



From Knowledge Mapping to Evidence Synthesis: A Critical Path Model for Constructing Coherent Scientific Texts

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Abstract

Background. Contemporary academic writing practice is increasingly determined by standardized requirements for publication structure and typologies of review studies. At the same time, formal compliance with these standards does not guarantee the methodological coherence of a scientific text, as the logic of knowledge formation often remains unarticulated.

Purpose. To propose a critical path model of knowledge synthesis, within which the preparation of a scientific text is considered as a sequential cognitive process governed by an invariant logic of epistemological operations.

Materials and Methods. The study was conducted in the format of a conceptual narrative review involving methodological works on evidence synthesis, typologies of review studies, and academic writing. The analysis was aimed at reconstructing functional cognitive operations, establishing causal relationships between them, and formalizing their sequence in the form of a critical path.

Results. Five invariant cognitive nodes were identified: orientation, conceptualization, verification, evidence synthesis, and interpretation. It was shown that these nodes form a critical path that determines the methodological coherence of a scientific text regardless of the publication genre. It was established that different types of reviews correspond to individual segments of this path but do not determine its logic. Typical violations of the critical path were identified, including meta-analysis without conceptualization, narrative generalizations without verification, and systematic reviews without orientation in the scientific field, which lead to predictable methodological deformations.

Discussion. The obtained results indicate that methodological problems of contemporary scientific texts have a structural character and are associated with the substitution of the logic of cognition by genre-based and formal requirements. The proposed model makes it possible to interpret these violations as consequences of disruptions in causal relationships between cognitive operations.

Conclusions. The methodological correctness of a scientific text is determined not by its formal type, but by the consistency of the preparation trajectory with the critical path of knowledge synthesis. The proposed model provides a basis for improving the quality of academic writing, peer review, and editorial evaluation.

Keywords: critical path model, knowledge synthesis, evidence synthesis, academic writing, methodological framework, systematic review, physical education, sport science.

Introduction

In contemporary academic practice, the preparation of scientific texts is increasingly carried out under conditions of a high level of formalization of requirements for publication structure, reporting, and types of research, which is particularly evident in the standardization of review studies and evidence synthesis procedures (Grant & Booth, 2009;

Page et al., 2021). However, such standardization does not eliminate, but often masks, problems of logical coherence in the process of knowledge formation. At the same time, the growth of formal standards is not always accompanied by a corresponding clarity regarding the logic of scientific knowledge formation, which precedes the choice of genre or type of article. As a result, scientific texts may comply with formal criteria while remaining conceptually unstable or methodologically ambiguous.

One manifestation of this situation is the emergence of hybrid texts that combine elements of narrative review,

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systematic review, and meta-analysis without a clear distinction of their functional roles within the overall cognitive process, which had previously been conceptually differentiated in typologies of review studies (Grant & Booth, 2009). In such cases, genre forms de facto substitute the logic of sequential knowledge synthesis, leading to structurally unstable or methodologically inconsistent texts. This complicates both the interpretation of results and their evaluation in the peer-review process.

In contemporary philosophy of science and approaches to evidence synthesis, there is an increasingly clear understanding of scientific knowledge as the result of a stepwise cognitive process, within which different forms of synthesis perform specific functions—from orientation within the scientific field to verification and synthesis of evidence (Arksey & O'Malley, 2005; Levac et al., 2010; Higgins et al., 2019). In this context, bibliometric analysis serves as a formalized tool for mapping the structure of scientific knowledge, identifying thematic clusters, and research trends (Donthu et al., 2021). The evolution of review typologies confirms that these forms are not alternatives, but reflect different segments of a unified process of knowledge formation (Grant & Booth, 2009). At the same time, in academic writing practice, these functional distinctions are often reduced to genre templates, which complicates the reproduction of the internal logic of the cognitive process. Under these conditions, genre requirements and reporting standards begin to act as substitutes for methodological reflection, despite existing approaches that conceptualize writing as a tool for knowledge production (St. Pierre, 2007). This creates the need for formalizing a unified causal model that integrates different forms of knowledge synthesis into a coherent cognitive process.

As a result, problems of methodological quality in scientific publications are often interpreted as authors' errors or non-compliance with standards, whereas their causes are structural and related to the absence of a formalized connection between stages of knowledge synthesis. Under such conditions, individual methods may be applied formally correctly but yield methodologically unstable results, which is partly due to the fragmentation of methodological guidelines and reporting standards across types of review studies (Tricco et al., 2018; Page et al., 2021). This necessitates a conceptual understanding of scientific text preparation as a coherent cognitive process with an internally determined sequence of operations.

In this paper, a critical path model of knowledge synthesis is proposed, which interprets the preparation of a scientific text as a sequence of invariant cognitive operations linked by causal relationships.

In the field of physical education and sport, this problem becomes particularly relevant due to the interdisciplinary nature of research, the combination of pedagogical, biomedical, and behavioral approaches, and the rapid growth in the number of review publications. Under such conditions, violations in the logic of transitions between stages of knowledge synthesis lead to the emergence of formally correct but methodologically fragmented studies, including systematic reviews without a clear conceptual framework or meta-analyses without adequate orientation in the scientific field. This complicates the interpretation of results and reduces their practical value for specialists in physical education and sport.

The purpose of this study is to conduct a conceptual narrative review aimed at formalizing and conceptually substantiating the critical path of cognitive operations as an invariant model of knowledge synthesis in the process of scientific text preparation. Within this approach, genres of scientific publications are interpreted as functional segments of a unified cognitive process, while methodological correctness is determined by the consistency of the chosen trajectory with the causal logic of this process.

Achieving this goal involves:

- (1) identifying invariant cognitive operations underlying scientific text preparation;
- (2) formalizing their causal relationships in the form of a critical path;
- (3) analyzing typical violations of this path and their methodological consequences.

Materials and Methods

Study Design

The study was conducted in the format of a conceptual narrative review aimed at the theoretical understanding of the logic of scientific text preparation in contemporary academic practice. The purpose of the methodological analysis was not to synthesize empirical results of individual studies, but to identify invariant cognitive operations and causal relationships that determine the methodological coherence of a scientific text.

The chosen format of a conceptual narrative review corresponds to contemporary approaches to the analysis of complex methodological phenomena, where the aim is not the aggregation of results of individual studies, but the reconstruction of the logic of the cognitive process. This approach is consistent with the interpretation of writing as a tool for research and knowledge production, rather than merely a means of its representation (St. Pierre, 2007).

Accordingly, the study does not belong to systematic reviews or meta-analyses and does not involve quantitative synthesis of data.

Research Material

The research material consisted of normative and methodological publications that define contemporary approaches to knowledge synthesis and the construction of review studies. The analysis included works that:

- (a) describe functional differences between types of reviews and their methodological roles (Grant & Booth, 2009);
- (b) substantiate the necessity of an orientation stage in expanding and fragmented scientific fields (Arksey & O'Malley, 2005; Levac et al., 2010);
- (c) formalize requirements for verification and synthesis of evidence in systematic reviews and meta-analyses (Higgins et al., 2019; Page et al., 2021);
- (d) conceptualize academic writing as a tool for cognition and the construction of scientific argument (St. Pierre, 2007).

These publications were considered not as empirical sources for result aggregation, but as methodological reference points reflecting the evolution of views on the logic

of knowledge synthesis and the status of different forms of review studies in scientific cognition.

Methodological Framework of Analysis

The methodological basis of the study was the interpretation of scientific text preparation as a sequential cognitive process that can be formalized in the form of a network model. Within this framework, genres of scientific publications were considered as forms of knowledge representation, while the main unit of analysis was functional cognitive operations.

The analysis was carried out through:

1. Conceptual comparison of different forms of knowledge synthesis with their cognitive functions.
2. Reconstruction of causal relationships between stages of scientific argument formation.
3. Identification of invariant nodes of the cognitive process, independent of the field and type of publication.

Procedure of Analysis

The research procedure included several interrelated stages:

1. Conceptual analysis of methodological sources to identify the evolution of views on the scientific text – from product to process of cognition.
2. Narrative synthesis of approaches to evidence synthesis with a focus on their functional role in the logic of knowledge formation.
3. Formalization of cognitive operations in the form of nodes of a network model and identification of logically necessary transitions between them.
4. Analysis of critical path violations, which made it possible to identify typical inadmissible trajectories of scientific text preparation and their methodological consequences.

The results of this stage formed the basis for the development of the critical path concept presented in the Results section.

Criteria of Conceptual Validity

The validity of the obtained conclusions was ensured not by statistical indicators, but by the internal logical consistency of the model and its ability to explain typical methodological deformations observed in academic practice.

The criteria of conceptual validity included:

- consistency of the model with contemporary views on the stepwise nature of scientific cognition;
- explanatory capacity with respect to identified inadmissible trajectories;
- coherence with the results and their interpretation presented in the Results and Discussion sections.

Methodological Limitations

The proposed approach is conceptual in nature and does not involve empirical verification on a corpus of specific publications. At the same time, it provides a methodological basis for further studies aimed at empirical analysis of scientific text preparation trajectories in different fields of knowledge.

Results

The analysis of contemporary approaches to evidence synthesis indicates that different forms of review studies historically developed not as alternatives to one another, but as responses to the limitations of previous approaches. Thus, the development of scoping approaches was driven by the need for orientation in expanding and fragmented scientific fields (Arksey & O'Malley, 2005; Levac et al., 2010), whereas systematic reviews and meta-analyses emerged as tools for increasing reproducibility and the strength of evidence (Higgins et al., 2019).

Logic of Scientific Text Preparation as a Network Cognitive Process

As a result of the conceptual narrative analysis of methodological approaches to knowledge synthesis, it was established that the preparation of a scientific text cannot be reduced to the choice of genre or type of publication. Instead, it follows an invariant logic of the cognitive process, which can be formalized in the form of a network model with clearly defined nodes and causal transitions between them.

These nodes correspond to functional cognitive operations, without which scientific generalization loses methodological stability.

Identification of Invariant Cognitive Nodes

The analysis of contemporary approaches to evidence synthesis, philosophy of science, and academic writing made it possible to identify five invariant cognitive nodes:

Orientation in the scientific field – provides an understanding of the structure of knowledge, thematic clusters, dominant approaches, and research gaps, including through bibliometric mapping techniques (Donthu et al., 2021).

Conceptualization of the problem – involves the formation of a theoretical framework, the logic of argumentation, and key concepts.

Verification of statements – is aimed at assessing the reliability and reproducibility of the empirical data and sources used.

Evidence synthesis – ensures the integration of results and the weighting of evidence, including quantitative synthesis.

Interpretation and projection – connects the obtained synthesis with theoretical positions and practical implications.

These nodes represent logically necessary states of cognition, regardless of the field of knowledge and the format of publication. The proposed logic has direct methodological relevance for the field of physical education and sport, where different forms of knowledge synthesis are often applied in isolation, outside their functional interconnection.

Critical Path of Scientific Text Preparation

In terms of network planning, the preparation of a scientific text has a critical path, the violation or omission of elements of which leads to methodological instability of the result.

The critical path has the following sequence:

Orientation → Conceptualization → Verification → Evidence synthesis → Interpretation

This path is epistemological rather than genre-based. It reflects the logic of scientific knowledge formation, whereas publication types represent only individual segments of this path.

The constructed network model of the critical path of knowledge synthesis is presented in Figure 1.

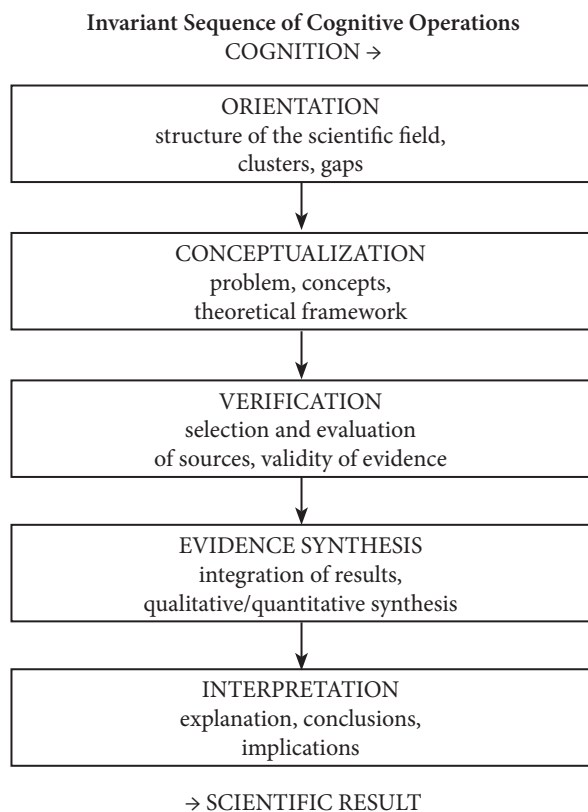


Fig. 1. Critical path of knowledge synthesis in scientific text preparation. Note. The critical path reflects an invariant, causally determined sequence of cognitive operations underlying knowledge synthesis. Violation or omission of individual stages of this path leads to predictable methodological deformations regardless of the formal type of publication.

Mapping of Cognitive Nodes to Forms of Knowledge Synthesis

Within the identified critical path, different forms of knowledge synthesis perform specific functions corresponding to individual cognitive nodes. This allows them to be considered not as alternative approaches, but as functionally interconnected elements of a unified process of knowledge formation. The correspondence between cognitive nodes and dominant forms of synthesis is summarized in Table 1.

Thus, forms of synthesis do not compete with each other, but functionally complement one another within a unified cognitive process.

Acceptable Trajectories of Scientific Text Preparation

The results of the analysis indicate that not all scientific texts are required to pass through the full critical path. At the same time, any acceptable trajectory must be consistent with its logic.

Table 1. Mapping of cognitive nodes to dominant forms of knowledge synthesis

Cognitive node	Dominant form of synthesis
Orientation	Bibliometric analysis; scoping review
Conceptualization	Narrative review
Verification	Systematic review
Evidence synthesis	Meta-analysis
Interpretation	Integrative conclusion

Note. Each form of synthesis corresponds to a specific functional stage within the critical path and does not substitute the overall epistemological sequence. Within these stages, specific tools may be applied; in particular, bibliometric analysis supports orientation in the scientific field by identifying knowledge structures and research trends (Donthu et al., 2021).

Examples of methodologically acceptable trajectories:

- Conceptual / theoretical work:
Orientation → Conceptualization → Interpretation
- Systematic review without meta-analysis:
Orientation → Conceptualization → Verification → Interpretation
- Meta-analysis:
Orientation → Verification → Evidence synthesis → Interpretation
(provided that a stable conceptual framework exists in the scientific field)

Violations of the Critical Path and Their Methodological Consequences

As a result of the conceptual narrative analysis, it was established that methodological problems of contemporary scientific texts are determined not by the choice of individual methods or genres, but by violations of the logic of the critical path of cognitive operations. Such violations have predictable consequences that manifest regardless of the field of knowledge and the formal type of publication.

The analysis made it possible to identify typical inadmissible trajectories of scientific text preparation that arise from omission or substitution of individual cognitive nodes. It was established that such violations are systemic and lead to predictable methodological deformations independent of the formal type of publication. The systematization of critical path violations and their methodological consequences is presented in Table 2.

The identified inadmissible trajectories are consistent with contemporary standards of evidence synthesis, within which the functions of conceptual justification, selection procedures, and interpretation of results are clearly differentiated (Page et al., 2021). Violation of this differentiation leads to formally correct but methodologically unstable results.

Conceptual Significance of Identified Violations

The identified violations are not individual author errors and cannot be reduced to non-compliance with formal standards. They are structural in nature and result from the identification of publication genres with the methodology of cognition. In such cases, individual stages of knowledge synthesis are applied in isolation, outside the logic of their functional interconnection.

Table 2. Typical violations of the critical path and their methodological consequences

Critical path violation	Methodological consequence
Meta-analysis without conceptualization	Statistically correct results lacking scientific meaning
Narrative conclusions without verification	Speculative generalizations
Interpretation without evidence synthesis	Essay-like reasoning without scientific validity
Systematic review without field orientation	Technical compilation without conceptual novelty

Note. Violations reflect disruptions in the causal sequence of cognitive operations rather than improper application of individual methods.

Thus, inadmissible trajectories reflect not the “weakness” of individual methods, but violations of causal relationships between cognitive operations, which leads to methodological instability of the scientific text.

Generalized Result

The obtained results indicate that the quality and scientific validity of a text are determined not by the completeness of applied methods and not by the formal type of publication, but by the consistency of the chosen trajectory of text preparation with the critical path of the cognitive process. Violations of this path lead to predictable and typical methodological deformations that can be identified at the stages of peer review and editorial analysis.

Discussion

Interpretation of Identified Violations of the Critical Path

The obtained results indicate that methodological deformations of scientific texts have a structural character and reflect disruptions in the logic of the cognitive process. The identified inadmissible trajectories specify the mechanisms of their occurrence, in particular the substitution of methodology by genre forms. In such cases, individual stages of knowledge synthesis are applied in isolation, without taking into account their functional role in the integral structure of scientific argument formation.

In particular, the emergence of meta-analyses without a clear conceptual framework is explained by the orientation toward formal criteria of evidence, while issues of meaningful interpretation are placed outside the scope of methodological analysis. Similarly, narrative generalizations without verification procedures are often the result of mixing theoretical reflection with empirical statements without proper differentiation of their status.

The identified violations of the critical path should be considered in the context of the fragmentation of methodological recommendations across publication types. The development of reporting standards for systematic reviews and scoping studies (Tricco et al., 2018; Page et al., 2021) has significantly increased the transparency of individual stages of knowledge synthesis, but at the same time has intensified the risk of their isolated application without a conceptual connection to other cognitive operations.

Structural Causes of Methodological Failures

They are formed within a broader context of contemporary academic practice, in which individual elements of the process

of scientific text preparation are regulated unevenly and in isolation. In particular, this context includes:

- the spread of templated requirements for the structure of scientific articles, arising from the standardization of reporting forms for specific types of review studies and contributing to the identification of genre with methodology (Grant & Booth, 2009; Tricco et al., 2018);
- the growing role of formal quality indicators within evaluation procedures for review studies, where compliance with reporting standards is used as a proxy indicator of methodological rigor (Page et al., 2021);
- the fragmentation of methodological recommendations across publication types, as a result of which individual stages of knowledge synthesis (orientation, verification, synthesis) are regulated independently of one another (Grant & Booth, 2009; Arksey & O’Malley, 2005; Levac et al., 2010);
- the shift of emphasis toward the rapid reproduction of formally correct results, which is reinforced by requirements for accelerated publication cycles and reduces the space for conceptual reflection at the stage of text preparation.

Under such conditions, the genre of a scientific article often begins to function as a methodological surrogate, substituting the logic of cognition, which correlates with the fragmentation of standards of review studies across publication types (Grant & Booth, 2009; Tricco et al., 2018).

The Significance of the Critical Path as an Interpretative Framework

The proposed critical path model makes it possible to interpret these phenomena not as a set of “errors,” but as consequences of violations of causal relationships between cognitive operations. Such an approach removes normative tension and shifts the analysis into the domain of methodological reflection.

In this context, the critical path does not function as a mandatory procedural scheme, but rather as an invariant logic with which different trajectories of scientific text preparation must be aligned. It is this alignment, rather than the completeness of applied methods, that determines methodological correctness and the scientific validity of results.

Implications for Academic Writing Practice and Evaluation

From the perspective of the obtained results, it becomes possible to reinterpret typical difficulties of peer review and preliminary editorial screening. Instead of evaluating

compliance with formal publication types, there emerges the possibility of analyzing the logic of the trajectory followed by the author.

For authors, this opens the space for the conscious selection of acceptable reduced trajectories without loss of methodological coherence. For reviewers, it provides a tool for identifying structural failures that are not always evident in superficial evaluation. For editorial boards, it creates a basis for explaining editorial policy without resorting to rigid normative prescriptions.

In the context of physical education and sport, this has direct practical implications. In particular, the use of systematic reviews and meta-analyses without proper conceptualization or orientation in the scientific field leads to the formation of generalizations that are difficult to integrate into educational practice or training programs. The proposed critical path model makes it possible to interpret these problems not as isolated methodological shortcomings, but as manifestations of violations in the logic of knowledge synthesis within the field.

Limitations and Future Directions

The discussed model is conceptual in nature and does not replace discipline-specific methodological standards. At the same time, it can serve as a meta-level for their coordination, as well as a basis for further research aimed at empirical verification of typical processes of scientific text preparation across different disciplines.

General Statement

Thus, the results and their discussion allow us to state that the problems of contemporary scientific texts are related not to a lack of methods or standards, but to insufficient articulation of the logic of the cognitive process, which precedes the choice of genre and determines the possibility of coherent knowledge synthesis.

Conclusions

Within the framework of a conceptual narrative review, it is substantiated that the preparation of a scientific text follows an invariant logic of the cognitive process that does not coincide with the traditional typology of scientific publications.

It is shown that genres of scientific articles reflect individual segments of this process, but do not determine its causal structure.

The formalization of the critical path of cognitive operations made it possible to identify typical inadmissible trajectories of scientific text preparation and the predictable methodological consequences of their violation.

The identified violations have a structural character and are caused by the substitution of methodology with genre and formal requirements of academic writing, which is consistent with typologies and standards of review studies (Grant & Booth, 2009; Page et al., 2021).

The proposed critical path model is not a normative instruction, but performs the function of an interpretative framework for analyzing the methodological coherence of scientific texts.

Methodological correctness is determined by the correspondence of the trajectory of text preparation to the logic of the cognitive process.

The obtained conclusions create a basis for the further development of tools for academic writing, peer review, and editorial evaluation oriented toward coherent knowledge synthesis.

Ethics approval and consent to participate

This study is conceptual in nature and did not involve human participants, animals, or the collection of primary data. Therefore, ethical approval and informed consent were not required.

Consent for publication

Not applicable.

Availability of data and materials

No datasets were generated or analyzed during the current study. All sources used are publicly available academic publications.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

All authors contributed to the conceptualization of the study, development of the methodological framework, analysis and interpretation of the results, and drafting and revision of the manuscript. All authors approved the final version of the manuscript.

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Notes on methodology

This article presents a conceptual narrative review and does not aim to provide prescriptive guidelines or empirical validation. The proposed framework is intended as an interpretative tool for understanding the logic of scientific text construction.

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Від картографування знань до синтезу доказів: модель критичного шляху побудови цілісних наукових текстів

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 8 с., 2 табл., 1 рис., 8 джерел.

Вступ. Сучасна практика академічного письма дедалі більше визначається стандартизованими вимогами до структури публікації і типологіями оглядових досліджень. Проте формальна відповідність цим стандартам не гарантує методологічної валідності, оскільки логіка формування знання часто залишається неявною або підміняється жанровими шаблонами, що призводить до системних спотворень синтезу доказів.

Мета дослідження. Формалізувати модель критичного шляху синтезу знань, у межах якої підготовка наукового тексту інтерпретується як послідовний пізнавальний процес, підпорядкований інваріантній логіці епістемологічних операцій.

Матеріали і методи. Дослідження виконано у форматі концептуального нарративного огляду з використанням підходів синтезу доказів, типології оглядових досліджень і теорії академічного письма. Аналіз передбачав функціональну декомпозицію пізнавальних операцій, реконструкцію причинно-наслідкових зв'язків між ними та формалізацію їх послідовності у вигляді критичного шляху.

Результати. Виокремлено п'ять інваріантних пізнавальних вузлів: орієнтація (формулювання проблеми), концептуалізація (побудова моделі), верифікація (оцінка доказів), узагальнення доказів (синтез), інтерпретація (теоретичне пояснення). Показано, що ці вузли формують критичний шлях, який визначає методологічну цілісність наукового тексту незалежно від жанру. Встановлено, що типи оглядових досліджень відповідають окремим ділянкам цього шляху, але не визначають його логіку. Ідентифіковано типові порушення, зокрема мета-аналіз без концептуалізації, нарративні узагальнення без верифікації та систематичні огляди без орієнтації, що призводить до передбачуваних методологічних деформацій.

Обговорення. Результати свідчать, що проблеми сучасних наукових текстів мають системний характер і зумовлені розривом причинно-наслідкових зв'язків між пізнавальними операціями та підміною логіки пізнання формальними вимогами. Запропонована модель дозволяє інтерпретувати ці порушення як прояви епістемологічної неадекватності.

Висновки. Методологічна коректність наукового тексту визначається не його жанровою формою, а узгодженістю траєкторії підготовки з критичним шляхом синтезу знань. Модель може бути використана як інструмент підвищення якості академічного письма, рецензування та редакційного оцінювання.

Ключові слова: модель критичного шляху, синтез знань, синтез доказів, академічне письмо, методологічна рамка, систематичний огляд, фізичне виховання, спортивна наука.

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