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GASTON BACHELARD'S PHILOSOPHY OF SCIENTIFIC METHOD: FROM BREAKTHROUGH TO VALIDATION AND ITS APPLICATIONS IN CONTEMPORARY SCIENCES

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Abstract. This article explores Gaston Bachelard's philosophy of the scientific method, focusing on the three main stages he proposes: epistemological rupture, knowledge construction, and empirical verification. We begin by analyzing Bachelard's concept of "epistemological rupture," where he emphasizes that scientific progress requires a break from traditional knowledge and previous concepts. This rupture is seen as a critical step toward more accurate and advanced knowledge. We then move to the "construction" phase, where Bachelard stresses the importance of building scientific models and hypotheses through methodical and experimental thinking. This phase is crucial in the active and organized development of knowledge, free from initial assumptions. In the "verification" phase, we discuss the role of experimentation in validating the hypotheses and models that have been constructed. The role of experimentation varies between the natural and social sciences, and the article highlights how epistemological barriers can be overcome in the pursuit of scientific knowledge. Additionally, we address the application of Bachelard's philosophy in contemporary sciences, both in physics and chemistry, as well as in social sciences, illustrating his impact on current scientific research practices. In conclusion, Bachelard's philosophy sheds light on the process of scientific thought evolution, which is not just about the accumulation of knowledge but also requires constant reevaluation and critical revision of previous concepts. Bachelard's ideas remain an essential guide for understanding science in the modern era and serve as a foundation for pushing science toward new frontiers of understanding and discovery.

Keywords*:* Education and Science, Gaston Bachelard, Scientific Method, Epistemological Rupture, Knowledge Construction, Philosophy of Science.

1. INTRODUCTION

The philosophy of science is one of the most prominent fields of philosophy in the 20th century, aiming to provide a rational explanation for scientific developments and transcend traditional boundaries of scientific thought. In this context, Gaston Bachelard stands out as a prominent figure in contemporary philosophy, offering a critical and novel perspective on the scientific method and its foundations. Bachelard is particularly known for developing the concept of epistemological rupture, which refers to the break between scientific knowledge and pre-existing knowledge, or what he calls "organized ignorance." This fundamental idea distinguishes his philosophy from other scientific philosophies by offering a radical perspective on knowledge development through rupture, construction, and verification (Bachelard, 1938, p. 45).

The scientific method is the backbone of scientific knowledge, enabling scientists to build testable hypotheses and systematically and rationally explain natural and social phenomena. Here lies the importance of Bachelard's philosophy, as it adds a profound philosophical dimension to the traditional understanding of science, focusing on the idea of rupture from previous conceptualizations to build new knowledge based on epistemological vigilance – a continuous critique and methodological surpassing of prevailing ideas (Kuhn, 1970, p. 60).

In modern sciences, knowledge constantly faces challenges that demand surpassing old explanatory models and embracing new theories. Here, Bachelard emphasizes that scientific progress is not linear but requires a rupture with the past and a transition toward a new constructive understanding that is corrected and developed through experimentation and scrutiny. Understanding this philosophical approach has a direct impact on how sciences – from physics to social sciences – are understood, as each requires a critical approach to scientific understanding (Popper, 1959, p. 73).

This article aims to analyze the scientific method according to Gaston Bachelard by studying the three stages that constitute the core of his philosophy: rupture, construction, and verification. Emphasis will be placed on the role of each stage in the development of scientific knowledge, starting with rupture, which represents the epistemological break from past errors and beliefs, through construction, which establishes new hypotheses and theories, and concluding with verification, which requires rigorous experimentation and continuous testing of acquired knowledge. Additionally, the article will explore how Bachelard contributed to shaping this critical concept of science and how it can be applied to contemporary sciences.

Epistemological rupture forms the first stage of Bachelard's method and refers to rejecting or criticizing previous knowledge to overcome epistemological barriers that hinder scientific thought development (Bachelard, 1949, p. 88). Rupture is essential for freeing the mind from past constraints, often rooted in tradition or habit. The second stage, construction, is where the researcher begins to formulate new models to explain scientific phenomena based on critical foundations and advanced hypotheses. Bachelard sees this stage as the core of science, where ideas and concepts are tested methodically and through multiple means (Bachelard, 1934, p. 63). The third stage, verification or experimentation, is where the acquired knowledge is tested through observation of reality, and hypotheses are validated through precise experimentation (Hacking, 1983, p. 120). Verification of knowledge is not a final goal but a continuous process of critique and correction, reinforcing the ongoing development of science.

In summary, Bachelard's philosophy deals with the tension between traditional conceptions and new knowledge, offering a philosophy based on challenging the status quo and continuously seeking truth through epistemological rupture, conceptual construction, and experimental verification. This vision is not just speculative philosophy but a practical approach that forms the basis for understanding scientific transformations in the modern world.

2. THEORETICAL FRAMEWORK OF BACHELARD'S PHILOSOPHY OF SCIENTIFIC METHOD

A. The Definition of Scientific Action in Bachelard's Philosophy

In Gaston Bachelard's philosophy, scientific action revolves around three key concepts: acquired science, constructed science, and verified science. These concepts are not just sequential stages in the scientific process but are fundamental elements in Bachelard's approach to understanding scientific knowledge. Acquired science refers to the knowledge already obtained through observation and experimentation, but this is not the endpoint. The scientist must go beyond this acquired knowledge and construct new concepts and theories, leading to constructed science. This construction is not done in a vacuum but is based on previous knowledge, continuously improving upon it through deconstruction and reconstruction.

Verified science means that any new scientific knowledge is only considered complete after it has been rigorously tested and verified through methodological and empirical means. It is not enough to construct knowledge based on assumptions; it must be verified through experiments and ongoing analysis. Bachelard describes this approach as one of the essential characteristics of modern scientific thought (Bachelard, 1938, p. 77).

Compared to other scientific theories, Descartes focuses on the importance of doubt as the first step in constructing knowledge. For Descartes, methodological doubt is a means of arriving at indubitable truths by systematically eliminating anything that can be doubted (Descartes, 1637, p. 23). On the other hand, Bachelard emphasizes constructive negation, where doubt serves as a tool for breaking through old epistemological barriers and constructing more accurate knowledge (Bachelard, 1949, p. 65).

Similarly, Thomas Kuhn's idea of scientific revolutions intersects with Bachelard's concept of epistemological rupture. Kuhn argues that science evolves through paradigm shifts, where the fundamental rules and frameworks of science change dramatically in each shift (Kuhn, 1962, p. 92). Bachelard, however, focuses on a continuous process of transcending traditional science through a critical and ongoing pursuit of more precise knowledge.

B. Philosophy of Rejection and the Idea of Epistemological Rupture

In Bachelard's philosophy, rejection plays a crucial role in the scientific method. He argues that rejecting old ideas is essential for transcending pre-scientific thinking, which often is posed as an obstacle to scientific progress. This concept is embodied in what Bachelard calls the "epistemological rupture", a necessary break between previous knowledge and modern scientific thought (Bachelard, 1934, p. 101).

Pre-scientific thinking is characterized by intuitive and often erroneous concepts treated as truths. For example, ancient ideas about the Earth being the center of the universe were based on superficial observations. In contrast, scientific thinking, according to Bachelard, is critical thinking that relies on experimentation and methodological doubt to verify hypotheses and overcome past errors (Bachelard, 1938, p. 140). Bachelard asserts that scientists must practice an "active rejection" of everything conventional as a first step towards constructing new knowledge.

This philosophy underscores the importance of constant renewal in scientific knowledge. No theory or hypothesis can ever be considered final or absolute; rather, the scientist must always push the boundaries and consider the possibility of improvement or replacement (Hacking, 1983, p. 144). This principle is evident in many scientific transformations, such as the transition from Newtonian physics to Einstein's theory of relativity, where Einstein applied the philosophy of rejection by rupturing traditional notions of time and space.

C. The Concept of "Methodological Doubt" in Modern Science

While Descartes introduced the idea of methodological doubt at the dawn of the modern era, Bachelard redefined this concept to fit the evolution of science. In Descartes' method, doubt is a tool for eliminating false ideas and arriving at absolute certainty (Descartes, 1637, p. 25). For Bachelard, however, doubt is a continuous and necessary process in the pursuit of scientific knowledge. The goal is not to reach final certainty but to continually transcend each level of certainty with greater accuracy.

Bachelard sees doubt not just as a means but as an ongoing process that helps improve and refine scientific understanding. Unlike Descartes, who believes that doubt ends in certainty, Bachelard argues that doubt must continue, even after what is considered certain has been reached because scientific knowledge is never truly complete (Bachelard, 1934, p. 87). This principle is particularly relevant in the empirical sciences, where experiments and results must always be re-evaluated to ensure accuracy and avoid what Bachelard calls "scientific dogmatism" (Bachelard, 1949, p. 74).

Thus, Bachelard's philosophy emphasizes the importance of constructive skepticism and rejection to the development of scientific knowledge. Instead of relying on inherited or fixed knowledge, methodological doubt and rejection must be integral to the scientific process. This approach aids in the development and verification of theories, resulting in a deeper and more precise understanding of scientific phenomena. Bachelard advocates that the scientist must always be ready to reject and transcend, even if it means abandoning concepts that were previously considered definitive truths

(Hacking, 1983, p. 172).

In this sense, doubt drives investigation and discovery, keeping science dynamic and evolving. Methodological doubt ensures that scientists remain vigilant in constantly revisiting and testing ideas and theories, contributing to the evolution of science by making it more adaptable and accurate (Popper, 1959, p. 82).

3. THE BREAK OR RUPTURE PHASE IN THE SCIENTIFIC METHOD

A. Definition and Importance of the Break (Rupture) Phase

In Bachelard's framework, the rupture or epistemological break is the first crucial stage in the scientific method. This phase involves breaking away from traditional, pre-scientific ways of thinking, which are often based on intuition, common sense, and unverified assumptions. The rupture, therefore, represents the first step toward constructing modern scientific knowledge—a break from previous frameworks that hinder progress. Bachelard's concept of rupture goes beyond mere skepticism; it is a deliberate severance from past epistemological structures that could limit scientific inquiry.

According to Bachelard, scientific knowledge is not merely an accumulation of facts but a revolutionary process, where each breakthrough requires rejecting older paradigms. The rupture phase enables the scientist to approach phenomena with a fresh perspective, unencumbered by outdated or ingrained beliefs (Bachelard, 1938, p. 99). This new epistemological orientation marks the transition from everyday thinking to scientific thought, which is systematically critical and methodologically rigorous.

The rupture is essential because it brings the scientist into the realm of objective knowledge, structured by experimentation, verification, and logical reasoning rather than by subjective or preconceived notions. For Bachelard, this phase is not a simple discovery of facts but an active rethinking of how we engage with reality—rejecting any knowledge that cannot withstand critical scrutiny. Thus, the break represents a fundamental shift in how knowledge is produced: it is not about gathering more data, but rather about restructuring the way we interpret and conceptualize that data (Hacking, 1983, p. 145).

In practical terms, the rupture might be seen in moments where scientists stop taking existing theories at face value and decide to challenge the status quo. This step often involves rigorous questioning, doubt, and the willingness to unlearn previously accepted truths.

B. The Difference Between Empirical Knowledge and Pre-scientific Thinking

Empirical knowledge is rooted in observation, measurement, and experimentation, and is always open to revision as new data becomes available. It contrasts sharply with pre-scientific thinking, which is often based on intuitive, untested assumptions that are taken as absolute truths. Pre-scientific thinking is conceptualized in terms of common sense, tradition, or uncritical acceptance of ideas passed down from previous generations. In this sense, the rupture represents the epistemic shift from intuitive, subjective ways of knowing toward a more structured, objective, and scientific approach (Bachelard, 1938, p. 133).

Bachelard's rupture corresponds to a movement away from a non-scientific view of the world, where phenomena are explained based on superficial observations or mythological beliefs, to a world where scientific explanation dominates. For example, before Newton, the understanding of motion was largely based on Aristotelian ideas, which were more philosophical and abstract, not empirical. Newton's rupture came when he abandoned those ancient ideas, focusing on measurable forces and mathematical models (Newton, 1687, p. 7). This change in approach allowed Newton to develop the laws of motion and universal gravitation, marking a fundamental shift in how the natural world was understood.

C. Case Studies from the Natural Sciences: Newton and the Discovery of Gravity

To understand the application of epistemological rupture in the natural sciences, we can examine the work of key historical figures who exemplify this process. One of the most prominent examples is Isaac Newton, whose discovery of the laws of motion and the law of universal gravitation represents a profound rupture with prior understanding.

Before Newton, scientists largely adhered to Aristotelian physics, which held that objects moved according to intrinsic properties (Aristotle, 350 BCE). This view posited that the Earth was the center of the universe, and heavenly bodies were made of a different, perfect substance. Copernicus, Kepler, and Galileo all challenged this view by proposing heliocentric theories and advocating for empirical observation, but Newton's rupture was particularly significant because it represented the first time that the motions of celestial bodies could be explained mathematically using the same principles as those governing earthly motion (Newton, 1687, p. 3).

Newton's Philosophiæ Naturalis Principia Mathematica (1687) exemplified the epistemological rupture in action. Newton dismissed Aristotelian ideas about motion, rejecting them in favor of a universal law that applied equally to both celestial and terrestrial bodies. This shift in thinking not only rejected earlier theories but also laid the groundwork for a new methodology of inquiry in physics. Newton's approach was built on systematic experimentation, mathematical precision, and empirical observation—all hallmarks of modern scientific thinking.

Another important example of the epistemological break in the history of science is Albert Einstein's theory of relativity. Like Newton, Einstein's work required a complete rupture from previously accepted notions of space, time, and motion. Einstein's theory radically challenged the Newtonian conception of absolute space and time by showing that both were relative to the observer (Einstein, 1915, p. 142). The break from Newtonian physics was not merely a refinement or an extension but a complete shift in the way we understand fundamental aspects of the universe, akin to a philosophical revolution within physics.

D. Epistemological Barriers: Obstacles to Knowledge and How to Overcome Them through the Break

While the rupture is a powerful tool for advancing scientific knowledge, there are also significant epistemological barriers that impede progress in science. These obstacles are often rooted in cultural beliefs, unquestioned assumptions, or institutional inertia, which can create resistance to new ideas and theories.

One common barrier is dogmatism—the tendency to cling to established knowledge or methods despite evidence to the contrary. For example, the early resistance to heliocentrism in the 16th and 17th centuries was largely due to the deeply entrenched belief in the geocentric model of the universe, which was supported by religious and philosophical traditions. The Roman Catholic Church, in particular, rejected the Copernican model for centuries, as it contradicted the teachings of the Church and the prevailing scientific consensus (Galileo, 1632, p. 89).

Another significant barrier is the cognitive bias of scientists themselves, which can prevent them from seeing beyond their existing framework. Scientists often become deeply invested in their theories and may develop a confirmation bias—a tendency to favor information that supports their ideas while ignoring contradictory evidence. Bachelard describes this as a "scientific prejudice," where the scientist unconsciously clings to certain views or methodologies (Bachelard, 1938, p. 112). Overcoming such cognitive biases often requires a radical shift in how one approaches problems and opens the door to innovation and discovery.

To overcome these barriers, Bachelard advocates for a constant process of critical reflection and methodological doubt, which ensures that scientists do not fall into the trap of uncritical acceptance of old ideas. The rupture is not just an initial break with tradition; it is a continuous process of questioning, verifying, and revising. For example, Charles Darwin's theory of evolution marked a profound epistemological break from earlier ideas about species creation, despite fierce opposition from religious and scientific communities (Darwin, 1859, p. 65). Through rigorous experimentation and observation, Darwin's work ultimately overcame the epistemological obstacles of his time and revolutionized the field of biology.

The rupture is thus not only about rejecting the past but about breaking through the epistemological barriers that prevent the full realization of scientific potential. Through this process, science can progress by continually breaking free from outdated frameworks and embracing new, more comprehensive ways of understanding the natural world.

4. THE CONSTRUCTION STAGE IN GASTON BACHELARD'S SCIENTIFIC METHOD

A. Defining the Construction Stage in Bachelard's Methodology

The construction stage represents the second phase in Gaston Bachelard's scientific method, following the rupture or epistemological break. This stage is characterized by the establishment and development of theories and scientific models based on the foundations laid after the break with previous knowledge. During this phase, the researcher constructs analytical models that help explain scientific phenomena systematically and reliably.

For Bachelard, scientific research is not merely about collecting data or observing phenomena; it is a process of knowledge construction, requiring the formulation of hypotheses based on solid scientific principles. The construction of knowledge demands that the researcher begins with clear and firm foundations, from which they can expand these principles by using empirical models, and then analyze the results to arrive at scientific explanations. In this context, Bachelard emphasizes the importance of the conceptual system, which serves as the theoretical framework that organizes all ideas and knowledge within a structured system. The conceptual system is not static or rigid but is dynamic, adjusting in response to discoveries (Bachelard, 1938, p. 245).

Constructing hypotheses is a crucial step in this phase, as it involves formulating the basic assumptions drawn from the knowledge gained in the rupture phase. These hypotheses then evolve into scientific models which are tested in the real world through experimentation and measurement. Models are cognitive representations that help organize and analyze data, and they are capable of predicting future phenomena, which enhances the power of the scientific method.

B. Steps in Building Knowledge: Explanation, Prediction, and Inference

For Bachelard, the process of constructing knowledge can be divided into three main steps: explanation, prediction, and inference. These steps form a comprehensive scientific process used to transform hypotheses into testable scientific knowledge.

- Explanation: The first step in building knowledge involves analyzing the studied phenomena and interpreting the reasons behind their occurrence. In this stage, researchers link the phenomena to scientific concepts and existing theories to establish a logical relationship between the various factors that contribute to the phenomenon. Scientific explanation is not merely a description of phenomena, but rather an attempt to understand the mechanisms that drive these phenomena. Therefore, explanation is a critical step in developing a profound understanding of scientific occurrences (Bachelard, 1938, p. 260).
- Prediction: After explanation comes prediction, which is a fundamental phase in the construction of knowledge. Prediction in science relies on the theoretical models developed during the explanation phase. The researcher applies these models to predict future outcomes or even to explain phenomena that have yet to be observed. Prediction is a hypothetical process that considers all possible variables that could influence the studied phenomenon, demonstrating the capacity to handle the unknown using scientific models (Bachelard, 1938, p. 265).
- Inference: In this phase, the researcher tests the predictions formulated based on theoretical models. Inference requires the researcher to apply empirical tools and collect data to determine whether the predictions are true. If the predictions align with the empirical data, this indicates that the hypotheses and models constructed are valid and reliable. Conversely, if the predictions are incorrect, the researcher must revisit the models and interpretations and adjust them to fit the newly discovered facts (Bachelard, 1938, p. 270).

Through these steps, Bachelard demonstrates that building scientific knowledge is an interactive and evolving process, where the researcher remains in continuous dialogue with both existing knowledge and empirical experimentation, ensuring that scientific knowledge is always in development.

C. "Epistemological Vigilance" and Social and Cognitive Challenges

The concept of "epistemological vigilance" refers to the critical awareness that researchers must maintain throughout the process of building knowledge. This vigilance requires the researcher to be constantly alert to all the assumptions and prior knowledge that may influence their ability to understand scientific phenomena accurately.

The concept of epistemological vigilance can be linked to Pierre Bourdieu's thought, which posits that researchers must possess a critical awareness of the society and culture in which they live, as these factors may create cognitive obstacles to a proper understanding of scientific reality. According to Bourdieu, the researcher is not merely a recipient of information but a producer of knowledge, which is inevitably influenced by the social and cultural frameworks they belong to. Therefore, researchers must transcend these influences to produce objective scientific knowledge (Bourdieu, 1990, p. 115).

Social and cognitive challenges represent fundamental obstacles that any researcher may face in the process of building knowledge. Researchers may often be influenced by prevailing social concepts, such as cultural biases, political orientations, or religious beliefs, which can direct the research process in non-scientific ways. Thus, it is essential for the researcher to remain vigilant to these influences and to ensure that the research maintains objectivity and neutrality, without allowing social or cultural factors to distort their thinking and conclusions (Bourdieu, 1990, p. 120).

Through the concept of epistemological vigilance, Bachelard shows that the scientific researcher must possess the ability to engage in continuous critical thinking and never accept prevailing knowledge or inherited ideas without scrutiny. This vigilance is the mechanism that ensures the development of genuine scientific knowledge that transcends cognitive and social biases

5. THE VERIFICATION OR INVESTIGATION STAGE IN BACHELARD'S SCIENTIFIC METHOD

A. The Importance of Experimentation in Scientific Knowledge Validation

In the scientific method as conceptualized by Gaston Bachelard, the verification or investigation stage is pivotal, as it determines whether the hypotheses constructed in the previous phase hold up under empirical scrutiny. This phase emphasizes the role of experimentation in testing the validity of hypotheses and, ultimately, in transforming theoretical propositions into scientific laws or generalized principles. The experimental process acts as a bridge between abstract knowledge and real-world applicability, ensuring that scientific models reflect the physical world and its dynamics.

For Bachelard, experimentation is not merely a tool for collecting data; it serves as a philosophical act of transformation. The transition from hypothesis to scientific law depends heavily on whether experimental results can consistently confirm the theoretical propositions. Experimentation in this context provides a concrete mechanism to demonstrate that the laws deduced from the scientific theories are not only possible but also necessary in explaining the phenomena in question. Bachelard explains that a hypothesis can only be validated through experimentation, and its ultimate truth is determined by how well it aligns with observable evidence (Bachelard, 1938, p. 290). Thus, experiment becomes the key method through which knowledge claims are either affirmed or rejected.

In the natural sciences, experiment serves to isolate variables, control for confounding factors, and repeatability tests. The experimental conditions are designed to allow for systematic observation, which confirms or refines the understanding of a specific phenomenon. By rigorously testing a hypothesis, scientists move beyond speculation and enter the realm of empirical verification. This verification can be used to formulate scientific laws, which are generalizable explanations that predict the behavior of natural systems under specific conditions.

Bachelard's emphasis on the experimental method challenges earlier philosophical traditions that prioritized a priori reasoning and theoretical assumptions without the grounding of empirical evidence.

Through scientific verification, experimentalists break with prior knowledge and continuously expand the frontiers of scientific understanding.

B. Comparing Experimentation in Natural and Social Sciences

While experimentation plays a central role in the natural sciences, its application in the social sciences is often a point of contention due to the qualitative nature of social phenomena. The natural sciences, such as physics and chemistry, rely on controlled experiments where conditions can be precisely manipulated to test hypotheses. For example, in physics, Newton's laws of motion or Einstein's theory of relativity are tested through mathematical predictions and controlled experimentation. The results of these experiments can be replicated in a controlled setting, providing a high degree of predictability and reliability.

In contrast, the social sciences, such as sociology and anthropology, face significant challenges in applying the experimental method due to the complexity and variability of human behavior. Social phenomena cannot always be replicated under controlled conditions due to the inherent unpredictability of human beings, their environment, and the cultural context that shapes their actions. While experimental research can still be conducted in some areas of social science (such as in controlled experiments with groups of people in laboratory settings), the methods often need to incorporate qualitative and descriptive tools like interviews, ethnographies, and case studies, as opposed to controlled lab experiments.

A major limitation of the experimental method in social sciences lies in the generalizability of findings. Unlike natural science experiments, which often rely on precise measurement and repeatability, social science experiments must grapple with the unique contexts and historical conditions that shape human behavior. Researchers in sociology, for instance, might study social phenomena through fieldwork rather than controlled experiments, recognizing that people's behaviors are shaped by social norms, cultural influences, and historical conditions, which cannot easily be manipulated in a laboratory setting.

Despite these limitations, Bachelard’s view is that experimentation in social science must aim at reaching a level of empirical verification through its methods. These methods may not always mimic the controlled environment of physical experiments, but they should still strive for scientific rigor and seek objective truths about human behavior. Bachelard’s epistemological framework suggests that social scientists should adapt scientific methods to their specific objects of study, seeking to ground their theories in evidence, even if that evidence does not always come from controlled experiments.

C. The Role of Experimentation in Overcoming Epistemological Obstacles

Bachelard’s notion of epistemological obstacles refers to the cognitive and historical biases that hinder the development of scientific knowledge. These obstacles manifest in the form of preconceived notions, cultural assumptions, and unquestioned beliefs that shape the way we interpret the world. For Bachelard, these epistemological obstacles are not merely theoretical; they are embedded in the very practices of scientific inquiry and in the way scientists approach their subject matter.

Experimentation plays a critical role in overcoming these obstacles by acting as a cleansing mechanism that removes these biases and allows the scientist to approach phenomena with an open mind. Through rigorous and systematic testing, experimentation serves as a process that disrupts established assumptions and challenges traditional ways of thinking. By validating or invalidating scientific hypotheses, empirical experiments push researchers to revise their existing knowledge and develop new models of understanding that are more aligned with reality.

For example, in the history of science, many epistemological obstacles were overcome through groundbreaking experiments that challenged conventional wisdom. Galileo's experiments on motion contradicted Aristotelian physics, and Newton's experiments on gravity shattered previous understandings of celestial mechanics. In each case, experiment-based results provided the means to overturn entrenched doctrines and usher in new paradigms of scientific thought.

Bachelard argues that scientific progress requires an active confrontation with these epistemological obstacles. Rather than accepting conventional wisdom, scientists must engage in self-reflection and critical evaluation of their assumptions. Experimentation thus becomes not just a tool for verifying theories but also a method for identifying and dismantling the obstacles that prevent the advancement of knowledge. The epistemological vigilance Bachelard advocates for helps ensure that knowledge is not merely confirmed but continuously refined and expanded.

6. APPLICATIONS OF THE PHILOSOPHY OF THE SCIENTIFIC METHOD IN CONTEMPORARY SCIENCES

A. Applications of Gaston Bachelard's Philosophy in Natural Sciences

The philosophy of the scientific method by Gaston Bachelard has had a profound impact on natural sciences, particularly in fields such as physics and chemistry. Bachelard's philosophy emphasizes the importance of epistemological rupture as the foundation for the transformation and development of scientific theories, suggesting that methodical doubt is the only way to overcome pre-scientific understanding and lead to new knowledge (Bachelard, 1938, p. 123).

In physics, for example, Bachelard's philosophy is exemplified by the significant developments that occurred in the 19th and 20th centuries. Einstein's theory of relativity and quantum mechanics are practical examples of how epistemological rupture occurred, where new theories in physics broke away from the classical Newtonian frameworks. Before these scientific revolutions, concepts of time and space were fixed and absolute, but thanks to Einstein's work, the relative nature of these fundamental concepts in physics was revealed (Einstein, 1915, p. 110).

In chemistry, the application of Bachelard's philosophy can be observed in the transformation of the understanding of molecular structure and chemical interactions. Bachelard argues that experimentation is the tool that allows us to overcome old concepts that might hinder new understandings (Bachelard, 1938, p. 143). For example, the concept of the atom in chemistry was only fully understood through the epistemological rupture introduced by scientists like Dalton and J. J. Thomson, who developed new models of atomic structure.

Bachelard's approach in the natural sciences allowed scientists to critically reassess inherited ideas and arrive at new concepts by continuously engaging with experiments, rigorously testing hypotheses, and opening new frontiers in scientific development (Bachelard, 1938, p. 167).

B. Applications of Gaston Bachelard's Philosophy in Social Sciences

While experimentation and the practical application of Bachelard's method were successfully achieved in natural sciences, applying Bachelard's philosophy to social sciences presents greater challenges due to the complexity and unpredictability of human societies. The epistemological barriers in social sciences include the difficulty of constructing empirical models that can be tested and confirmed in the same rigorous manner as in physics or chemistry (Bourdieu, 1990, p. 59).

However, Bachelard's method can be successfully applied to social sciences by adopting the epistemological rupture between traditional knowledge and modern critical knowledge. In the field of sociology, for example, social phenomena that affect individuals and groups can be viewed as subjects for critical inquiry. If we apply Bachelard's philosophy, scholars must reject inherited ideas and continuously critique familiar social concepts. This kind of thinking can help uncover the hidden structures of social systems and understand how factors like power and economics shape social patterns (Bourdieu, 1990, p. 87).

Social experimentation, such as case studies and social surveys, can be a valid tool within Bachelard's framework. For example, studies on poverty or violence can be tested using a range of social theories to analyze their impact on everyday life. This type of experimentation requires a critical approach and in-depth examination of social concepts so that the prevailing ideas are not accepted without challenge but rather new models are developed to improve our understanding of social phenomena (Harvey, 2011, p. 32).

One of the main challenges faced by social scientists is the variation in context. While experimentation in natural sciences relies on fixed controls that can be easily replicated, in social sciences, conditions, and interactions can vary greatly, making it difficult to repeat experiments strictly. Thus, social scientists must adopt a critical method that accounts for these differences and incorporates fieldwork alongside evolving theories.

C. The Relationship Between Bachelard's Philosophy and Modern Technology

Bachelard’s philosophy is not confined to the development of scientific knowledge in the natural and social sciences but also significantly influences modern technology. In today’s rapidly evolving world, where technology progresses at a fast pace, the impact of Bachelard’s philosophy on technological innovation is evident.

Experimentation and scientific verification are core principles of Bachelard that have contributed to the advancement of technological progress. For example, in biotechnology and artificial intelligence, modern innovations require the transformation of theoretical hypotheses into practical applications that can be tested and verified. In artificial intelligence, mathematical models are designed and tested to improve intelligent systems. These systems rely on continuous experimentation to test hypotheses in fields such as machine learning and neural networks (Johnson, 2017, p. 72).

In the field of renewable energy, Bachelard’s philosophy serves as a foundation for developing new energy technologies such as solar power and wind energy. These technologies require constant rethinking of traditional energy models and applying methodical doubt as the basis for re-innovating solutions that meet the needs of the modern age (Maxwell, 2019, p. 45).

Additionally, technological innovation in various fields depends on an epistemological rupture with old theories, as seen in the field of medicine, where the traditional understanding of diseases is being reshaped through technologies like gene therapy and stem cell treatments. This has allowed new technologies to find their place in the scientific and technological world (Johnson, 2017, p. 55).

7. CONCLUSIONS

In conclusion, Gaston Bachelard’s philosophy of scientific methodology offers a profound and comprehensive framework for understanding how knowledge is constructed and validated in the sciences. His work represents a crucial departure from traditional views of scientific inquiry, emphasizing the importance of epistemological rupture, the rejection of preconceived notions, and the active construction of knowledge. By analyzing the three main stages of his method – cutting, building, and verifying – Bachelard provides a nuanced perspective on the evolution of scientific thought and its transformative power. This conclusion will summarize the key points discussed throughout the paper, reflect on the implications of Bachelard's philosophy for both natural and social sciences, and explore its relevance to contemporary scientific practices.

Bachelard's most groundbreaking contribution to epistemology is his concept of the epistemological break or rupture (Bachelard, 1938). In his view, scientific progress is not a linear, cumulative process; rather, it involves a radical discontinuity with prior knowledge. The first stage of his method, the “cut,” involves an intellectual separation from traditional, everyday ways of thinking. This stage is crucial for moving away from pre-scientific assumptions, biases, and beliefs, which hinder genuine scientific progress. The epistemological break, as Bachelard describes it, signifies a departure from naive realism and unexamined ideas, allowing researchers to engage with the world more objectively and rigorously.

This concept is deeply embedded in Bachelard's broader vision of science as a transformative process. Scientific theories are not merely discovered but are actively constructed by the scientist. This construction of knowledge, however, cannot proceed unless the researcher is willing to engage in a systematic rejection of the “naïve” or “pre-scientific” ways of understanding the world. The break from these unreflected assumptions is essential for establishing a firm foundation for scientific inquiry, where knowledge can be constructed anew and tested rigorously.

The second stage of Bachelard's scientific method, the building phase, centers on the creation of theoretical models and hypotheses. Here, Bachelard draws heavily on the idea of constructing knowledge based on rational thought and systematic theory-building. Unlike earlier models of knowledge acquisition that emphasized mere observation, Bachelard emphasizes that scientific knowledge is fundamentally constructed. This construction is based on abstract reasoning, guided by existing scientific theories, and generates models that are capable of explaining and predicting phenomena.

The construction of scientific models requires intellectual creativity, but it also demands strict adherence to logical reasoning and consistency. The researcher, while drawing upon existing theoretical frameworks, must develop new hypotheses that push the boundaries of current understanding. These hypotheses serve as tools for organizing observations and guiding further experimentation. The building phase, therefore, involves a continual process of refining and re-evaluating existing models in light of new data.

Importantly, Bachelard also highlights the concept of epistemological vigilance, which involves a heightened awareness of the limitations of our knowledge and the potential biases that may arise during the process of theory-building. This concept has been further developed by other scholars, such as Pierre Bourdieu, who underscores the importance of maintaining a critical stance toward the influences of social and cultural factors on the construction of knowledge (Bourdieu, 1990). As Bachelard suggests, constructing a scientific theory is not merely a rational endeavor but also a process fraught with potential pitfalls that must be carefully navigated.

The third and final stage in Bachelard's method is the verification stage, where hypotheses and theoretical models are tested against empirical reality. In this stage, the scientist must move beyond abstract theorizing and confront the real world through experimentation and observation. The goal of this stage is to confirm or refute the predictions made by the theory, thereby either validating or revising the scientific model.

Bachelard's emphasis on verification ties closely to his overall philosophy of science, which regards knowledge as contingent and provisional. Scientific knowledge is always subject to revision and refinement as new data becomes available. This iterative process of hypothesis testing, refutation, and adjustment is the hallmark of scientific progress. Through rigorous experimentation, scientists can move beyond simple theoretical speculation and arrive at more accurate, reliable explanations of natural phenomena.

However, as Bachelard acknowledges, the verification stage is not always straightforward, particularly in fields like the social sciences, where the complexities of human behavior and social structures introduce significant challenges to the process of experiment. In these cases, researchers may need to rely on alternative methods, such as case studies, surveys, or ethnographic research, to gather empirical data. Nonetheless, the core idea of verification remains a central pillar of scientific practice, highlighting the importance of grounding knowledge in real-world observations.

Bachelard's philosophy of the scientific method has wide-reaching implications for both natural and social sciences. In the natural sciences, his emphasis on epistemological rupture and the construction of scientific models has helped shape contemporary practices in disciplines like physics, chemistry, and biology. Modern scientific research, particularly in fields such as quantum mechanics and evolutionary biology, continues to reflect Bachelard's insights into the fluid, evolving nature of scientific knowledge. The idea that scientific progress is not linear but involves periods of radical change and transformation is especially relevant in understanding paradigm shifts, such as the revolution in physics brought about by Einstein's theory of relativity.

In the social sciences, Bachelard's ideas have proven to be equally influential. Researchers in fields such as sociology, anthropology, psychology, and pedagogy have incorporated his notions of epistemological vigilance and rejection of pre-scientific assumptions into their methodologies. However, as noted earlier, the social sciences face unique challenges in applying the verification stage of

Bachelard's method. Unlike the natural sciences, where controlled experiments can be conducted in laboratories, social scientists often deal with more complex, multifaceted phenomena that resist simple experimentation. This has led to the development of new methods of inquiry in the social sciences, including qualitative research techniques and mixed-methods approaches.

Bachelard's philosophy also resonates with the growing emphasis on interdisciplinary research. In an increasingly interconnected world, scientific advancements are often the result of collaboration across disciplines. Bachelard's insistence on the importance of constructing models and theories that are grounded in empirical reality provides a valuable framework for integrating knowledge from diverse fields, encouraging researchers to build upon one another's work while maintaining rigorous standards of scientific validation.

Gaston Bachelard's philosophy of the scientific method offers a powerful tool for understanding the nature of scientific inquiry and the process by which knowledge is generated and refined. His emphasis on the epistemological break, the construction of scientific models, and the verification of knowledge through experimentation has had a lasting impact on both natural and social sciences. By rejecting pre-scientific assumptions and building knowledge from the ground up, Bachelard provides a blueprint for the continuous evolution of scientific thought.

The application of Bachelard's philosophy is particularly relevant in the context of contemporary science, where rapid advancements in technology and interdisciplinary collaboration require scientists to constantly re-evaluate their methods and assumptions. Bachelard's work serves as a reminder that science is not a static body of knowledge but a dynamic process that evolves through a combination of theoretical innovation, empirical validation, and intellectual vigilance.

Ultimately, Bachelard's ideas continue to shape how we think about knowledge, science, and the world around us. By challenging traditional views of scientific progress and emphasizing the importance of epistemological rupture, he has made a significant contribution to the philosophy of science, one that remains relevant and influential in contemporary discourse.

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Алі Алліу. Філософія наукового методу Гастона Башляра: від перелому до валідації та її застосування у сучасних науках. *Журнал Прикарпатського університету імені Василя Стефаника*, **12** (1) (2025), 15-27.

У цій статті досліджується філософія наукового методу Гастона Башляра, зокрема три основні етапи, які він пропонує: епістемологічний розрив, побудова знання та емпірична перевірка. Автор розпочинає дослідження з аналізу концепції Башляра "епістемологічного розриву", де наголошує, що науковий прогрес вимагає відмови від традиційних знань і попередніх концепцій. Цей розрив вважається критичним кроком до більш конкретизованого та розвиненого знання. Далі автор досліджує фазу "конструкції", де Башляр акцентує увагу на важливості побудови наукових моделей і гіпотез через методичне та експериментальне мислення. Ця фаза є вирішальною для активного та організованого розвитку знань, вільних від початкових припущень. У фазі "перевірки" окреслено значення експериментів для перевірки гіпотез і моделей, що були побудовані. Виявлено, що значення таких експериментів варіюється між природничими та соціальними науками, і стаття презентує, як можна долати епістемологічні бар'єри у процесі наукового пізнання. Крім того, розглянуто застосування філософії Башляра у сучасних науках: як у фізиці та хімії, так і в соціальних науках, ілюструючи її вплив на сучасні практики наукових досліджень. Підсумовано, що філософія Башляра висвітлює процес еволюції наукового мислення, який полягає не лише у накопиченні знань, а й у постійному переоцінюванні та критичному перегляді попередніх концепцій. Ідеї Башляра залишаються важливим орієнтиром для розуміння науки в сучасну епоху та слугують основою для її розвитку та нових відкриттів.

Ключові слова: освіта і наука, Гастон Башляр, науковий метод, епістемологічний розрив, побудова знання, філософія науки.