DOI 10.36446/af.e1051

PRAGMATISM, FICTIONALISM, AND SCIENTIFIC MODEL BUILDING

Pragmatismo, ficcionalismo y la construcción de modelos científicos

Nélida Gentile [a]
https://orcid.org/0000-0003-4254-6717
nellygentile@gmail.com

Susana Lucero [b]
https://orcid.org/0000-0002-2967-8849
susanalucero78@gmail.com

[a] Universidad de Buenos Aires, Buenos Aires, Argentina.
[b] Universidad Nacional de Luján, Buenos Aires, Argentina.

Abstract

In our present article, we first offer a critical review of the pragmatic conception of science and how this doctrine has evolved to the present day. Secondly, we propose to examine the model-target relationship whose epistemic value has been questioned by some advocates of the pragmatic view**.** One of the main goals of the paper is to show that including the model-target relationship in some particular context —for example in the inferential view of models—, is not at all incompatible with the pragmatic conception**.** On the other hand, we examine the relationship between pragmatism and fictionalism in the context of model building. Regarding this issue, we reject the position we have called *full fictionalism* and assume a deflationary attitude, a *narrow fictionalism* that admits only one class of non-realistic components of a model: those that refer to no existing entities.

Key words: Scientific Models; Methodological Pragmatism; Scientific Pluralism; Representational Relationship; Fictionalism; Cognitive Function.

Resumen

En el presente artículo, ofrecemos en primer término una revisión crítica de la concepción pragmática de la ciencia y cómo esta doctrina ha evolucionado hasta la actualidad. En segundo lugar, nos proponemos examinar la relación modelo-*target* cuyo valor epistémico ha sido cuestionado por algunos defensores de la visión pragmática. Uno de los principales objetivos del trabajo es mostrar que incluir la relación modelo-*target* en algunos contextos particulares —por ejemplo, en la concepción inferencial de modelos— no es en absoluto incompatible con la visión pragmática. Por otra parte, exploramos la relación entre pragmatismo y ficcionalismo en el contexto de la construcción de modelos. Con respecto a este tópico, rechazamos la posición que hemos denominado "ficcionalismo completo" y asumimos una actitud deflacionaria, "ficcionalismo estrecho", el cual admite

solo una clase de componentes no realísticos de un modelo: los que refieren a entidades no existentes.

Palabras clave: Modelos científicos; Pragmatismo metodológico; Pluralismo científico; Relación representacional; Ficcionalismo; Función cognitiva.

1. Introduction

Although the question of scientific models and their representative function originated when the semantic view of theories gained space in the academic field, the problem has taken on a new perspective in the last decades, giving a fundamental role to the imagination. This has led to the emergence of the so-called "fictionalist conception of scientific models". Along with the fictionalist tendencies in dealing with models, a purely pragmatic account of scientific modeling has recently grown. Moreover, within the pragmatist doctrine, a branch has emerged in the last decades of the twenty-first century that focuses mainly on methods and procedures used in concrete scientific research; that approach is known as *methodological pragmatism*.

A distinctive feature of general pragmatic theory is that it highlights the practice and uses of model building rather than the representational relationship between the model and its target. In addition, many advocates of the pragmatic view have incorporated fictionalism because they emphatically value the role of the non-realistic components of a model in the acquisition of knowledge. As a consequence, it has introduced a specific research topic: the elucidation of how assumptions that have no correspondence, in reality, contribute to the production of knowledge of aspects of the world.

Indeed, a considerable number of philosophers have devoted themselves to elucidating the role of fiction in model building. Most of these proposals take as referents two classical theories of fictions: Vaihinger's *Philosophy of 'as if'* (1935) and the pretense theory of Kendall Walton (1990). Those who follow Walton's view offer an ontological and epistemic characterization of scientific models, which are considered *props in games of make-believe* (Frigg, 2006, 2010a, 2010b; Toon, 2012a, 2012b, 2016; Levy, 2012, 2015). Whereas those who adopt Vaihinger's lines of reasoning give priority, in most cases, to the cognitive function of fictions rather than their nature, and emphasize the fundamental role they accomplish in the production of scientific knowledge. Some scholars have set aside the truth value of fiction and focused on the ability to allow quick and expeditious inferences about the objective phenomenon (Suárez, 2009, 2010). By

adopting this methodological strategy about the truth value of fictional statements, they distance themselves from Vaihinger's original purpose. It is worth recalling Vaihinger's claim about the falsity of all fictions: "I wanted to give a complete enumeration of all the methods in which *we operate intentionally with consciously false ideas,* or rather judgments" (1935, p. xli, our italics). Regarding the role of fictionalism, we point out some difficulties that pragmatism faces when it embraces a strong form of this position; we also state our preference for a more deflationary version of it.

We analyze in this article the main postulates of both pragmatism and fictionalism and offer our point of view on each position. Regarding pragmatism, we propose to reappraise the representation relation as a methodological strategy within some scientific contexts of model building. Furthermore, we argue that the representational relation is fully compatible with the pragmatic view of models. As for fictionalism, we discuss the weight of fictions in the structure of models and favor a deflationary narrow account on this subject.

The topics to be developed are ordered as follows: section two deals with the pragmatic account of models and the thesis of scientific pluralism. Section three presents some criticisms of the representational conception of models. In this same section, we propose to re-evaluate the model-target relation and define its limits and validity in the context of the pragmatic view. In section four, we examine the relationship between pragmatism and fictionalism and provide our point of view about the role of fiction in model building. Section five summarizes our main conclusions.

2. The Pragmatic Account of Models and the Relationship to Scientific Pluralism

2.1. Antecedents of the philosophical pragmatist perspective

Pragmatism is a philosophical tradition that flourished in the United States near 1870 through the salient figures of Charles Sanders Peirce (1839-1914) and William James (1842-1910). Some years later, the movement was enriched by the great influence of John Dewey's ideas (1859-1952) that brought about the pragmatist principles to educational, social, and political fields. It is pertinent to outline the main principles that nurtured the pragmatist tradition, as they are alive in contemporary accounts of the philosophy of science through authors such as Richard Rorty, Hilary Putnam, Robert Brandom, Susan Haak, and many others. Today those thinkers are included in a movement called "Neopragmatism"

because they reaffirmed and complemented the central ideas of the classics about knowledge, science, and research (Legg & Hookway, 2024). In more recent years, the pragmatist tradition has gained new momentum from a movement named "Methodological Pragmatism" (Gillespie et al., 2024; González, 2020; Rescher, 2020; Kaushik & Walsh, 2019, among others). The scholars who enlist in Methodological Pragmatism consolidate the central notions of classical pragmatism, and in many cases, strengthen the position giving rise to "Pragmatism as a Research Paradigm" (Kaushik & Walsh, 2019). Thus, we can distinguish three phases in the movement: Classical Pragmatism, Neopragmatism, and Methodological Pragmatism.

A central tenet of the traditional pragmatist doctrine (from now on "Classical Pragmatism") is the concept of human action; only through the action we connect with the world, get to know its features, and integrate the world as a part of it. In this transaction with nature, experience is necessary to acquire knowledge and guide action. Classical pragmatists, in particular William James, embraced a kind of radical empiricism. They also supported the relevant role of scientific methods, context-bound scientific practice, and the presupposition that true beliefs are closely related to the results and consensus reached by the scientific community (Peirce, mentioned in Misak, 1991). For his part, William James stood up for metaphysical and methodological pluralism, a core thesis for our argumentation, as will be seen in the following sections.

As we have just mentioned, Pragmatism experienced a revival nearly the middle of the twentieth century giving birth to Neopragmatism by a number of recent philosophers like Richard Rorty, Hilary Putnam, and many others. Rorty dismissed the idea of truth as a metaphysical concept and contrasted firmly to *representationalism* with respect to beliefs and utterances. Putnam rescued the main topics of classical pragmatism and brought to the forefront what he called "the primacy of practice" (Legg & Hookway, 2024); their contributions to philosophical problems are now actualized in the contemporary philosophy of science.

For its part, advocates of Methodological Pragmatism also confirm the role of experience in the acceptance of beliefs and state the supremacy of methods when developing a research program emphasizing the process over the product. Nicholas Rescher characterizes methodological pragmatism in the following terms:

> […] the philosophical pragmatism is prepared to forsake general principles, doctrinal ideologies, and theoretical idealizations and use instead as this guide the arbitrament of experience. Its focal concern is for outcomes, for how things evaluate in practice (Rescher, 2020, p. 70).

Methodological pragmatists also argue that one important goal of research is getting answers to the questions formulated by scientists, and the methods adopted for this purpose serve as mediators in scientific activity. Moreover, this methodological vision underlines the necessity of taking into account the scientific and social context when applying the pertinent methods.

Theories and models that scientists apply in their investigations are conceived as *tools* that facilitate the production of knowledge (Gillespie et al., 2024). Thus, models are not copies of the world, they do not reflect reality. What methodological pragmatism demands is to evaluate the research process on the basis of the quality of the product, which has to be effective and, if possible, efficient (Rescher, 2019, p. 7). This is a pragmatic criterion for evaluating the scientific enterprise, rather than attempting to mirror reality.

It is worth adding that methodological pragmatism incorporates —as a relevant component of its scope— a diversity of perspectives (perspectivism thesis), and strongly favors the current famous thesis of *methodological pluralism* pre-announced by James (1909), Schlick (1925) and Suppes (1978).

The following section examines scientific pluralism more carefully to give grounding to the representational view.

2.2. The thesis of scientific pluralism

As has been said, pragmatism in all its phases adopts from the outset the thesis of scientific pluralism, which fulfills a special role in our argumentation. The thesis has its historical roots in the writings of William James (1909) and John Dewey (1938); a few years later it was emphatically defended by Patrick Suppes (1978) and adhered to by many other philosophers (Karl Popper, Nancy Cartwright, Peter Galison, Ian Hacking, among others). The movement emerged as an alternative —and simultaneously in opposition— to the ideal of a unification of science, and the notion of philosophy as a unified knowledge. Since then, it has grown through the thinkers of American and European philosophers, encompassing multiple levels: metaphysical, epistemological, methodological, and social aspects. Pragmatists of the twentieth and twenty-first centuries understood that diversity is not a problem, but rather a productive feature of science (Ludwig & Ruphy, 2021). In this respect, the pluralist thesis questions a naïve monism that asserts that a phenomenon or area of research can be completely explained by a single, comprehensive theory. At present, there are moderate versions and radical forms of pluralism, but in all cases, the

fact that the sciences apply various theories and/or models to account for their subject matters is emphatically stressed.[1]

Beyond the diversity of modalities, pluralism has been projected to both scientific and meta-scientific levels. It authorizes a variety of representational schemes, classifications, explanations, methodological strategies, models, and theories, and the proper strategies to respond to them (Kellert et al., 2006). In terms of research methods, pluralism highlights the epistemic advantages of applying different methods to the study of the same type of phenomena. We contend that there is a narrow relationship between scientific pluralism and pragmatism in general, since the diversity of accounts depends on the epistemic interests and goals of the scientists who work in definite contexts of investigation.

Kaushik and Walsh citing other scholars claim:

> Certainly, one important strategy for inquiry would be to employ multiple methods, measures, researchers, and perspectives. However, this should be done reasonably and practically (Patton, 2002). It has been established that, as a paradigmatic position, pragmatism assumes an independence of methods (Greene & Caracelli, 2003; Teddlie & Tashakkori, 2009) in which researchers do not have to absolutely commit themselves to a particular research method (Robson, 1993) (Kaushik & Walsh, 2019, p. 7).

Other advocators of contemporary methodological pragmatism stand for pluralism, Wenceslao González states:

> Both pragmatism and pluralism are, in principle, open to a diversity of methods in science, in general, in a group of sciences (natural, social, or artificial), and in specific sciences (physics, economics, computer sciences, etc.). This implies that they do not start from a macrotheoretical scheme of unity of science or from the need for a methodological unification of sciences […] (González, 2020, p. 2).

And Gillespie et al.:

[1] Kellert et al. distinguish a modest kind of pluralism (Mitchell, 2002; Kitcher, 2001), a radical pluralism sustained by Dupré (1993) who defends a *promiscuous realism*: there are infinite approaches to examining and classifying objects, and none of them is more correct than the others. A third position, deemed "pluralist stance," is an epistemological and local view of pluralism; the latter is the point of view defended by the authors (see Kellert et al., 2006, xii-xv).

> […] we need methodological pluralism, as no single method or body of data could account for differences in perspective and the study of human action (Gillespie et al., 2024, p. 46).

The thesis of scientific pluralism is a key concept in the context of the present work. Including this principle in our point of view allows us to support our conviction that the representation relation —among many other procedures— is an available methodological strategy that has contributed to obtaining useful conclusions about some aspects of reality. Moreover, it has been successfully applied in a large number of case studies, as can be found in contemporary literature.

To deepen this line of argument, we examine in the next section the connection of pragmatism with the representation relation.

3. Pragmatism and Representation

3.1. Some criticisms of the model-target relationship

In recent times**,** many authors have assumed a very critical attitude towards the traditional conception that took the relationship between the model and a defined objective as the unit of analysis; this perspective is often referred to as "representationalism" or "representational paradigm"[2]. Nowadays, it is quite common to find criticisms pointing out the excessive importance given to this relation that has caused –according to the critics— a serious limitation in the understanding of the subject. Knuuttila (2010, 2011) notes that the thesis of indirect representation developed by Weisberg (2007) and Godfrey-Smith (2006), in conjunction with the pragmatic view, contributed to decoupling the model-target relationship that has been, from the start, the unity of analysis in the traditional version of representation. In defense of this decouple she argues that the representation relationship has produced serious limitations such as not paying attention to the models

[2] Godfrey-Smith (2017) has been struck by the vagueness and ambiguity of the concept of representation, and the fact that there are many ways to come to it. Generally, it is understood as a copy or reproduction of an object by some kind of symbol, without committing to an interpretation of how the process is carried out. In the latter case, on the contrary, we find several philosophical and psychological theories that intend to explain its nature and function. Godfrey-Smith's remarks have the merit of distinguishing between an everyday sense of representation and the term *representationalism*, as a philosophical theory. In this work, we will refer to representation in the framework of scientific model construction to evaluate the model-target relationship and the role it fulfills in the acquisition of knowledge. We are grateful to an anonymous reviewer who redirected us to Godfrey-Smith's points of view.

as constructed entities, to the mutual relations between models, nor to the various means used to represent.

Look at the following remark from Knuuttila:

> As I have argued, the pragmatic accounts of representation, somewhat paradoxically, make apparent the *limits* of representational paradigm as regards the epistemic value of modeling. Consequently, *abandoning the representational approach* to models, I suggest, actually enable us to pay attention to the very means of representation with which scientists build their models (Knuuttila, 2010, p. 171, italics added).

In another place, she adds**:** "However, I will argue that this situation could be avoided if we did not choose the representational model-target dyad as the basic unit of analysis […]" (Knuuttila, 2011, p. 6).

Another source of criticism on the representational relationship comes from the perspective of pragmatist philosophers who exhibit an instrumentalist-oriented view. In his article "Modeling without Representation" (2013), Alistair Isaac argues that models that have not been formulated for an explanatory purpose can be justified without reference to their representational properties. His proposal is to offer an alternative strategy that accounts for phenomena, a strategy that justifies the practice of modeling on purely pragmatic grounds, i.e. that models are evaluated in the context of each particular use case and by virtue of the goals achieved for which they have been constructed. The virtue of models lies primarily in their ability to lead to empirically testable predictions; whereas the truth of the model's assumptions and their supposed connection to some defined target are not significant:

> On this view [the realist perspective], the justification of modeling as a scientific practice must ultimately rest upon an analysis of how models represent: representation is conceptually prior to success. *Ironically this attitude runs contrary to the pragmatic methodology* […] (Isaac, 2013, p. 2, italics added)

Isaac contrasts a realist conception of modeling practice —which attributes to models an explanatory function—, with the pragmatic perspective he advocates. The realist view assumes that models explain by virtue of correctly representing the modeled system; that is, representation is paramount.

But, "Ironically this attitude runs contrary to the pragmatic methodology" because what prevails in the pragmatic conception is the

success of predictions and not the correctness or incorrectness of the representational role. "The pragmatic methodology of modeling on offer here won't work for models which are intended as explanations" (Isaac, 2013, p. 9).

However, the contrast between pragmatism and realism is not a topic defended by all the proponents of pragmatism. Pragmatism does not necessarily oppose the realist conception of science. Some of its strongest advocates think that methodological pragmatism is open to realism and even to the idea of truth as correspondence. For Rescher (2020) the selection of methods that have proven to be most effective in scientific practice function as mediators in the estimation of true beliefs, at least for the time being.

> The more varied and complex the range of phenomena being addressed successfully the greater will be our confidence in the adequacy of the methods and consequently in the reliability of their deliverances. And on this basis, *methodological mediation becomes the gateway to realism*, with the acceptability of factual claims vouched for by the efficacy of their methodological procedures (Rescher, 2020, p. 79, italics added).

It is worth clarifying that the representational relation that models carry out does not intend to *copy* the world, since in representing a defined target, the modeler takes advantage of idealizations that distort the represented phenomenon, sometimes to such an extent that it makes impossible a subsequent des-idealization.

3.2. Revisiting the model-target relationship

In this section, we revisit the representation relationship in light of the various criticisms we summarized in section 3.1. In our view, these criticisms require further analysis. Our argument is to defend the idea that some limits should be imposed on the scope of application of the model-target relation; however, this does not mean ruling it out from all scientific contexts. Moreover, there are circumstances in which the representation relationship is not at all dispensable, as we shall see below.

Before giving our points of view on the matter, we will encounter a question that is not entirely clear: to which position(s) exactly does the term "representationalism" refer?

The term suffers from certain vagueness in the texts where it appears, we will try to clarify two different uses. In the first place, it seems to refer to substantive theories of representation that postulate a

privileged relation between the properties of two objects: the model and the target, with little or no involvement of agents. This view was superseded by Giere's perennial claim "S (the agent) uses X (the model) to represent W (some aspect of the world) for the purposes P" (Giere, 2004, p. 743). But the term "representationalism" also seems to refer to some deflationary conceptions of scientific representation that —while taking into account the agents' goals and the context of the research— view the model-target relationship as a relevant and even necessary feature to gain knowledge of aspects of the world. Authors who defend this point of view probably believe that it is precisely this relationship that allows them to obtain the information they are seeking (Bokulich, 2011, 2018; Chakravartty, 2010; Giere, 2010; Frigg, 2010a, 2010b; Frigg & Salis, 2020; Kuorikoski & Ylikoski, 2015; Nguyen, 2020; Suárez, 2004, 2010, 2015; Teller, 2009; Fang, 2019).

From her part**,** Knuuttila includes some proponents of the deflationary theory as those that also focus on the representation relationship. Some deflationary theories that follow Giere's postulate in proposing an irreducibly triadic relationship (vehicle-target-user) would fall under representationalism; and this is so because those theories, like the substantive versions, retain the model-target relationship as a starting point. For Knuuttila (2011, p. 8): "their point of departure is the same as that of the two-place accounts: the relationship of a single model with its putative real target system". She also casts doubts over its epistemic value because it is not clearly established how we could learn from models (Knuuttila, 2011, p. 263).[3]

Our point of view is in some way different; on one hand, we propose to restrict the so-called "representational paradigm" to the substantive view. Only when the only thing at stake is the two poles of representation understood as two objects —the model and its target— the representational relationship does monopolize the whole process. On the other hand, we believe there are good and sufficient reasons to preserve the representational relationship in the case of some deflationary theories, for they can accommodate the relation without preventing scientists from analyzing and manipulating the whole model, and they do this to achieve their intended goals within the context of each particular research.

[3] Knuuttila (2021) offers an alternative to the traditional view, the *artifactual* theory of models that conceives of models as epistemic artifacts (per se objects); they are subject to analysis, manipulation, and interconnections. The advantage of the artifactual account over the representational approach rests in that it avoids the problem of representation, and accommodates the modal dimension of models (Knuuttila 2021, p. 2). For thematic and space reasons we will not revise the artifactual view here.

To illustrate the point, let us consider some deflationary theories such as the one put forward by van Fraassen in the framework of his Empirical Structuralism; van Fraassen's account does not prevent digging deeply into the model itself. Quite the contrary, the construction of a data model intended to represent a phenomenon requires a great number of measures, calculations, and methodological decisions in accordance with a theory or theories. Although van Fraassen argues for an embedding relationship between the two structures in question (the substructure of the theoretical model and the data model of the phenomenon), the representation is determined from the outset by the interests and choices of the user, who is selective in representing the phenomenon "in a certain way and to a certain extent" (van Fraassen, 2008, p. 254). Van Fraassen's central tenet is: "Nothing represents anything except in the sense of being used or taken to do that job or play that role for us" (p. 253).

In line with this approach, it may be useful to bring to the scene the analysis of Roman Frigg and Fiora Salis (Frigg, 2010b; Frigg & Salis, 2020). According to them, representation is central to understanding the role of models in scientific research: "This distinction, I think, is crucial to understanding how scientific modeling works and a failure to keep the two separate has led to considerable confusion" (Frigg, 2010b, p. 112).

They also develop a detailed analysis of the model-target relationship using the comparison with maps; the idea is that model systems are t-representations (representations of the target) in the same way that maps are representations of some territory. The connection between the model and its target system is satisfied when the properties and relations that belong to the constructed model system are imputed to the target via a key. It also needed a key as a sort of interpretation that allows the user to impute facts about the map to assertions about the target system. That is the *Deki* Model.

Although Frigg's theory is based on analogies with literary fictions, they should not be interpreted as all the same. An important difference between fictional objects and scientific models is that:

> Fictional scenarios in science are often *created with a specific target system in mind,* and the scenario is chosen such that t-representation can be set up — [those] considerations play only a marginal, if any, role in literature (2010b, p. 125, our italics).

The above quotation shows how Frigg places the representational relation at the core of the theory; thus, it cannot be moved to the background except for methodological reasons.

Mauricio Suárez's account is another position that focuses on the representational relationship. According to inferential theory, the two vectors that structure the relationship between a model A and a target system B are representational force and inferential capacity (Suárez, 2004). A competent and informed agent to draw specific inferences from A to B. A pragmatic virtue of this theory is that it presupposes no relation of reference or denotation between A and B:

> The notion of representational force is defined so that it is fulfilled by any attempt at reference or denotation, however unsuccessful, that accords to the social practices and norms conventionally adopted in the use of such representational force. Also the notion of "inferential capacity" is fulfilled by any model that has sufficient internal structure to permit inferences regarding its "target," regardless of whether it denotes it, or indeed regardless of whether it is intended to denote it. (Suárez, 2009, p. 171).

But note that Suárez's inferential theory does not rule out the model-target relation, but rather relaxes the type of representationalism compared to previous conceptions that include denotation as a necessary condition (Hughes, 1997; Frigg 2010b; Frigg & Salis, 2020). Incorporating the model's capacity to generate surrogate reasoning as a central feature of the theory does not mean excluding the representation relationship, quite the contrary: note that this type of reasoning has its premises in the model while its conclusion refers to the target. Without the representational relation, surrogate reasoning would be unfeasible.

In the same line of thought, Alisa Bokulich (2018) extends the notion of representation to the construction of scientific explanations. She promotes an *eikonic* conception as opposed to the ontic approach. The *eikonic* view underlines the essential role of representation when performing a scientific explanation, conceived as the output of an epistemic activity. Moreover, her proposal favors a kind of pluralism since it could be built on more than one explanation about the same phenomenon, and that plurality increases our knowledge of the world:

> As argued earlier, this plurality of representations is not a weakness of the investigation, rather it is a strength, allowing us to learn more about an entity or phenomenon than we would with any one representation alone (Bokulich, 2018, p. 17).

All the above remarks adopt a general deflationary perspective on the model-target relation, which, in a way, contrasts with the leading role

it had in previous accounts of models. We welcome the fresh air brought about by the critics. Still, we argue that it might be possible to complement that view with a more flexible account of the representation relationship as another strategy that, under special circumstances, achieves the desired results. Knuuttila seems to approve of this idea:

> Although this account [the artifact view] provides an alternative to the representational view of models, it is not directed against representation *per se*. I do not doubt that *in many cases* we have good reasons to believe that our scientific representations succeed in adequately depicting some real-world targets (Knuuttila, 2011, p. 270, italics added).

3.3. The model-target relationship in the context of the pragmatic view

As we have just seen, the current literature shows a variety of representational relation-based theories that provide reliable knowledge about aspects of the world. Our proposal in this section is, on the one hand, to assess the scope and relevance of representational meta-theories, and on the other hand, to show that such theories can be perfectly accommodated into the pragmatist view of models.

Without exception, proponents of the pragmatic approach claim that model building and other practices such as experimentation, measurement, new theoretical concepts, and well-established data are resources for acquiring knowledge. So far, so good, however, in most cases, the modeler anticipates the emergence of a final stage where she intends to align the model with its designated target. We have already mentioned that some instrumental-oriented pragmatists claim that the main goal of modeling is to formulate testable predictions setting aside the representation relation. Isaac says:

> In the context of the day-to-day life of a laboratory, however, *it is having a prediction to test which is important*, its correctness or not is determined *ex post facto* (Isaac, 2013, p. 10, italics in the original).

However, it is difficult to make this move —the *ex post facto* confirmation stage— without resorting to the coordination of the model to the real phenomenon. This seems to be a necessary condition to test the efficiency of the model at stake. We propose another way out. It consists of distinguishing two phases in the pragmatic account of modeling: a first phase in which the representation relationship is set aside for the time

being and the focus is on the model as an independent artifact with its own right to be examined and manipulated. This is a methodological step that undoubtedly pays off. However as the validation of the model depends to a large extent on the fulfillment of its specific function (which is to gain knowledge of some aspects of the world), the representational relation has to be re-installed. Only then, we can verify if the model has achieved the intended purpose. In addition, users almost always have in mind some kind of correspondence between their models and the phenomenon under investigation. No matter whether it is a conscious or unconscious idea, this expectation underlies their modeling practices. We believe it is desirable to maintain the epistemic intentionality that drives the modeler to reconnect with the world.

Let us go back now to the pragmatism view, we want to pose two questions about the issue:

(a) Is the model-target relationship compatible with the pragmatic approach summarized in this work?

(b) Should we relegate the model-target relationship to the background because the priority is the analysis and manipulation of the model?

In the second section, we have summarized the basic ideas of Classical Pragmatism and how they evolved to make up the hard core of contemporary Methodological Pragmatism. One of the fundamental postulates of pragmatism (in both the classical stage and now) is its commitment to methodological pluralism; it is time to return to the point. We have just affirmed the central role of that thesis in our proposal: Surely, we are firm supporters of methodological pragmatism and scientific pluralism in research activities. It is because of such adherence that we will answer both questions. To question (a): "Is the model-target relationship compatible with the pragmatic approach summarized in this work?" our answer is affirmative. Our argument favors the point that methodological pragmatism supports epistemic and methodological diversity following the theses of scientific pluralism, as has been shown throughout quotations from various advocates of the movement. Thus, returning to the context of model building, the principle of scientific pluralism allows us to reinstate the controversial representation relationship as a necessary component of some views of the scientific model's function.

The answer to question (b) "Should we relegate the model-target relationship to the background because the priority is the analysis and manipulation of the model?" is negative. Any procedure or strategy that has been proven effective in achieving the desired cognitive goals is welcome to the platform of methodological pragmatism (Rescher, 2020).

The representational relationship is a constitutive part of the inferential view of representation defended by several scholars (Frigg, Suárez, Nguyen, Salis, Fang) who have worked successfully in many case studies of various disciplines. Thus, the strategy of coordinating a constructed and manipulated model with a defined target in specific circumstances of research can live in complete harmony with a variety of other equally effective procedures and similar epistemic values inside the pragmatist framework in general, and in methodological pragmatism in particular. We conclude that the pragmatic view is broader and more encompassing than expected. Nor do we find any convincing reason to distinguish hierarchies of tasks; thus, the pragmatic approach is certainly broader and more encompassing than it might be supposed.

4. Pragmatism and Fictionalism

We have already mentioned at the beginning of the article that several pragmatists, who investigate the construction of scientific models, incorporate a fictional point of view in their accounts. Two classic theories of fictions function as theoretical frameworks for fictional positions: the philosophy of 'as if' by Hans Vaihinger (1935) and the pretense theory by Kendall Walton (1990).

The anchoring point of the pretense theory is the deployment of human imagination. As previously stated in the introduction, Walton builds his famous categories for the analysis of fiction in terms of games of make-believe, props, principle of generation, ad hoc games, and authorized games. Many scholars have applied Walton's theory by looking for analogies between scientific models and works of art (Toon, 2012a, 2012b; Levy, 2012; Frigg, 2010a). They projected Walton's technical concepts to the modeling activity; for instance, a description of the model is seen as a *prop,* which invites us to imagine a fictitious situation they identify with the content of the model. Model systems usually are presented to us by way of descriptions, and on some occasions**,** these descriptions should be understood as props in games of make-believe. Characteristically, model system descriptions begin with 'consider' or 'assume' and thereby make it clear that they are not descriptions of facts, but an invitation to ponder – in the present idiom: imagine — a particular situation (Frigg, 2010a, p. 260)

The pragmatists who follow Vaihinger's line of thought rather than focusing on the nature of fiction concentrate on its cognitive function; it is no surprise they have recognized the resounding echos from the Philosophy of 'as if'.

> An idea whose theoretical untruth or incorrectness, and there with its falsity, is admitted, is not for that reason practically valueless and useless; for such an idea, in spite of its theoretical nullity may have great practical importance (Vaihinger, 1935, p. VIII). [...] Fictions are never verifiable, for they are hypotheses which are known to be false, but which are employed because of their utility (p. XLII).

For example, Suárez explicitly affirms, as a difference from the German philosopher, that he follows Vaihinger's characterization of fiction; however, he frees fiction from its truth value. While for Vaihinger fiction is false, and used with full consciousness of its falsity, for Suárez the truth value is a secondary aspect.[4] What characterizes fictions in model building is that they allow for quick and convenient inferences to be made about the real system; in other words, fictions are defined by their function: "In particular, I insist that convenience in inference is the main defining function of a scientific fiction" (Suárez, 2009, p. 159). In this conceptual framework, functional characterization is paramount, while truth-value is at most a by-product.

But, what is more important to the proposal of this work is that philosophers who apply the ideas of Walton's theory of make belief as well as the philosophy of 'as if' by Vaihinger, both state the ubiquity of fiction in the scientific language, and by extension, in the construction of models. Indeed, they look worried about making clear the analogies and differences between the works of art and literature on the one hand, and scientific models on the other. This view is a consequence of having adopted a too wide version of fictionalism that we call *full fictionalism*. The supporters of full fictionalism consider as fiction not only the assumptions of the model that fail to denote (ether, phlogiston) —but are nevertheless maintained because they cooperate in achieving the explanatory and predictive objectives—, but they also qualify the operations of abstraction, idealization, and distortion as fictions. As a result, scientific models are plagued by fictions. Once it has been assumed full fictionalism, making a difference between works of art and models becomes imperative since science runs the risk of becoming science fiction. Our position is in favor of restricting the concept of fiction only to those models' suppositions that lack reference to the real world. We call *narrow fictionalism* to that restrictive mode of fictionalism. As for the idealizations and distortions that scientists operate in the construction

[4] Suárez considers that Vaihinger "[…] failed to distinguish the truth-conditional and the functional characterizations, and tended to run together the thought that the truth-value of fiction is irrelevant and the thought that fictions are false" (Suárez, 2010, note 18).

of models, we take them as methodological procedures to facilitate the calculation and draw inferences about the target phenomenon.

An example of full fictionalism is the inferential theory by Mauricio Suárez (2010). The two senses that we have just discussed are separated inside Mauricio Suárez' view. He distinguishes a *fictional* representation from a *fictive* one. The former refers to an imaginary and non-existent entity from an ontological point of view, while the latter represents inaccurately a real entity. But, although Suárez differentiates both concepts, he seems to assume that all models are fiction, precisely because they are fictional or fictive (or both simultaneously). In other words, like the followers of the pretense theory, Suárez stands for full fictionalism. One of the consequences of adopting full fictionalism is that there is no more criterion for identifying fiction. In effect, the advocates of full fictionalism who propose to identify fiction by its cognitive function, get in trouble because if the only criterion we have to recognize fiction is the function it plays within a model, then how are we going to distinguish between fictional and no fictional components of a scientific model? When assuming full fictionalism, its advocates seem to be unable to justify the identification criterion of fictions. Remember that models are heterogeneous structures, complex unities composed of numerous elements such as theories, empirical evidence, mathematical formulae, metaphors, concepts from a background of accepted beliefs, and even unrealistic assumptions with no counterpart in the world. These various elements are integrated into a structured system, invested with a representational function.[5] So, since the non-fictional components of a model contribute, along with the fiction (if there is any in the model), to the formulation of fast and convenient inferences, we have no longer a criterion for identifying fiction as a separate class from the class of non-fictional elements. Thus, the cognitive function is inappropriate for giving identity to fiction since many assumptions with a counterpart in the real target serve the same function.

As the strategy of *divide et impera*,[6] we contend that narrow fictionalism shows an advantage over full fictionalism; it does allow for distinguishing between the components directly connected to the target and those that only play a complementary role; for not all the elements

[5] In complete agreement with this idea, José Díez coined the term *ensemble-plus-stand-for* to express the same concept in reference to a cluster of entities, properties, and relations that are articulated in the model in a special way to "stand for" certain target (Díez, 2021, p. 120).

[6] The strategy of *divide et impera* proposed by Stathis Psillos (1999) with antecedents from Philip Kitcher (1993) stands as a form of selected realism to face the antirealist argument of the pessimistic meta-induction. See Psillos, 1999.

of the model are fiction. Thus, in the context of scientific model building, fiction loses the cognitive prominence granted to it.

In a similar way, Paul Teller distinguishes between the "component-idealizations" of a discourse and the "component-fictions". The latter refer to fabulated objects, properties, or states of affairs that do not exist (Santa Claus, the ether); while the former are fictional descriptions of real objects, as when a physical object is described as a point particle or water as a continuous fluid.[7] Both types of components can be inserted as parts of a model. But, note that the model in question can still be "veridical"[8] about those aspects of the real phenomenon in which we are interested, even if the model contains fictitious objects as its parts:

> In cases like these, it would be very misleading to say that the discourse or other representation has been turned into something that as a whole counts as fictional, that as a whole counts as a fiction in the inclusive sense […] Component fictions do not generally turn a *larger veridical representation* itself into a fiction or make it, as a whole, fictional (Teller, 2009, p. 243, our italics).

On the other hand, assigning to a model a property that the phenomenon does not have or suppressing a property that the modeled system does have can be used to make the reasoning and calculations convenient, but it could simply be an error that must be corrected later. However, it is worth pointing out that errors are not fictions. According to Teller, error and fiction are different epistemic categories:

> Characterization as a mistake or as a fiction functions as epistemic categories. As we noted before, a fiction is never a mistake. A mistake is a claim made in the belief that it is true or accurate, although in fact it is false or inaccurate. A fiction is also a description that is false or inaccurate. But it is one that is known as such (Teller, 2009, p. 246).

[7] The case of Teller illustrates an intermission stance since he names "fictional descriptions" of real objects to the activity of idealization, distortion, etc.; while for us they are only methodological resources.

[8] Teller uses the term "veridical" and not "true" to refer to a sentence, a statement, or a model when it is enough accurate according to our present interests and needs: "I will use the term veridical as the umbrella success term when, with respect to present interest, a representation succeeds in representing things as they are, in the way achieved by an accurate map, a true (enough) statement, and other sorts of accurate but not completely exact representations" (Teller, 2009, p. 237).

In line with our point of view, Margaret Morrison narrows the field of what she considers fictitious. Unreal models are descriptions of a situation that cannot be true about a real phenomenon, e.g., the Maxwell model of the ether (Morrison, 2009, p. 110). In contrast, the processes involved in abstraction and idealization are typically not the same as those involved in fictional models; they constitute a different intellectual activity. From his part, Alejandro Cassini also limits to some extent the scope of the fictitious components. Indeed, he claims "[…] we should consider as fictions those elements of a model whose existence is physically impossible according to our fundamental theories" (Cassini, 2013, p. 359, our translation).

Moreover, as advocates of narrow fictionalism, we minimize analogies between scientific models and fictional works of literature and other arts. We think that scientific models have a fundamental function, which is to achieve knowledge of some aspects of the world, but this does not seem to be the main purpose of works of art. Thus, we distance ourselves from the Waltonian perspective and from those positions that incorporate full fictionalism.

In summary, the justification of fiction in scientific contexts seems to be more problematic than the advocates of full fictionalism try to show. In the history of science, there are some examples of entities postulated for predictive or explanatory purposes that were taken as useful fictions at the beginning but were later shown to have a real existence (the atom could serve as an example).

There are other examples in which the application of a property that proved to be non-existent was considered a mistake by the practitioners of the time, although they continued to use it for convenience. However, sometime later the property acquired the status of fiction. This happened with the attribution to the water of the property of continuous medium (Teller, 2009). Such cases exhibit the historical relativity of the concept. The modest attitude we adopt (narrow fictionalism) has no minor advantages: First of all, it is ontologically economic because it does not claim to provide a theory on the nature of fiction, since no consensus has been reached on the matter for the time being. Moreover, it avoids the thorny question of establishing a proper demarcation between literary works and scientific models, between science and science fiction. We believe that delving into the development of the philosophy of "as if" or even the theory of pretension may be an attractive and possibly fruitful philosophical exercise, but it is not a prerequisite for coming to understand modern scientific practices from a pragmatic perspective.

Our approach allows us to affirm that pragmatism does not demand the proponents to enlist in the lines of fictionalism and even less in those of

full fictionalism. Although some pragmatists adopt the latter as their own (Suárez), this is only an option. However, those who choose that option, be pragmatist or not, should face and resolve many relevant troubles some of which have been pointed out throughout the current manuscript. Pragmatism is thus exempted from assuming strong commitments to fiction in science.

5. Conclusions

Throughout the development of the article, we have referred to Pragmatism and Methodological Pragmatism as philosophical doctrines that offer broad space to accommodate model building activity. One of our main goals in this subject was to revise the model-target relationship, which has been strongly questioned. We agree about the need to put some limits to its application, as some critics have pointed out (Knuuttila, 2010, section 3.1); however, despite the criticism, the model-target relationship should not be excluded from all research contexts. At least, it is necessary to be maintained in most theories such as the inferential view of scientific models. That said, we have suggested reinstalling the model-target relationship because it is desirable to keep the epistemic intentionality that drives the modeler to reconnect with the world. Finally, we showed that reinstalling it is in no way incompatible with the pragmatism approach, in virtue of the scientific pluralism thesis, which is an important tenet of pragmatic doctrines.

On the other hand, we addressed the connections between pragmatism and scientific fictionalism and exposed the reasons for rejecting full fictionalism. Regarding this issue, we adopt a modest attitude towards fiction (narrow factionalism). The perspective we have adopted does not deny the role of imagination in the construction of models; however, our position is modest in the sense that it restricts the hegemonic role of fictitious assumptions. Moreover, it is true that there are models that contain some fictional element (ether, phlogiston), but it always occurs in an intimate integration with the realistic assumptions, and it is precisely this conjunction of heterogeneous parts that allows the formulation of inferences that transfer information from the model to the objective system. Thus, full fictionalism does not diffuse invasively into the content of a model.

In sum, adopting a pragmatic point of view does not constrain us to assume a commitment to fictionalism or to the nature and function of fiction in science.

References

Bokulich, A. (2011). How scientific models can explain. *Synthese*, *180*, 33-45. https://doi.org/10.1007/s11229-009-9565-1

Bokulich, A. (2018). Searching for non-causal explanations in a sea of causes. In A. Reutlinger & J. Saatsi (Eds), *Explanation beyond causation: Philosophical perspectives on non-causal explanations* (pp. 141-163). *Oxford University Press.* https://doi.org/10.1093/oso/9780198777946.003.0008

Cassini, A. (2013). Modelos, idealizaciones y ficciones: Una crítica del ficcionalismo. *Principia, 17*(3): 345-364. https://doi.org/10.5007/1808-1711.2013v17n3p345

Chakravartty, A. (2010). Informational versus functional theories of scientific representation. *Synthese, 172*: 197-213. https://doi.org/10.1007/s11229-009-9502-3

Dewey, J. (1938). Unity of science as a social problem. In O. Neurath, C. W. Morris & R. Carnap (Eds.), *International Encyclopedia of Unified Science* (Volume I, No. 1, pp. 29-38). Chicago University Press. Reprinted in J. Dewey (1988), *The Later Works of John Dewey* (Volume 13: *1938-1939,* pp. 271-280). Southern Illinois University Press.

Díez, J. A. (2021). Scientific representation as ensemble-plus-standing-for: A moderate fictionalist account. In A. Cassini & J. Redmond (Eds.), *Models and idealizations in science: Artefactual and fictional approaches* (pp. 115-131). Springer. https://doi.org/10.1007/978-3-030-65802-1_5

Dupré, J. (1993). *The disorder of things: Metaphysical foundations of the disunity of science.* Harvard University Press. Cited by S. H. Kellert, H. E. Longino, & C. K. Waters, (Eds.) (2006), *Scientific pluralism.* University of Minnesota Press.

Fang, W. (2019). An inferential account of model explanation. *Philosophia, 47*, 99-116. https://doi.org/10.1007/s11406-018-9958-9

Frigg, R. (2006). Scientific representation and the semantic view of theories. *Theoria: An International Journal for Theory, History and Foundations of Science*, *21*(1), 49-65. https://doi.org/10.1387/theoria.553

Frigg, R. (2010a). Models and fictions. *Synthese, 172*, 251-268. https://doi.org/10.1007/s11229-009-9505-0

Frigg, R. (2010b). Fiction and scientific representation. In R. Frigg & M. Hunter (Eds.), *Beyond mimesis and convention: Representation in art and science* (pp. 97-138). Springer. https://doi.org/10.1007/978-90-481-3851-7_6

Frigg, R., & Salis, F. (2020). Of rabbits and men: Fiction and scientific modeling. In B. Armour-Garb & F. Kroon (Eds.), *Fictionalism in philosophy* (pp. 187-206). Oxford. https://doi.org/10.1093/oso/9780190689605.003.0010

Giere, R. (2004). How models are used to represent reality. *Philosophy of Science, 71*(5). 742-752. https://doi.org/10.1086/425063

Giere, R. (2009). Why scientific models should not be regarded as works of fiction. In M. Suárez (Ed.), *Fictions in science: Philosophical essays in modeling and idealization* (pp. 248-258). Routledge.

Giere, R. (2010). An agent-based conception of models and scientific representation. *Synthese, 172*(269). https://doi.org/10.1007/s11229-009-9506-z

Gillespie, A., Glăveanu, V., & de Saint Laurent, C. (2024). *Pragmatism and methodology: Doing research that matters with mixed methods.* Cambridge University Press. https://doi.org/10.1017/9781009031066

Godfrey-Smith, P. (2006). The strategy of model-based science. *Biology and Philosophy*, *21,* 725-740. https://doi.org/10.1007/s10539-006-9054-6

Godfrey-Smith, P. (2017). Dewey and anti-representationalism. In S. Fesmire (Ed.), *The Oxford handbook of Dewey* (pp. 151-172). Oxford University Press.

Gonzalez, W. J. (2020). Pragmatism and pluralism as methodological alternatives to monism, reductionism and universalism. In W. J. González (Ed.), *Methodological prospects for scientific research: From pragmatism to pluralism* (pp. 1-18). Springer. https://doi.org/10.1007/978-3-030-52500-2_1

Greene, J. C., & Caracelli, V. J. (2003). Making paradigmatic sense of mixed methods practice. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (pp. 91-110). Sage. Cited by V. Kaushik, & C. Walsh (2019), Pragmatism as a research paradigm and its implications for social work research. *Social Sciences, 8*(9), 255.

Hughes, R. I. G. (1997). Models and representation. *Philosophy of Science*, *64*, S325-S336. http://www.jstor.org/stable/188414

Isaac, A. M. C. (2013). Modeling without representation. *Synthese, 190*, 3611-3623. https://doi.org/10.1007/s11229-012-0213-9

James, W. (1909). *A pluralistic universe*. Longmans, Green & Company.

Kaushik, V., & Walsh, C. (2019). Pragmatism as a research paradigm and its implications for social work research. *Social Sciences, 8*(9), 255. https://doi.org/10.3390/socsci8090255

Kellert, S. H., Longino, H. E., &Waters, C. K. (Eds.) (2006). *Scientific pluralism.* University of Minnesota Press.

Kitcher, P. (1993). *The advancement of science: Science without legend, objectivity without illusions*. Oxford University Press.

Kitcher, P. (2001). Science, truth, and democracy. Oxford University Press. Cited by S. H. Kellert, H. E. Longino, & C. K. Waters, (Eds.) (2006), *Scientific pluralism.* University of Minnesota Press.

Knuuttila, T. (2009). Representation, idealization, and fiction in economics. In M. Suárez (Ed.), *Fictions in science: Philosophical essays in modeling and idealization* (pp. 205-231). Routledge.

Knuuttila, T. (2010). Some consequences of the pragmatist approach to representation: Decoupling the model-target dyad and indirect reasoning. In M. Dorato, M. Suárez & M. Rédei (Eds.): EPSA *Epistemology and Methodology of Science*: *Launch of the European Philosophy of Science Association* (Volume I*, Epistemology and Methodology of Science,* pp. 139-148). Springer.

Knuuttila, T. (2011). Modeling and representing: An artefactual approach to model-based representation*. Study in History and Philosophy of Science*, Part A, *42*(2), 262-271. https://doi.org/10.1016/j.shpsa.2010.11.034

Knuuttila, T. (2021). Epistemic artifacts and the modal dimension of modeling. *European Journal for Philosophy of Science, 11*, 65. https://doi.org/10.1007/s13194-021-00374-5

Kuorikoski, J., & Ylikoski, P. (2015). External representation and scientific understanding. *Synthese, 192*, 3817-3837. https://doi.org/10.1007/s11229-014-0591-2

Legg, C., & Hookway, C. (2024). Pragmatism. In E. N. Zalta & U. Nodelman (Eds.), The *Encyclopedia of Philosophy* (Winter 2024 ed.). https://plato.stanford.edu/archives/win2024/entries/pragmatism/

Levy, A. (2012). Models, fictions, and realism: Two packages. *Philosophy of Science, 79*(5), 738-748. https://doi.org/10.1086/667992

Levy, A. (2015). Modeling without models. *Philosophical Studies*, *172*(3), 781-798. https://doi.org/10.1007/s11098-014-0333-9

Ludwig, D., & Ruphy, S. (2021). Scientific pluralism. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Winter 2021 ed.). https://plato.stanford.edu/archives/win2021/entries/scientific-pluralism/

Misak, C. J. (1991). Truth and the end of inquiry: Peircean account of truth. Oxford University Press. https://doi.org/10.1093/0199270597.001.0001

Mitchell, S. (2002). Integrative pluralism. *Biology & Philosophy, 17*, 55-70. https://doi.org/10.1023/A:1012990030867. Cited by S. H. Kellert, H. E. Longino, & C. K. Waters, (Eds.) (2006), *Scientific pluralism.* University of Minnesota Press.

Morrison, M. (2009). Fictions, representations, and reality. In M. Suárez (Ed.), *Fictions in science: Philosophical essays in modeling and idealization* (pp. 110-135). Routledge.

Nguyen, J. (2020). Do fictions explain? *Synthese*, *199*, 3219-3244. https://doi.org/10.1007/s11229-020-02931-6

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Sage. Cited by V. Kaushik, & C. Walsh (2019), Pragmatism as a research paradigm and its implications for social work research. *Social Sciences, 8*(9), 255.

Psillos, S. (1999). *Scientific realism: How science tracks truth*. Routledge.

Rescher, N. (2020). Methodological pragmatism. In W. J. González (Ed.), *Methodological prospects for scientific research: From pragmatism to pluralism* (pp. 69-80). Springer. https://doi.org/10.1007/978-3-030-52500-2_4

Robson, C. (1993). *Real world research*. Blackwell. Cited by V. Kaushik, & C. Walsh (2019), Pragmatism as a research paradigm and its implications for social work research. *Social Sciences, 8*(9), 255.

Schlick, M. (1925). *Allgemeine Erkenntnislehre* (2nd ed.). Springer.

Suárez, M. (2004). An inferential conception of scientific representation. *Philosophy of Science*, *71*(5), 767-779. https://doi.org/10.1086/421415

Suárez, M. (2009). Scientific fictions as rules of inference. In M. Suárez (Ed.), *Fictions in science: Philosophical essays in modeling and idealization* (pp. 158-178). Routledge.

Suárez, M. (2010). Fictions, inference, and realism. In J. Woods (Ed.), *Fictions and models: New essays* (pp. 225-245). Philosophia. https://doi.org/10.2307/j.ctv2nrzgsf.9

Suárez, M. (2015). Scientific representation, denotation, and fictional entities. In U. Mäki, I. Votsis, S. Ruphy & G. Schurz (Eds.), *Recent developments in the philosophy of science: EPSA13 Helsinki* (*European Studies in Philosophy of Science*, volume 1, pp. 331-341). Springer. https://doi.org/10.1007/978-3-319-23015-3_25

Suppes, P. (1978). The plurality of science. *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association, 1978*(2), 2-16. https://doi.org/10.1086/psaprocbienmeetp.1978.2.192459

Teddlie, C., & Tashakkori, A. (2009). *Foundations of mixed methods research*. Sage. Cited by V. Kaushik, & C. Walsh (2019), Pragmatism as a research paradigm and its implications for social work research. *Social Sciences, 8*(9), 255.

Teller, P. (2009). Fictions, fictionalization, and truth in science. In M. Suárez (Ed.), *Fictions in science: Philosophical essays in modeling and idealization* (pp. 235-247). Routledge.

Toon, A. (2012a). Models as make-believe. In R. Frigg & M. Hunter (Eds.), *Beyond mimesis and convention: Representation in art and science* (pp. 71-96). Springer. https://doi.org/10.1007/978-90-481-3851-7_5

Toon, A. (2012b). *Models as make-believe: Imagination, fiction and scientific representation*. Palgrave Macmillan. https://doi.org/10.1057/9781137292230

Toon, A. (2016). Imagination in scientific modeling. In A. Kind (Ed.), *The Routledge handbook of philosophy of imagination* (pp. 451-462). Routledge.

Vaihinger, H. (1935). *The philosophy of 'As if'*. Kegan Paul, Trench, Trubner, & Company.

Van Fraassen, B. (2008). *Scientific representation: Paradoxes of perspective*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199278220.001.0001

Walton, K. (1990). *Mimesis as make-believe: On the foundations of the representational arts*. Harvard University Press.

Weisberg, M. (2007). Who is a modeler? *The British Journal for the Philosophy of Science, 58*(2), 207-233. https://doi.org/10.1093/bjps/axm011

Received 8th December 2023; revised 26th November 2024; revised 29th April 2025; accepted 16th May 2025.