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SYSTEMICITY IN MATHEMATICAL TERMINOLOGY: THEORETICAL AND PRACTICAL APPROACHES

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Annotation: This article explores the formation of a system of mathematical terms, their systematic classification, semantic relations, and didactic significance from a scientific and theoretical perspective. Within the principle of systemicity, the structural features of mathematical terminology, linguistic and cultural factors, and interdisciplinary integration aspects are analyzed. Moreover, proposals are developed to improve the effectiveness of the terminological system in modern mathematics education. This study contributes to ongoing research in mathematical terminology from both linguistic and methodological perspectives.

Keywords: mathematical terminology, systemicity, semantics, interdisciplinary integration, linguistic analysis, structural relations, term classification, didactic tool.

Terminology is a fundamental tool in the development of any scientific discipline. In abstract and exact sciences like mathematics, the precise, concise, and consistent expression of scientific concepts plays a vital role in accurate understanding. Today, a systematic approach to mathematical terminology is necessary not only in linguistics but also in didactics, translation theory, and artificial intelligence.

1. Theoretical Foundations of Systemicity

Systemicity refers to the organization of specific units into an interconnected structure based on certain principles. In terminological systems, these units are terms that are related semantically, morphologically, syntactically, or functionally. Research by scholars such as Yu.N. Karaulov, V.M. Leychik, and L.V. Sakharny has applied the theory of systemicity effectively to the analysis of terminological structures.

2. Structural Features of Mathematical Terms

Mathematical terms are typically characterized by brevity, precision, and universality. Many of them are derived from Greek or Latin and are often used across multiple disciplines:

For example: “function”, “integral”, “matrix”, “vector”, “set”.

These terms form systems based on paradigmatic and syntagmatic relations. Paradigmatically, they include synonymy, antonymy, hypernymy-hyponymy, while syntagmatically, they appear in specific combinations within mathematical texts.

3. Semantic Relationships Among Mathematical Terms

This paper explores the semantic relationships that exist among mathematical terms, drawing from linguistic theory, ontology engineering, and computational methods. By analyzing how mathematical concepts are interconnected semantically, we can enhance the

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understanding, teaching, and formalization of mathematical knowledge. The study proposes a multidimensional approach combining terminological analysis, ontological modeling, and natural language processing (NLP) techniques to uncover deep relationships among mathematical terms. Mathematics is often considered a purely formal discipline, grounded in logical structures and symbolic manipulation. However, it also functions as a highly structured language, with its own lexicon, grammar, and semantics. Understanding the semantic relationships among mathematical terms is essential not only for theoretical purposes but also for applications in education, knowledge representation, and artificial intelligence.

This study aims to investigate the different types of semantic relationships that exist among mathematical terms, how these relationships can be formally represented, and what role they play in shaping mathematical reasoning and pedagogy.

In general linguistics, semantic relationships describe how meanings of words relate to one another. These include:

Synonymy: different terms with the same or similar meaning (e.g., non-negative integer ↔ natural number),

Antonymy: opposites (e.g., even vs. odd),

Hypernymy/Hyponymy: general-to-specific relationships (e.g., function → linear function),

Meronymy: part-whole relations (e.g., radius is part of a circle),

Polysemy: one term with multiple meanings (root of a number, root of a function).

These relationships can be transferred into the mathematical domain to enrich understanding and structure.

Ontologies provide a structured framework to represent knowledge, including entities (concepts), their properties, and interrelations. Mathematical ontologies such as:

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Mathematics Subject Classification (MSC) are used to formalize and disambiguate the semantics of mathematical terms. Ontological relationships often include:

is-a (subclass): e.g., polynomial is-a function,

has-part: e.g., triangle has-part angle,

used-in: e.g., integral used-in area calculation,

defined-by: e.g., derivative defined-by limit.

A specialized corpus of mathematical texts (textbooks, arxiv papers, encyclopedias) is used to extract domain-specific terminology. Natural language processing (NLP) tools, such as

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spacy or NLTK, help identify key terms and their co-occurrence patterns. Terms are treated as nodes in a semantic network, and their relationships (edges) are labeled based on syntactic patterns or ontological knowledge. Word embeddings (e.g., Word2Vec, Fast Text, or BERT) are used to model semantic proximity between terms. Using tools like Gephi or Tens or Board, the semantic network is visualized to identify clusters of related terms (e.g., geometry-related vs. algebra-related terms) and hierarchical relationships.

Synonym Sets: e.g., zero of a function ≈ root of a function.

Hierarchical Structures: e.g., trigonometric function → periodic function → function. Conceptual Clusters: analysis revealed tightly grouped clusters in domains like calculus, topology, number theory.

Some terms showed polysemy or domain-dependent definitions, suggesting the need for contextual disambiguation. Semantic modeling can aid in developing intelligent tutoring systems that guide learners through concept maps based on term relationships. Mathematical ontologies can enhance search engines, digital libraries, and theorem provers by providing structured knowledge of concepts and their dependencies. By mapping mathematical terms and their relations across languages, educators can develop multilingual teaching resources.

Conclusion

Understanding the semantic relationships among mathematical terms offers valuable insights into the structure of mathematical knowledge. By combining linguistic analysis, ontological modeling, and computational techniques, we can build rich representations that enhance both human understanding and machine processing of mathematical language. Expanding the corpus to include more languages and educational levels. Integrating semantic models into interactive learning platforms. Applying deep learning models to predict unseen term relationships based on known semantics. Systemicity in mathematical terminology is not merely a linguistic order but a foundational means of understanding, teaching, and researching mathematics. A systematic analysis of mathematical terms reveals not only their linguistic properties but also their didactic and cognitive aspects. This enhances the effectiveness of education and contributes to the development of precise terminological frameworks in scientific research.

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