in the world we inhabit and, therefore, in our conception of it.

Karabeg proposes that design could substitute for tradition because there are better ways to approach innovative processes in science than in classical epistemology [52]. However, when Karabeg refers to design sciences⁹, he thinks of pure and applied sciences. Therefore, this should be the goal of epistemology—that it transcends classical thinking.

Karabeg’s theoretical framework concerning design constitutes a perspective that is a replacement that is perhaps too unconventional for classical epistemology. The role of design models has been very relevant for the new trends in the justification of knowledge and its application to solve problems in scientific research. This approach indicates that, unlike classical epistemology, design epistemology is more dynamic and enables the incorporation of new elements that emerge during research. Introducing innovation from design models into classical or analytic epistemology is equal to Bengoa’s “epistemology of design”. With respect to the characteristics that Karabeg indicates [31], what he calls “wholeness” is especially relevant. He defines it thus:

Wholeness is the quality that characterizes a perfectly developed and healthy organism, or a complete and immaculately functioning mechanism: All the parts work well and in synergy with one another, and fulfill their purpose within the whole, so that the whole can function well and fulfill its purposes within even larger wholes. [52] (p. 3)

The idea of wholeness is related to “transdisciplinarity”, which would take the form of the “Knowledge Federation”: a federation of knowledge and disciplines with the aim of being able to approach any phenomenon from different perspectives, like looking through a kaleidoscope. Another concept related to design epistemology is “design theory”, which is addressed by L. E. Östman [53] in his paper, “Design theory is a philosophical discipline—Reframing the epistemological issues in design theory”. According to Östman, design philosophy is not a social science, or a natural science, but rather a philosophical discipline, which takes pragmatism as the framework for the reasons behind design theory. Thus, it is not a question of fixing knowledge to straightforward truth, but of addressing problems and promoting understanding through clarification, reasoning and criticism.

These statements constitute the basis of his proposal, which focuses on knowledge for problem solving, not as a means to reach the truth, or at least not only as such and not primarily, but also to offer an epistemology and methodology of sciences oriented to changing the world. Östman distinguishes between “Design research”, which takes design as a field of research, and “design theory”, which is the set of knowledge shared by the different areas in which design processes take place.

Furthermore, Östman also relates design theory with H. Simon [49], which gives us an idea of his interest in applied science, despite differing on the concept of theory. In fact, Simon’s theoretical framework inspires the science of the artificial defined as science that not only describes the world but also aims to change it. The philosopher Ilka Niiniluoto takes up Simon’s idea [50] in order to clarify the different methodologies in pure and applied sciences. In this regard, a pressing challenge is to address the fact that moral values, ideologies, emotions, perspectives, and assumptions always accompany actions. Pragmatism provides a theoretical framework to relate this dimension to the strictly scientific one and, through abduction, to understand that hypotheses aimed at changing the world entail values such as having an idea of how the world can be better or worse.

4. Pragmatism as the Epistemic Basis of Design Theory

One of the issues addressed by the epistemology of design is the adequacy of classical logical-epistemological models for this new epistemic framework. We have already seen that one of the definitions takes the form of presenting the epistemology of design as an alternative to analytic epistemology, opting rather for what was called “synthetic” epistemology. We can consider pragmatism to be the model that could be at the heart of this epistemology, which would be primarily based on abductive reasoning. Östman [54] wrote a book on pragmatist design theory and its impact on architecture.¹⁰ He considers that:

The pragmatist philosophy of Dewey as an appropriate philosophical foundation for design theoretical reasoning, as it includes a distinctive theory of knowledge and research. It can integrate both the scientific methods, the reflective and interpretative methods of the social sciences and the humanities, but it cannot be fully understood in the light of one of these. It needs its own paradigm or epistemology. [54] (p. 11)

One of the elements that Östman considers especially interesting for the epistemology of design is that Dewey’s philosophy takes: “an interest in development, research and ethics—providing means for controlling actions in an insecure world” [54] (p. 12). In conclusion, according to Östman, “the pragmatist philosophy of Dewey basically provides a theoretical model of creative design actions, with experimentalism and evaluative steps as the core elements” [54] (p. 17). This amounts to a whole series of characteristics that correspond to reasoning in applied sciences. The pragmatic perspective underpins most approaches to design theory insofar as it provides a lens through which concepts can be interpreted and also a set of conceptual tools that support the realisation, understanding and communication that apply to design. This perspective would be reflected, according to Östman, in a series of aspects:

Design is a controlled creative action; design knowledge is a set of repertoires intended to enable the managing of problems, desires, values and puzzling situations, and the changing of an existing situation into a preferred one; a design problem is not a single and simple issue, but rather a complex situation where we want to improve or change something; and creativity is the dynamic capability to manage problems and situations, and to generate solutions that match expectations. [54] (p. 8)

Based on these considerations, pragmatism comes to constitute the philosophical foundations of design epistemology. Peter Dalsgaard [56] is also committed to pragmatism. He considers that pragmatism constitutes conceptual scaffolding for design thinking. Additionally, he adds: “I employ the term design thinking in an inclusive sense to denote

the ways of framing, approaching and addressing challenges that characterize design” [56] (p. 144). Therefore, we consider that the pragmatic perspective can be of great value in at least three interrelated aspects:

1. The theory/praxis relationship [21,23], the interrelation between experimentation and technology [57].
2. The implications for design of a pragmatic perspective (the theses of Östman and Dalsgaard that we are addressing in this section).
3. The application of the concepts of pragmatism in various fields of the humanities [22].

Clearly, these aspects do not exhaust the factors involved in design, but there is no doubt that they are key issues when it comes to study and discussion of design. Dalsgaard concludes: “Deweyan pragmatism offers a set of concepts that can contribute to the efforts to articulate designerly inquiry and thinking, as well as a framework for understanding the relations between these concepts” [56] (p. 152). The recovery of Peircean abduction by the EC model allows us to methodologically express Dewey’s notion of inquiry through abductive reasoning: intelligent organisation to arrive at practical judgments that improve life in the community (freedom and democracy) (cf., [58,59]).

Kees Dorst [60] wonders what the core of design thinking is and what it can contribute to professionals in other fields. Based on these questions, he considers that logic provides us with a set of concepts that show us how design reasoning can be adopted as a new paradigm to address problems in various professional fields, especially in information technology (e.g., [61]) and in business (e.g., [62]). We can also add science education, medicine, pharmacology, etc. The basic pattern of reasoning would be abduction, that is, abduction as the logical model of design within a pragmatist meta-epistemology of design.

In “Abductive Thinking and Sensemaking: The Drivers of Design Synthesis”, Jon Kolko [63] turns to abductive thinking for what he calls “design synthesis”. Here, Kolko uses the idea of synthesis not as an alternative to analytic epistemology, but as a method of designing based on synthesising all the different elements that the designer has been able to bring together in order to elaborate the artefact in question. By way of conclusion, he points out that this way of designing supposes an abductive perspective on the processes of manipulating, organising, selecting and filtering data in the context of a design problem. Although no express reference is made to it, the design-centred alternative takes on characteristics of the cognitive approach in epistemology and philosophy of science. In particular, it has special relevance for the EC model, as we will see in the following section.

5. Convergence between the EC Model and the Epistemology of Design

As we have already stated in Section 3 above, in this work we adopt the eco-cognitive perspective of abduction, also known as the EC model. The main reason for this is that this model or perspective assumes a contextualisation of human praxis based on an embodied perspective of cognition and mediated through abduction [64]. Therefore, the logic of abductive reasoning is based on the practical realisation of abductive reasoning [65]. At this point, abduction can be incorporated into design theorists’ use of Dewey’s concept of inquiry introduced above. Even though the naturalisation of reasoning is based on realisation through an anthropomorphic conception of cognitive processes [24] (p. 138) which aims to explain processes of adaptation to the environment, it can also be approached from a broader perspective that highlights how the general form of the mechanism of continuous opening up in order to acquire information, in turn, implies variations in the theoretical frame of reference from which research is conducted. An interpretation such as that provided by the EC model allows us to broaden the conception of abduction to contemplate the second and third aspects that a pragmatic theory must have in order to be applied to design theories:

1. The implications of a pragmatic perspective for design (the theses of Östman and Dalsgaard that we are considering in this section).
2. The application of the concepts of pragmatism in diverse fields of the humanities [22].

Just as we have already said that the EC model of abduction is in many ways a naturalised reinterpretation of Peirce's Pragmatic Principle or Maxim, it is in his theory that we can also encounter the bases for the extension that we propose here. Summing up what has been said so far, Peirce locates the hypothesis as the basis of perception. An interesting point to keep in mind is that perception, for Peirce, is semiotic in nature and involves social and cultural relationships with natural habits [66].

This fact is crucial in order to have a correct understanding of the social and cultural dependence of the meanings of concepts. Similarly, we could include the idea that one of the objects to be researched is the construction of a socially and culturally shared worldview. In a very specific sense, human relationships can be considered highly tentative. Primarily this is because our gestures, glances, dynamics, tendencies, etc., that make up our interactions with each other presuppose many interpretive hypotheses in order to understand them and to contextualise the situation that is experienced in each case. From this social perspective, hypothetical adaptability predisposes us to act in accordance with these interpretations of our relationships with other people.

By considering the social and cultural framework that intervenes in human interactions, we can involve factors that are crucial to determining our understanding of the environment where we human beings live, our social reality: the resulting product of the relationship between personal worlds (microscopic) and social structures (macroscopic) [67]. Therefore, to understand better the relationship between agents and their environment, the notion of abduction can be extended to include the social and cultural framework in which human interactions take place. Likewise, it is also necessary to bear in mind that the contextualisation of reasoning implies a necessarily temporary situation. To put it another way, hypothesising is a present projection into the future. Without entering here into detail about the involvement of memory and recollections (past), a projection into the future can be understood in terms of anticipating: (a) what you want tomorrow to be and (therefore) (b) what you start to do today. This anticipation can be characterised in terms of abduction [68], as a way of characterising the initiating mechanism of design thinking in the sense of wanting to change the world.

The advantage of incorporating this conception of design thinking into a perspective that contemplates the interactions between people within a particular social and cultural framework is that it reflects that the activity of the agent-designer arises from the tension between the individual and collective aspects that make up a society: a general sense of deliberation and the habitual relationships that do not necessarily target any premeditated objective [69]. In this way, we can see that the processes of acquiring information are also defined by those of distribution and that, between the two, the various negotiations that take place between the members of a society intervene. The grey area that exists around these negotiations leads to a general activation of the pragmatic postulate by the agents in order for them to act on assumptions that they consciously accept as provisional [70]. In other words, the instability of the grey areas represents the propitiating foci for social change. Therefore, these are the spaces where actions follow the new project and promote its realisation.

5.1. Design Thinking Is an Abductive-Based Process

From the perspective of the agent-designer, the complexity resides in the fact that a particular design must take on board conscious and unconscious conflicts of interests, as well as the individual and collective ones that occur at the different levels of social interaction. Therefore, the mere fact of imagining a solution, abducting a future, in many ways requires anticipation of a transformation of a conflict into a new course of action. For this reason, although a design project may yield results that are considered final, in a certain sense it will always remain unfinished. So the tension triggered by a design project is unresolvable because it is of a social and practical nature, and it involves material and bureaucratic conditions, as well as people's demands and customs [71] (p. 46).

The designer's reasoning must make a hermeneutical effort to subsume all these conditions within the final product [56] (p. 145). Therefore, the designer's challenge with every project begins with the awareness of a difficulty and this implies a design which, although it may resolve the problem in the first instance, must also be able to co-evolve along with social reality. We could say that a design should offer the possibility of transforming an obstacle into an opportunity. From this perspective, the contextualisation of cognition takes on much greater value, since people's actions can become centres of attention that suggest lines of research aimed at exploring solutions to conflicts. Problem solving is also a form of interaction based on the application of different cognitive strategies that forms part of the socially and culturally shared worldview. The application of these cognitive strategies in a specific and shared setting generates what is known as a cognitive niche: the environment that results from the changes actively sought by human beings in their attempt to seek out opportunities [72].

This conception of ecologically situated cognitive systems offers a perfect perspective from which to understand how the context is generated as a setting in continuous transformation based on the range of shifting relationships that we maintain with objects and other agents. In this sense, every designed product can be understood in terms of affordances that reflect the values and meanings implicit in perception, which offer opportunities for action [72] (p. 241). As can be seen, the incorporation of values forces us to expand the classic notion of affordance [73] towards one that allows us to postulate that the interaction can imply modifications of social behaviour based on changes in perception brought about because of designs. In this sense, opportunities are social transformers because they are transferred in the form of new actions that offer new ways of interacting with the environment and signifying it.

5.2. The Value of the Future for the Epistemology of Design

The epistemological tension that results from relating the ethical or moral dimension to the descriptive one is overcome from the perspective of contextualised cognition of the EC model of abduction. By applying this model to society, we can see the need to relate these two dimensions to each other in order to account for the synergies that arise between human beings. The realisation of this relationship is abductive precisely because, on the one hand, it is highly tentative and, on the other, this seems to be intrinsic to all interaction. In the same way, it is plausible to think that an activity that focuses on tackling conflicts that arise precisely from these synergies can also weakly (abductively) relate all the dimensions that make up the social reality in which a society develops.

Here, Dewey's pragmatist approach once again sheds some light on the subject. In his analysis of human nature and behaviour, we can discern the important role played by values in causal perception when oriented towards future consequences. These situations, says Dewey, are moral because they affirm how things should be, often appealing to values such as justice, order, and goodness [74] (p. 18). When applied to design, we can add that a designer's project often already aims to resolve a problem of an ethical nature. Therefore, the designer's task of anticipating a solution to a specific problem implies "carrying out" in the sense that the design process itself (the project) is part of the solution. The process of designing is highly tentative from the point of view of resolving social issues and it can be identified with the abductive mechanism because, in many ways, the practice of the designer can be seen as a process of managing social uncertainty: problems whose only solution is not to finalise anything.

For example, designing a library (building) that takes on board the values of the community that lives in the place where it is to be built is a constant trigger [75] because it involves circumstances that is highly susceptible to change. Therefore, by accepting the constant openness to change required of many design projects, we are contemplating the dimension of transformation of society through modification (design) of the environment. Bearing in mind that actions are one of the social tools at our disposal to improve the world, it is plausible that the transformation of the environment where actions are carried out is

also an important factor when it comes to changing the reality of the present. Likewise, from the perspective of the agent-designer, the project of change in the present will anticipate an enhanced environment that calls on the rest of society to similarly perform better actions.

Returning to the case of a public library, we see that the conception we have of such a building is intimately related to the practices that take place inside it: reading, writing, studying, etc. [76]. For example, a building that was not a library before can end up being one simply through having fitted it out in such a way as to allow the practices that we associate with being a library to be carried out there. Therefore, design emerges as a determining factor because it brings together and combines within a single building tradition and adaptation to new challenges [54]. For this reason, it can be said that a library should look like a library [77] (p. 541). This means that the design of the building must predispose agents to behave according to the standards, customs and habits associated with these institutions. Similarly, the actions of the agents are what will ultimately constitute the place as a library [78].

From this point of view, abduction emerges as the ideal reasoning to explain the design process. Using the multimodal perspective of human cognition that the EC model of abduction offers, we can see that [69]:

- (a) Our cognitive processes are mediated by the way we interact with our surroundings; and
- (b) Due to the fact that all the resources that we have available to understand what surrounds us act to make sense of what we experience through the abductive process.

Therefore, the result of anticipating (future) assumptions (design) in the present (perceived case) can trigger an abductive hypothesis that indicates a line of action to resolve a normally conceptualised conflict that is socially and culturally mediated. The same worldview that embraces the conflict that triggers the design process predisposes designer-agents to assume an attitude that reflects the social reality in which they live. Thus, we can consider that design thinking is the praxis of transformation of the environment where other activities take place, realised many times by abductive reasoning.

6. Conclusions

Science evolves not only through changes in theories but also via new epistemic values and methodological models. As a consequence, the historical perspective of science cannot avoid these types of changes, which also have a great impact on scientific research. The present work gives an account of this by addressing the role of design epistemology, abduction and pragmatism in the challenges that philosophy faces when configuring a multidisciplinary framework that embraces applied science.

Design epistemology forms part of philosophical reflection concerning the foundations of theoretical and practical knowledge. This is knowledge that history has taught us has been constructed through trial and error, with certainties and uncertainties, but always driven by the desire to comprehend the surroundings in which we move. Thanks to this, we humans have survived and evolution has given rise to beings with sufficient cognitive abilities to face up to the challenges of the complexity of the world we inhabit.

There can be no doubt that in our search for knowledge, praxis has had to play a very important role so that theory did not remain as mere speculation but rather came to provide us with skills for basic life activities, such as healing, cultivating crops, educating and learning. In order to achieve this, humans have used techniques ranging from the most primitive to the science and technology that we have today. This has meant that, on the one hand, we have had to devise forms of sociability and collaboration, and on the other, it has been necessary to search for forms of reasoning that can epistemically address the convergence of theory and praxis in problem solving. Additionally, it is at this point that design epistemology comes into play as do, moreover, abductive reasoning and the pragmatic turn, with the cognitive approach and design culture as their philosophical frameworks. These are the principal axes that support the objective of this work: to analyse the extent to which abductive reasoning, understood under the spectrum of the

philosophical system of pragmatism, can serve as a logical and cognitive mechanism to constitute the basis of design epistemology.

As we have moved through this work, we have been able to bring to the fore some of the most important epistemic issues related to the search for the reasons behind our knowledge of the natural and social world. Thus, abduction allows us to manage our different experiences of novelty through the process of generating and selecting hypotheses [27]. As for pragmatism, it is to be understood as the practical link between the real world and theory in an attempt to account for the future [21] (p. 11), which is realised through processes of abduction [23]. Design epistemology presents itself as an alternative to classical epistemology, which is usually described as analytic, as opposed to the synthetic nature of the epistemology of design. Among the characteristics that we can attribute to this topic we should include interdisciplinarity, as the dimension from which to address dynamic and complex problems, and social concern expressed through design thinking that hinges on human-scale design.

All this leads us to the connection between the eco-cognitive model of abduction and design epistemology, thus making possible the contextualisation of cognition within which the actions of agents become centres of attention which in turn can suggest lines of research for exploring resolutions of conflicts. Additionally, thinking of praxis, we can conclude that problem solving is also a form of interaction based on the application of different cognitive strategies that is part of our socially and culturally shared worldview.

In conclusion, the connection between design, abduction and pragmatism provides a practical theoretical framework with enormous possibilities for the challenges that humanity has to face given the complexity of the phenomena of the current world. In addition, and no less important, is the possibility of addressing issues such as values, the ethics of the actions we carry out and, in general, the social context in which we humans develop.

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Notes

- ¹ The programme for the naturalisation of philosophy involves questioning a priori epistemology and a commitment towards taking the empirical results of the sciences into account when configuring epistemic and methodological models. As an example of this type of analysis, see Estany [5] on the debate between neutral and theory-laden observation. This is a noted example.
- ² CP is the internationally recognised abbreviation for the Collected Papers of Peirce.

- 3 These explanations of the theses are ours, not those of Kapitan. Our objective is simply to introduce the basic notions for readers who are not familiar with the theory of abduction.
- 4 C.f., [21] p. 29–30.
- 5 The classic schematic representations of abduction are known as the AKM schema and the GW schema. With regard to the first, the A refers to Aliseda [34,35], the K to Kowalski [35], Kakas et al. [36] and Kuipers [37], and the M to Magnani [30] and Meheus [38]. Similarly, the second is named for Gabbay and Woods [27].
- 6 We are referring here to inductive hypotheses or hypotheses that are to be tested, as propounded by Hempel, which have influenced the philosophy of science considerably [40] (ch. 2).
- 7 We use the term “cosmovision” to refer to the unified image of social and cultural interpretations of the world generated by human agents [43].
- 8 That is, relativism that arises precisely because we do not start from a holistic perspective.
- 9 Design sciences are the result of a process of scientification and mechanisation of the arts, seen as practical activities and skills. H. Simon [49] refers to sciences such as engineering, medicine, architecture and education, the aim of which is not only to know how things are but how they need to be in order to achieve certain practical ends.
- 10 Although Östman applies it to architecture, the general principles and criteria for considering design epistemology suitable for the field of architecture are the same as those behind its suitability for medicine and research in the health sciences in general. For a case study in medicine see Estany [55].

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