The Axiomatic Method and Interdisciplinary Studies: Towards a Holistic Vision of Contemporary Sciences

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Abstract:
This article examines the axiomatic method as a central mechanism for activating interdisciplinary research across fields of knowledge, highlighting its theoretical dimensions and methodological functions. The analysis proceeds from the concept of interdisciplinarity as an epistemic formulation aimed at overcoming disciplinary closure and reintegrating disciplines within an encyclopaedic system capable of encompassing complexity and composite phenomena. This article demonstrates how the axiomatic method provides a formal structure grounded in fundamental assumptions and abstract inferences, thereby enabling abstraction, rational analysis, and the formulation of symbols as a means of expressing the structural relations between concepts, independent of direct empirical reference. Drawing on examples from physics, such as the equivalence between wave mechanics and quantum mechanics, this article illustrates the method's capacity to reveal symmetry, equivalence, and correspondence between theories, thereby enhancing the understanding of the interdisciplinary system of knowledge. The study concludes that the axiomatic method not only organises the sciences but also contributes to constructing a holistic horizon for encyclopaedic thought, one that balances specialisation and totality and establishes a robust epistemic integration capable of addressing the challenges of contemporary knowledge.
Keywords: Axiomatic method; interdisciplinary studies; epistemic integration; formal systems; abstraction; contemporary sciences

1. Introduction

During the nineteenth century, mathematics underwent profound transformations across its various levels, including subject matter, methods, and results. Mathematics had been regarded as an exact and certain science, free from defect; however, this status came under epistemological revision as a result of decisive scientific developments that led to a radical change in mathematicians' conceptions, concepts, and methods. Whereas Euclidean geometry, attributed to Euclid (300–265 BCE), had occupied a preeminent position in classical mathematics as the only possible model, new geometries emerged that were characterised by systematicity and plurality, thereby changing many of the fundamental concepts upon which mathematical proof had been based. These geometries also introduced a different conception of both mathematical space and its foundational principles, as embodied in the emergence of non-Euclidean geometries, to which we will return later.

In the context of this scientific development in mathematics, what came to be known as spatial geometry also emerged, alongside the discovery of discontinuous functions, after the prevailing classical conception held that a function is, by nature, continuous. Set theory was also established by the German mathematician Georg Cantor (1845–1918 CE), which constituted a decisive turning point in the history of mathematics. These transformations collectively led to the emergence of what became known as the crisis of foundations in mathematics, prompting scholars to reread this science anew. The subject matter of contemporary mathematics was no longer those self-evident truths that classical rationalism had taken as its basis; rather, its subject matter became relations or, more precisely, structures. With this shift from concern with objects to a focus on structures, it became clear that the branches of mathematics are not independent domains but different forms of structures united by common essential properties. Hence, the mathematical method was no longer intuitive or deductive in the old sense but became a set of procedures and transformations applied to those structures (Al-Jabri, 2011). Thus, the mathematician worked within a formal system that carried out specific operations and transformations within an interconnected mathematical structure, relying on a new method grounded in hypothetico-deductive reasoning, namely, the axiomatic method.

The axiomatic method seeks to achieve a set of fundamental objectives, foremost among which is the establishment of interdisciplinary coherence among the various mathematical and epistemic systems, as well as an effective instrument for organising and regulating knowledge within harmonious formal structures. Its significance is manifested in the intellectual and practical functions it performs, whether at the levels of abstraction, analysis, or methodological unification. Therefore, this study seeks to address the following central problem: To what extent has the axiomatic method, in view of the fragmentation of knowledge and the increasing proliferation of specialisations in our contemporary reality, succeeded in achieving its aim of activating the mechanisms of interdisciplinary studies among the various sciences, within a horizon that seeks to construct a holistic conception of knowledge without compromising the specificity of epistemic fields?

In light of the accelerating scientific and technological revolution witnessed by the contemporary world, the importance of the scientific method in research has increased until it has become an urgent necessity and a fundamental tool for addressing epistemic problems and dilemmas. It has thus become an essential pillar of human knowledge across its various domains. Most countries, particularly developed countries, have devoted considerable attention to scientific research to overcome the problems that hinder their developmental trajectories. They have consequently opened up to various fields of knowledge and adopted new methodological approaches based on integration rather than separation. In this context, interdisciplinary studies have emerged as a methodological framework that seeks to integrate different specialisations into a unified body of knowledge, thereby enabling the holistic analysis of complex phenomena. Consequently, the concept of interdisciplinarity has become prominent in contemporary thought, necessitating the question of what is meant by interdisciplinary studies and what is their importance in the production of scientific knowledge.

2. The Concept of Interdisciplinary Studies

The term *interdisciplinary* consists of two basic components: *inter*, meaning "between", and *discipline*, meaning a specific field or domain of study. Accordingly, interdisciplinarity is defined as the study of two or more leading fields of knowledge (Amin, 2020). Its importance is not confined merely to bringing disciplines together; rather, it goes beyond this to achieve a form of epistemic integration that enables the production of a deeper and more comprehensive understanding of the phenomena under study, within an encyclopaedic horizon that seeks to integrate the parts within a coherent whole, whereby specialisation is subsumed within a broader epistemic unity that may be termed inherent interdisciplinarity.

At the outset, it is necessary in this article to clarify certain terms related to the subject of the research and to remove any ambiguity that may surround them so that no conceptual confusion arises that might affect the treatment of the problem under consideration. Among the most prominent of these terms are multidisciplinary and interdisciplinary studies, two concepts that may appear similar but differ in the way they relate to disciplines. The first term refers to studies that bring together two systems, "A" and "B", to solve a given problem without integrating them. In contrast, the second refers to studies that combine two systems, “A” and “B”, to solve a given problem through their integration, thereby arriving at a deeper understanding of an integrated field of knowledge, for example, “C” (Amin, 2020, p. 2).

There is a difference between one science needing another to participate in solving a pending scientific dilemma and one science integrating with another so that they become subsumed and points of convergence between them are sought, thereby forming a new scientific field. For example, health and society medicine is a new field of knowledge that emerged from the integration of several disciplines, such as sociology, medicine, psychology, and the geographical environment.

3. Interdisciplinary Study

Interdisciplinary studies constitute a creative vision based on the dialogue of methods, the cross-fertilisation of ideas, and the plurality of perspectives, allowing phenomena to be connected and deepening the relations between different issues. They represent an emerging epistemic field in which disciplines converge, combining a precise, specialised perspective with a comprehensive, holistic vision of knowledge. Within this framework, the researcher seeks to transcend the narrow boundaries of specialisation by adopting an encyclopaedic approach that enables the studied phenomena to be grasped in their complexity and composition, thereby producing more comprehensive and profound results. Thus, interdisciplinary studies are closely linked to the concept of “epistemic integration” as a methodological horizon that seeks to unify knowledge without abolishing its specificities.

4. Concept of the Axiomatic Method

This section falls within the general problem of the study, which centers on the extent of the axiomatic method's efficacy and effectiveness in activating interdisciplinary studies across the various sciences. Having presented the concept of interdisciplinarity and defined the dimensions of interdisciplinary studies, we seek at this stage to encompass the concept of the axiomatic method in its various aspects, with a view to highlighting its theoretical foundations and methodological functions, thereby allowing an understanding of the epistemic value it possesses, which constituted a principal motive for choosing this topic.

Linguistically, *axiomatique* is derived from the word *axiome*, which, according to the French philosopher André Lalande (1867–1963), originally meant the critical study of axioms, despite the different meanings of this word, which are taken as principles for the reasoning of geometry. Its most commonly used meaning is as follows: a syllogistic premise regarded as evident and accepted as true by all who understand its meaning. This essence is admitted by the doctrine as a postulate or, more properly, as self-evidence. It therefore requires no demonstration (Lalande, 2001).

In terminological terms, however, axiomatic, or axiomatics, according to Robert Blanché (1898–1975), denotes the completed form that a deductive theory takes today. Rather, it is a system in which the undefined terms and unproven propositions are fully declared, insofar as the latter are posited as mere hypotheses from which all the propositions of the system can be constructed according to logical rules that are fully and explicitly defined (Blanché, 2004). The axiomatic method proceeds from hypotheses selected by the researcher from among a wide set of possible hypotheses, from which mathematical propositions and theorems are then deduced, provided that these propositions are consistent and noncontradictory with the primitives from which they proceeded, to preserve the unity of the mathematical system and its internal coherence. This method is characterised as hypothetico-deductive; that is, it focuses on the formulation and deduction of propositions according to abstract formal and logical rules, without regard to the content of the symbols or their real significance at the level of sensory experience.

Mathematicians have identified three fundamental conditions that must be observed methodologically when any axiomatic system is constructed:

5. Conditions for Establishing Primitives

1. The mathematician must declare the primitive terms, namely, the definitions he formulates; that is, he must specify the concepts, words, terms, and limits he employs in constructing his mathematical system. He must also assign these words and symbols determinate and precise meanings and adhere to their use in a manner that does not conflict with what he initially established so that no contradiction arises in subsequent inferences.
2. The mathematician must declare the primitive propositions upon which he will build his mathematical system; that is, he must state the hypotheses and primitives that he acknowledges and adopts as the basis for his future proofs and inferences in a manner that ensures the stability of the system's unity and prevents any internal contradiction.
3. The relation between the primitive terms and hypotheses must be based on an abstract formal logic such that it remains independent of the semantic meanings of the symbols and terms employed. In other words, the methodological construction of the axiomatic system should be based on a purely formal formulation, without reliance on references to external reality or on the meanings of symbols in sensory experience.

6. The Benefits of the Axiomatic Method in Enhancing Interdisciplinary Studies among Forms of Knowledge

The application of the axiomatic method is not confined to the field of mathematics; rather, it extends to all fields of research, regardless of their subjects, seeking to expand and organise the domain of knowledge within an integrated system. After identifying the fundamental conditions for establishing primitives, which constitute the methodological basis of any precise and coherent scientific inquiry, the axiomatic method enables openness to interdisciplinary pathways, in which different sciences converge and transcend the narrow boundaries of specialisation to analyse complex and composite phenomena. From this standpoint, researchers seek to produce integrative knowledge that goes beyond limited structural forms, thereby moving from closed, unilateral thinking to an encyclopaedic and open form of thought that is capable of accommodating interdisciplinary studies and elucidating the interwoven relationships among different phenomena, allowing for a deeper and more comprehensive understanding of the subjects under investigation.

The axiomatic method considers the plurality of mathematical and epistemic systems across various fields, such as economics, politics, logic, and philosophy, while preserving the unity of the method according to the conditions it imposes. By relying on primitive structures as a basis, mathematics achieved unity at three levels: the unity of subject matter, the unity of method, and the unity of subject matter and method. This method also enabled the formulation of a common language across different structures, reflecting one of the most prominent manifestations of the intellectual progress achieved by humankind in contemporary age.

The axiomatic method has other objectives that are purely interdisciplinary in character. Its importance lies in the intellectual and practical functions it performs, as evidenced by several applied examples that demonstrate its effectiveness in organising knowledge and analysing problems.

1. A valuable instrument for abstraction and analysis. In the first respect, the transition from a concrete theory to the same theory axiomatised and then formally formulated renews, while continuing, the work of abstraction that leads, for example, from the concrete number, a heap of apples, to the arithmetical number, then from arithmetic to algebra, with individual terms being replaced by variables whose relations alone are determined, and finally from traditional algebra to modern algebra, where not only are the objects themselves no longer concretely determined, but the operations performed upon these objects also become so in turn (Blanché, 2004, p. 72). The axiomatic method is considered an important instrument of rational abstraction through its adoption of the symbolic style as a tool of formulation; that is, it distances itself from sensible or external reality, which constitutes an obstacle to achieving absolute symbolism, by focusing on logical relations without regard to the semantic meanings of symbols. In the second respect, the basic concepts of a theory often remain obscure prior to axiomatic treatment, possessing excessively rich and insufficiently explicit significations. The axiomatic method, however, involves the analysis of primitive concepts, requiring the isolation of certain properties explicitly stated in the primitives and the use only of these properties or of those that may be deduced from them (Blanché, 2004, p. 72).
2. Generalisation: Any advance in abstraction is matched by an advance in generalisation. After the process of analysis was previously undertaken, involving the isolation and reduction of concepts, we widened the domain of extension or comprehensiveness. Generalisation, as Russell states, is the transformation of a constant into a variable. This is precisely the work of axiomatics when it replaces the straight line and congruence with x, y, and so forth, which satisfy the relations stipulated by the primitives. Thus, when we exclude intuitive significations, we create for ourselves a polyvalent rational instrument that can be used for all theories that are structurally analogous to the first (Blanché, 2004, p. 73). These precise rational operations, which we employ in generalisation through the axiomatic method, enable us to formulate any theory within an abstract formal mould, away from the semantic plurality of linguistic terms. For example, if the symbols “x”, “y”, and “d" denote a table, a chair, and papers, respectively, then “z” may denote a desk. In this way, linguistic terms that may carry multiple or overlapping meanings are replaced

by determinate, clear symbols, thereby allowing the relations between concepts to be expressed purely formally and avoiding linguistic overlap or misinterpretation. This formal mould resulting from generalisation has made axiomatised theory a kind of "theoretical function" into which concrete theories are inserted. The axiomatic method has likewise become not merely a mathematical method but also an effective instrument for organising knowledge, whether in a specific science such as physics, through the systems of Newton or Einstein, or in any other field of knowledge, whatever its kind. This approach can also be applied to educational materials or lectures by rearranging ideas and concepts within a framework of primitive principles or basic rules, thereby facilitating their assimilation and understanding of their internal relations.

3. Analysing problems logically, the axiomatic method helps treat problems systematically, enabling researchers to identify the essential variables of the problem under study. It also assists in formulating consistent and logical hypotheses that ensure that the conclusions drawn are compatible with, and do not contradict, the basic premises, thereby enhancing precision and reliability in scientific research.
4. Providing a common framework for the sciences: The axiomatic method, particularly in mathematics, offers a framework that can be applied across various sciences, thereby facilitating communication and collaboration among researchers from multiple fields. For example:

- Physics and mathematics: Mathematical tools are used to describe the laws of motion and gravity.
- Engineering and physics: Physical concepts are applied in the design of buildings and machines.
- Economics and mathematics: mathematical models are employed to analyse markets and predict economic trends.

These examples are grounded in contemporary epistemic reality, where the axiomatic method has helped unify the various sciences within a common framework, thereby serving as a basis for modern scientific research and the development of interdisciplinary studies.

5. The axiomatic method is a vital tool that enables researchers to uncover the fundamental structural relations among theories, sciences, or subjects. It assists in identifying symmetry between disparate phenomena, equivalence between essentially convergent systems, and correspondence between basic referential structures and their various applications, thereby enhancing the understanding of internal connections and facilitating integration between scientific disciplines.

a. Symmetry: The axiomatic method helps reveal the latent unity between phenomena that may initially appear divergent or incompatible through the structural analysis of scientific systems. For example, before the beginning of the twentieth century, the branches of physics were studied independently of one another: light was studied separately from magnetism; light and magnetism were studied separately from energy; and electricity was also studied separately. However, contemporary scientific developments have revealed essential relationships between these phenomena, such as electromagnetic phenomena and quantum energy, highlighting the axiomatic capacity to identify a common structure across different sciences.

b. Equivalence: The axiomatic method also helps to reveal interdisciplinary equivalence between two different systems or sciences within a given field through the analysis of the basic structures of each. Even if the formulations or outwards forms of theories differ, the axiomatic method can identify their essential similarities. For example, the equivalence between the theory of wave mechanics developed by Louis de Broglie (1892–1987) and quantum mechanics formulated by the German physicist Werner Heisenberg (1901–1976) shows that, despite differences in method and formulation, both theories arrived at the same essential conclusion: the nature of the electron is dual, negative and positive at the same time, contrary to what had previously been familiar.

c. Correspondence: The axiomatic method helps to distinguish the basic ideas or reference structure upon which model structures or the various applications of those structures are based. For example, the axiomatic analysis of ideal axiomatic systems among philosophers such as Plato, Hegel, and Bergson shows that they are not independent systems in themselves but represent different applications of a single intellectual system that may be called the system of idealist thought, which is based on three fundamental principles:

a. Granting priority in existence to thought.

b. Granting primacy in knowledge to thought rather than to external reality or experience.

c. Granting primacy to values, both ethical and aesthetic, whose source is thought rather than reality.

6. The axiomatic method allows the use of calculating machines and computers to perform mathematical or research calculations across various sciences, such as physics and medicine, thereby helping conserve researchers' intellectual effort so that they may focus on solving more complex problems that exceed the capacity of traditional computation. This mathematical systematicity also helps scientists focus on the applications and discoveries that artificial intelligence has achieved, rather than reconstructing theoretical foundations each time, thereby securing a considerable economy of intellectual effort and increasing the effectiveness of scientific research, which always seeks objectivity.

7. Conclusion

This study has examined the axiomatic method and its role in fostering interdisciplinary research across the sciences. At the outset, the concept of interdisciplinarity and interdisciplinary studies was clarified as an instrument for finding appropriate solutions to complex problems within a holistic encyclopaedic system, whereby specialisation is subsumed within an integrated whole and becomes part of the comprehensive structure of knowledge. This study highlights the axiomatic method and its fundamental objectives, including achieving interdisciplinary coherence among various mathematical and epistemic systems and serving as an effective instrument for organising knowledge. It is therefore clear that the role of the axiomatic method is not limited to the theoretical dimension alone but extends to influencing the intellectual and practical functions of researchers through rational abstraction and the formulation of symbols and abstract logical relations, independent of the sensible. The study also demonstrated the capacity of the axiomatic method to achieve harmony among different sciences and to facilitate the integration of disciplines that may initially appear impossible to combine, whether through symmetry or equivalence between theories. An example from physics highlighted the difference between de Broglie's wave mechanics and Heisenberg's quantum mechanics, where both theories led to the same essential conclusion about the electron's dual nature, despite their different formulations. Moreover, the axiomatic method helps to distinguish the basic referential structures from which different theories and applications proceed, allowing a deeper understanding of the relationships between diverse concepts and theoretical frameworks. Thus, the axiomatic method emerges as a central instrument for achieving encyclopedic thought, epistemic organisation, and integration among the sciences, making it an important pillar in addressing complex problems and developing scientific research in the contemporary age.

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