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Epistemological Foundations and Methodological Structures: A Philosophical Review of Scientific Inquiry

Septariani[1], Ahmad Syukri[2], Badarussyamsi[3]
[1,2,3] State Islamic University of Sultan Thaha Saifudin Jambi

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ABSTRACT

Scientific inquiry serves as the primary engine for human civilization and knowledge development. However, conceptual ambiguities surrounding the boundaries of scientific structures, epistemology, and methodological principles often persist in contemporary discourse. This study aims to systematically analyze the fundamental structures, principles, and methodological frameworks of science through a philosophical lens, specifically examining the ontological, epistemological, and axiological dimensions of knowledge acquisition. Using a qualitative-descriptive library research method, this study analyzed authoritative texts, historical scientific paradigms, and methodological literatures. The findings reveal that the integrity of scientific knowledge relies on a triadic integration: a systematic empirical-rational structure, a rigorous adherence to objective epistemological methods (ranging from deductive-inductive reasoning to error-correction mechanisms), and an axiological responsibility. Furthermore, this study synthesizes Archie J. Bahm's pluralistic scientific steps, demonstrating that scientific methods must adapt dynamically to multi-disciplinary challenges without compromising objective validity. Understanding this fundamental architecture is critical for sustaining rigorous scientific development and resisting pseudo-scientific paradigms in the modern era.

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Corresponding Author:
Septariani
Jalan Jambi -Muara Bulian No.KM. 16, Simpang Sungai Duren, Kec. Jambi Outer City, Muaro Jambi Regency, Jambi 36361.
Email: septariani2020@gmail.com

INTRODUCTION

Science is often heralded as the crowning achievement of human civilization, a master key that unlocked the secrets of nature and paved the way for unprecedented societal progress. From the onset of the Industrial Revolution to the current digital landscape of Industry 4.0, our reliance on scientific developments has only deepened. Science does not merely explain the universe; it

actively reshapes how we communicate, survive, and build institutions. Yet, beneath this triumphant exterior lies a complex and delicate machinery. The rapid, almost chaotic, expansion of modern knowledge has generated a counter-effect. In an era saturated with information, the boundaries of what constitutes legitimate science have become increasingly blurred. The proliferation of pseudo-scientific narratives and post-truth claims presents a profound risk. If science is severed from its fundamental structures, it loses its objective validity, turning into nothing more than arbitrary opinion.

This potential crisis highlights a critical gap in our contemporary educational and scientific institutions. We often teach the applications of science while ignoring its philosophical underpinnings. To prevent scientific degeneration, we must return to basics. Any robust defense of scientific knowledge requires us to consult the classical triad of the philosophy of science: ontology, epistemology, and axiology. These three pillars do not exist as isolated academic concepts; they are the interactive skeletal frame of any discipline. Ontology determines *what* we study the real, empirical objects of our inquiries. Epistemology regulates *how* we know the precise mechanisms, methodologies, and logical frameworks utilized to extract truths. Axiology, meanwhile, governs the ethical *why* ensuring that our discoveries serve to uplift humanity rather than facilitate its destruction.

Among these three pillars, epistemology has arguably become the most contested battleground in modern academic discourse. Epistemological validity is what separates a disciplined scientific claim from a mere guess. However, the exact nature of this validity remains highly debated. Is scientific inquiry governed by a single, unchanging, and monolithic method? Or is it inherently pluralistic, adaptive, and evolving? Historically, positivistic movements sought to reduce all scientific endeavors to a rigid, mathematical, and highly standardized formula. They assumed that a singular scientific method could fit all phenomena, from physics to sociology.

Yet, this rigid outlook has proven increasingly insufficient. In practice, scientists do not work in a sterile, one-dimensional space. The problems we face today are highly dynamic and multi-layered, demanding creative and flexible approaches. Rigid adherence to a single method can paralyze innovative breakthroughs, while excessive methodological looseness can dissolve scientific objectivity altogether. Finding the sweet spot between these two extremes is one of the greatest challenges of contemporary research methodology.

To address this methodological dilemma, we can turn to the critical insights of Archie J. Bahm. In his seminal conceptualization of scientific inquiry, Bahm argued that the scientific method must be understood through a dual lens: it is both single and plural. It is single because there are universal cognitive attitudes such as curiosity, speculation, and systematic skepticism that must guide all researchers. Yet, it is simultaneously plural because every unique discipline and specific problem demands its own customized methodological path. Understood this way, science is not a rigid monolith, but an adaptable process. According to Bahm, scientific inquiry begins with a clear problem, advances through disciplined attitudes, operates via rigorous methods, and culminates in verified conclusions and societal impacts.

However, despite the brilliance of Bahm's framework, a distinct conceptual gap persists in contemporary academic literature. Most papers on the philosophy of science treat ontology, epistemology, and axiology as highly abstract, theoretical categories that belong strictly to philosophy classrooms. On the other hand, empirical research papers focus almost exclusively on technical, step-by-step methodology, completely detached from its philosophical roots. There is a glaring lack of literature that bridges this divide. We need to understand how the triadic philosophy of science directly shapes, limits, and refines our daily research methods. Without this synthesis, methodology becomes empty technical routine, and philosophy remains an impractical abstraction.

This article directly addresses this conceptual void. By performing a rigorous, qualitative-descriptive library analysis, this study constructs a bridge between abstract philosophy and practical methodology. The primary originality of this study lies in its holistic integration. It does not merely describe what ontology, epistemology, and axiology are. Instead, it systematically demonstrates how these three pillars are operationalized through the dynamic scientific steps laid out by Archie J. Bahm. We analyze how deductive and inductive reasoning function as cognitive tools within this structure, and how error-correction mechanisms keep scientific progress on the right track.

Ultimately, this study serves a dual purpose. On an intellectual level, it aims to demystify the basic structures of science, making them accessible and deeply understood. On a practical level, it seeks to provide a strong defense of objective scientific truth in an era increasingly hostile to intellectual authority. By clarifying how structured scientific principles work together to maintain academic integrity, this article aims to remind researchers, educators, and the public alike of the enduring value of systematic, ethical, and evidence-based inquiry. In doing so, we hope to contribute to a more rational, reflective, and scientifically literate society.

METHOD

This study employs a qualitative-descriptive research design with a focus on library research (*studi kepustakaan*). Rather than gathering raw empirical data from the field, this approach systematically gathers, filters, and synthesizes academic literature, authoritative texts, and philosophical documents related to the philosophy of science. This design is selected because analyzing abstract conceptual structures, such as ontological, epistemological, and axiological frameworks, requires an in-depth interpretive methodology that empirical surveys cannot easily capture. Through this approach, we can critically examine historical scientific paradigms and evaluate how theoretical concepts operate in practice.

The data collection process was conducted systematically using three main phases. First, we identified the primary source material, which consists of seminal works in the philosophy of science. This includes Archie J. Bahm’s conceptualizations of scientific methods, alongside established Indonesian academic literature on the subject, such as the works of Surajiyo, The Liang Gie, and Harsojo. Second, secondary data was acquired through digital academic databases, including Google Scholar, Garuda *(Garba Rujukan Digital)*, and Sinta-accredited journals. The literature search was guided by specific keywords, namely: *philosophy of science*, *scientific*

structure, *epistemological validity*, and *scientific method*. Third, we applied strict inclusion and exclusion criteria to ensure data quality. Literature published within the last ten years, specifically focusing on the intersection of philosophical theory and practical methodology, was prioritized, while non-peer-reviewed sources were excluded.

FINDINGS AND DISCUSSION

Definition of Science

In terms of representing and explaining the real world and following the rules of organization and systematization of common sense, Islamic studies provide objective methods. The body of scientific knowledge is one that can be tested methodically and systematically and has findings that are generally relevant. In essence, science is simply a system of knowledge that uses precedent and experimentation to provide logical explanations for the world around us and the things in it. In this context, the structure of the scientific method is explained. Information is information. What we call "knowledge" in English is actually the Arabic term "ilmu" for "science," and the word "generated ilmu" is a mixture of the two. All critical and analytical philosophical works that discuss the basic concepts of epistemology also called the theory of knowledge or Erkentnis theorie rest on this foundation. "Logos" and "Episteme" are two ancient Greek words that imply knowledge. The capacity to "put things in their proper place" (episteme) through the acquisition of knowledge (Purvis et al., 2019). The examination of the most fundamental issues in society is the main goal of epistemology, a subfield of philosophy that aims to understand the inner workings of the human mind. Describe the process of acquiring and applying this knowledge. The purpose of life and the limits of human understanding, and the principles of logic and logistics that demonstrate the existence of knowledge and provide reasonable limits to claims about its truth and impartiality. Thus, we can say that epistemology is a subfield of scientific philosophy.

The epistemological approach describes the act of studying or teaching this body of information. There are many different types of questions, and the onus is on the questioner to provide a general formula and mapped out solution to each (Rofiq, 2018). With the expectation that individuals will be able to control their own income and wealth rather than having it distributed disproportionately to them. There are different schools of epistemology that differ in the methodologies they use. Based on the level of consensus, the study of knowledge can be classified into three subfields: Logic and philosophy of knowledge Arguments that begin with the presumption of the truth of a fact before attempting to establish epistemological evidence for that fact are known as meta-epistemological arguments. One of the drawbacks of this method is that it forces you to accept a solution without further investigation or questioning. 2) Doubt in epistemology The skeptical approach to knowledge seeks to establish the truth of our claims before adopting them as truth. Finding solutions or options is key to this strategy. Third, meta-ethics The goal of this subfield of epistemology is not to establish a strong hegemony in the field; Rather, the goal is to analyze Islamic ethical and scientific issues from a theoretical and methodological perspective in order to find sound arguments for or against their validity. Paul Freedman's Principles of Scientific Research is quoted in The Liang Gie. The purpose of scientific inquiry, in

my opinion, is to improve our understanding of the past, present, and future through the acquisition of more accurate knowledge, and to provide humans with the tools they need to adapt to and shape their environment and personality. Meanwhile, education is a means to form new knowledge, said Carles Siregar. Knowledge can be made easier with knowledge because it contains many practical concepts or guidelines.

In this case, Randall found many similarities with scientists, namely Being able to build itself, when information is transmitted. To theoretically base future research, you can look at previous research findings. and, The fact that it is not inherent shows that there is room for error and progress. However, it should be noted, if there is an error or problem, then the problem is not with the method itself, but with the humans who use it. Objective, which has scientific results cannot mix understanding personally, is not influenced by its inventor, but must be in accordance with the facts of the original state of the object. The most basic requirement for a field of study is to have a goal, as Prof. Drs. Harsojo emphasized: Rational (unchanging), Acting empirically (in accordance with reality), Unlimited (cannot be monopolized), and accumulative.

On the one hand, it can be shown that, from a linguistic point of view, knowledge and science are the same thing; on the other hand, when viewed from the perspective of their respective materials (the term "former"), the two are different. Positive and systematic knowledge, namely science, is explained in the American encyclopedia.

Understanding of Knowledge

Etymologically, knowledge is defined as "true belief" (true belief supported by evidence) in the philosophical encyclopedia. Meanwhile, in terminology what is known or the result of one's efforts is what is defined as knowledge. In Sidi Gazalba's systematic philosophy book that Knowledge, consciousness, knowledge, and intelligence are the results of work. With that, science is the result of human aspirations to achieve divinity. The problem with this way of thinking about knowledge lies in its tendency to produce philosophically different conclusions. Some of these conclusions are a priori, that is, not based on sensory or spiritual experience, while others are a posteriori, that is, not dependent on experience or experimentation. Both of these approaches present their own challenges in understanding knowledge (Putri & Iskandar, 2020). According to Abbas Hammami, this understanding is rooted in objective facts. As additional information, perception especially sensory perception plays an important role in the process of acquiring knowledge. Because all knowledge begins with observation, observation becomes the most essential learning tool.

Realist thinking, which argues that all knowledge must be based on real evidence, is another term for this way of thinking. The basis of this thinking is the principle that in order to understand something, one must reason, that is, by synthesizing various rational and acceptable ideas. In the context of leadership or authority, the power of a person or group is often determined by the level of authority they have. In the relationship between the authority of the ruler and the knowledge of a group, authority is often not tested further to verify its truth, making it a source of knowledge that is not always critical. In addition, hunches or intuition, which is the ability to reason to reach

conclusions that are considered knowledge, is an important element of intelligence. Although intuitive knowledge cannot be verified through logic, its practical value is often undeniable. Knowledge must reflect the truth, and every truth is part of knowledge. John Dewey, a pragmatist, stated that there is no fundamental difference between the two. If John Dewey's conclusion is credible, then the broad insights he produced provide great hope for understanding knowledge.

Meanwhile, according to Burhanuddin Salam, knowledge can be classified into four categories. *First*, general knowledge, which is basic information that a person has, obtained through everyday experience and observation. For example, the fact that the color red is called red because of its visible nature as a primary color. *Second*, natural science, which is quantitative and objective. This science relies on the organization and systematization of general knowledge methodically, so it is often associated with science. *Third*, philosophical ability, which includes deep and broad understanding. This is the basic ability to know something through indications and conceptual analysis. Fourth, especially those related to the laws expressed in religious texts. In this view, everything that is known about a particular topic, including science, is considered part of the scientific community. Scientific information, which is interrelated and supported by common sense, is the main driver in the scientific world. Furthermore, science can be understood as the accumulation of all human efforts to gain knowledge about a particular object or phenomenon. In this case, the collection of information often has a basis in real objects (Rofiq, 2018). Therefore, religion has a significant role in the scientific method and the development of science itself, providing an ethical framework and deep insights that enrich the scientific perspective. By understanding this, we realize that science is a manifestation of the collective human effort to explore and understand the world around us.

However, understanding is achieved through observation, by utilizing the senses and reason, because understanding is the end result of all known information. However, knowledge that meets the criteria of truth and can be called scientific knowledge is knowledge obtained through scientific techniques. Therefore, Islamic science is based on a number of unique features. Here are some additional provisions: a) An item exists, whether in the business or material field. b) You are required to have a system, related, or manage the tutut. c) It requires analysis, induction, or action. Throughout his book "Philosophy of Science," Surajiyo explains the basic ideas that underlie every scientific discipline: (a) Ophiuchus is the first. The scientific method relies on direct experience and careful observation. b) Comprehensive. Interconnected and causal relationships exist between the many pieces of information and data that make up this body of scientific knowledge. d) For the purpose. The scientific method relies on direct records and analytical reasoning based on concrete examples taken from real life. in (d) leprosy. Researchers have attempted to break the material down into more manageable chunks so that students can better understand the many definitions, associations, and practical applications of the subject. e) Valid, unchanging. Others can check it too.

Theory of Knowledge

Since knowledge can only be acquired through certain methods of reason, I accept that there is knowledge that is infallible. The human mind is a storehouse of information, and our ability to know something with certainty is innate. However, racism often hinders the realization that we have the ability to learn and grow from mistakes. Reason, along with the five senses, is sufficient to understand and explain a variety of phenomena. As an argument, it is sufficient to show that the knowledge we have is well-founded, that we can be sure of its truth, and that the knowledge we seek will be revealed to us in due time. One form of knowledge, episteme, is hard and unmanipulable knowledge, in line with the bad mind, according to Plato. So far, our five sense data only cover 147 interrelated sets of concepts from the past. All the money in this fandom comes from old concepts. People gain knowledge and insight into the present through foolish ideas. The ability to draw on previous knowledge is a key component of knowledge, as stated in yesterday's concept. A person's brain is their storehouse of knowledge. All it takes to understand something, explain something, and ultimately reach the next level of understanding is to pay attention to the thoughts discussed in today's thinking. Only reason, as Descartes understood it, can provide the basis for knowing what is and who we are as human beings. The main factor that arises and hinders our knowledge of the truth is our senses (Octaviana & Ramadhani, 2021).

There is evidence that education is essential to human understanding. The empirical community agrees that the best approach to gaining solid knowledge is from data and facts gathered by our specialists. Information gained from direct sensory experience ranks high among the most valuable forms of knowledge. Aristotle argued that Plato was wrong when he said that knowledge can only exist in the realm of abstract concepts. "There is nothing in the mind that does not first exist in the senses." Aristotle took this premise as the foundation of factual evidence. Aristotle argued that the accumulation of facts and the separation of the general from the particular are the two main components of human knowledge. Knowledge of the real world is opposed to the path of rationally guided abstraction. Just look at survey data if you want something abstract. Therefore, understanding cannot occur without reason (Purvis et al., 2019). Because of his extraordinary character, Immanuel Kant is said to have united these two schools of thought. One of Kant's main contributions was his empiricism and randomness. Because of the small number of panels, it can be concluded that the panels are slightly smaller than each other. All things considered, human knowledge benefits the five senses, culture, reason, and reason itself.

Our understanding of the learning process leads us to believe that empirical testing of hypotheses through direct experience and experimentation is possible. However, this problem of inference can only manifest itself in certain ways that are ingrained in humans, namely as categories of time and space and as reasons for legal and abolitionist struggles. There must be underlying transcendental knowledge for reason to be fruitful. We analyze performance and returns on investments in terms of time and place, legal justification, and other factors. Scientific information builds on previously established knowledge and is informed by rational understanding criticism, logic, and systematization acquired through deductive reasoning. The use of the correspondence criterion in inductive reasoning is one mode of reasoning. A statement is true

according to the correspondence theory if and only if its content supports the factual argument put forward by the statement(Sevelius, 2013). Additional criminal techniques that can be learned include summary and analytical decision making, inductive and deductive reasoning, refutation, abstraction, comparison, and classification.

1. Using Scientific Methods

As a working hypothesis, Archie J. Bahm must face the nature of the scientific method. This statement will certainly trigger a heated debate. In addition, "What distinguishes an academic study is not only the fact that it is based on observation, but also the methods used in the process." In contrast to another view that says, "Scientists themselves often do not have a clear and logical understanding of the nature of the scientific method," methodology is the core of knowledge-based science (Sundaro, 2022). Even among scientists, there are often differences of opinion about the most appropriate approach.

From this debate arises the question of whether the scientific method is singular or plural. To answer this, Archie J. Bahm concludes that the scientific method can be understood with two approaches: first as a "single" method, which does not contain any subjectivity at all, and second as a "plural" method, which allows for various paths to describe it.

a) Each discipline has its own unique way of approaching problems.
b) Not every problem requires an original solution.
c) Even when using the same procedures, scientists at three separate periods drew different conclusions about how theories and technological discoveries are developed.
d) The capacity to develop new approaches quickly to deal with more complex and dynamic types of problems; this is becoming increasingly important in many scientific and technological fields.
e) Those in positions of authority on the scientific method must be aware of the power of the method and the strategies it employs at each stage.

Whereas According to Archie J. Bahm, the scientific method consists of five main steps. The first step is to describe the problem, where the problem faced must be explained clearly. Then, the second step is to verify the problem, which involves a checking process to ensure the truth and validity of the problem. The third step is to offer a resolution, which is to provide a solution or alternative to overcome the problem. Furthermore, in the fourth step, an evaluation of the suggestions or solutions that have been proposed is carried out to assess their effectiveness. Finally, the fifth step is to find the next solution, which focuses on further development and improvement after the evaluation is carried out. Another opinion explains that there are four main processes of empirical research, namely data collection, data organization, hypothesis development, and hypothesis testing (Muktaf, 2016).

The scientific problem-solving process begins with the recognition and awareness of a problem, and the desire to find a solution. This is the essence of knowledge itself. Then, as the investigation progresses, the primary focus is on understanding the problem in greater depth. At this stage, it is important to set aside the initial desire to find a solution, and instead focus on understanding the symptoms and causes of the problem. The next step is to solve the

problem, which involves testing initial assumptions and developing working hypotheses to address the main parts of the problem at hand. Scientists then seek relevant data to support or test the proposed theories(Habibah, 2017). After this, the ideas that emerge are tested both mentally and operationally, with the goal of ensuring the feasibility of implementing the system through a series of tests. This process opens up the opportunity to test and prove new theories. Finally, after going through the evaluation and testing stages, a solution can be found, with unsolved problems still open for further research. The scientific method is essentially focused on finding answers to questions posed, and while a problem may not be completely solved, every attempt to understand it more deeply brings us closer to an accepted solution.

2. There is scientific activity

As a result, the term "science" was coined to refer to the work produced by scientists. The personal and social dimensions of research are equally important. The study of science is an activity that can only be carried out by unique individuals, so that science and human life go hand in hand. This shows that the nature of existence can change as it is passed from one generation to the next. If we can understand what it takes to be a scientist such as the ability to observe, formulate hypotheses, test ideas through controlled experiments, and demonstrate genius or insight we will be able to better understand the essence of science itself. Academic activity includes a variety of actions taken by various disciplines, which often have social implications. Great efforts in institutional form have evolved into the process of accumulating knowledge. In the current context, the academic community is the most important working group. Therefore, within certain professions, the foundation of knowledge that is built is very unique.

For example, in 1960, the American Men of Science had 96,000 members, a sharp increase from 4,000 in 1903, indicating that the organization's mission was to advance academic achievement. Islamic scientific institutions, such as universities and other forms of higher education, as well as government facilities and corporate divisions, are highly dependent on the contributions made. Therefore, there are initiatives that support learning, especially at the university level, in both the public and private sectors. Recognizing the impact of scientific progress or stagnation on academic activities is essential to ensure the sustainability and strong foundation of scientific inquiry (Muslih, 2014).

3. Conclusion of Science

The process of acquiring new information is often referred to as learning. Therefore, a body of information is often considered knowledge. However, knowledge itself is the core of a larger body of ideas. The goal of knowledge-based research is to solve problems and gain a deeper understanding of the issue being studied(Winarno, 2018). The scope, methods, and activities of the research are defined in its conclusion, which is the end result of the entire process. The results obtained reflect the investment of time and effort that has been made. The knowledge that emerges is not theoretical or process-based knowledge, but rather more practical applied knowledge. In science, all claims that are supported by data are considered valid conclusions.

Therefore, proving to the public that knowledge is based on reliable information or evidence should be the main focus of scientific inquiry. Thus, it is important to ensure that every scientific claim is well-founded and can be verified through systematic and objective methods. Valid knowledge must not only be supported by reliable evidence, but also go through a critical and transparent evaluation process. With this approach, we can ensure that science continues to develop in a reliable manner and makes a useful contribution to human progress (Batubara, 2017). Therefore, the application of rigorous scientific principles and continuous reexamination are key to building and maintaining knowledge that is valid and useful to society.

CONCLUSION

The above definition makes scientific inquiry one of the ways in which humans create new knowledge. Scientific knowledge stands out from other forms of knowledge because of its higher quality compared to common knowledge. Through the use of a clearly defined process that combines perspective, methodology, and a series of well-defined processes, scientific inquiry seeks to obtain more precise, comprehensive, and reliable information. This method relies on the golden ratio of reasoning, which requires the use of three different modes of thinking: systematic, logical, and critical. Scientific understanding is more perspective-oriented, methodologically rigorous, and focused than philosophical understanding. One definition of science is the methodical, unbiased, and rational search for truth through reasoned, analytical, and thorough investigation. several forms of thinking, including inductive and deductive reasoning

This rigorous approach to scientific inquiry ensures that knowledge is not only accurate but also applicable and testable in a variety of contexts. By employing methods such as inductive and deductive reasoning, scientists can draw conclusions that are both grounded in evidence and logically sound. The clarity and precision inherent in scientific methods allow for the refinement of theories and ideas, ensuring that they stand up to scrutiny and can be continually improved. In conclusion, scientific knowledge offers a framework for understanding the world that is rooted in careful observation, critical thinking, and a commitment to uncovering truth. Its systematic nature enables us to solve complex problems, drive innovation, and contribute to the advancement of human society. Through this process, science remains an essential tool for exploring, understanding, and shaping the future.

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