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# PHILOSOPHY OF MATHEMATICS IN PRIMARY EDUCATION MATHEMATICS LEARNING: ONTOLOGICAL, EPISTEMOLOGICAL, AND METHODOLOGICAL

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***ABSTRACT***

The purpose of this study is to examine the relationship, position, and role of the philosophy of mathematics in learning mathematics in basic education through the perspective of the scope of philosophy, namely ontological mathematics, epistemological mathematics, and methodological mathematics. This research is a qualitative descriptive research with a literature study approach. Data collection techniques are carried out through the documentation method of articles originating from the Google Scholar database, as well as books related to the philosophy of mathematics. Data analysis techniques consist of data reduction, data presentation, and conclusion. The results highlight three main aspects within the scope of the philosophy of mathematics: ontological, epistemological, and methodological. Ontological mathematics addresses the ontological foundations of mathematics for teaching, including the role of mathematics in various contexts. The epistemology of mathematics emphasizes the importance of understanding the discipline from multiple perspectives to enhance learning and curriculum design. Meanwhile, the methodology of mathematics highlights the role of specific methods in determining mathematical solutions. In conclusion, understanding the philosophy of mathematics in these three aspects is important for educators to improve the learning process of mathematics at the primary level comprehensively and optimally.

**Keywords:** Philosophy of Mathematics for Basic Education; Philosophy of Mathematics; Ontological Mathematics; Epistemological Mathematics; Methodological Mathematics.

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## PRELIMINARY

Mathematics is one of the fields of study that must be studied in basic education. By learning mathematics, it is none other than to train students in solving real-world problems or phenomena by using mathematics outside of school creatively (Fajri, et al., 2022). The position and role of mathematics in science can be understood from a philosophical perspective.

Philosophy and mathematics have a very close relationship that is not in doubt, where the role of philosophy is as a thought process to clarify the meaning of the presence of mathematics itself (Sinaga, et al., 2021; Sadewo, et al., 2022; Zalukhu, et al., 2023). So that the main purpose of the philosophy of mathematics is to explain the position of mathematics in the world of education (Syahnia, et al., 2022). As well as providing a record of the nature and methodology of mathematics to understand the position of mathematics in life (Sari & Armanto, 2021).

The philosophy of mathematics is developed through external issues such as the history, origins, and practice of mathematics with internal issues such as epistemology and ontology (Simanjuntak, et al., 2021). Epistemologically, the purpose of mathematics is the assumption and basis, origin, nature, and reflection of the mind of knowledge, while ontology is a discussion within mathematics that includes mathematical statements (Parnabhhakti, et al., 2020).

The scope of the philosophy of mathematics itself includes mathematical epistemology, mathematical ontology, and mathematical methodology (Parnabhakti & Fidiawati, 2021). The foundation or scope of the philosophy of mathematics is interrelated and inseparable in supporting the learning implementation process (Nur'rohim & Somakim, 2022).

A good understanding of the philosophy of mathematics is needed in learning because the three main flows in learning (input, process, and output) are interrelated with each other and are closely related to philosophy (Zalukhu, et al., 2023). Philosophy of mathematics is a reflective thinking process for mathematics education that aims to explain the nature and components of mathematics as an effort to explore mathematics based on a philosophical perspective (Nugraheni, et al., 2021; Mahendrawan, et al., 2021; Sadewo, et al., 2022). Based on this description, researchers are interested in examining the relationship, position, and role of the philosophy of mathematics in learning basic education mathematics through the perspective of the scope of philosophy, namely ontological mathematics, epistemological mathematics, and methodological mathematics.

## METHODS

This research is a qualitative descriptive study with a literature review research approach. The study aims to analyze and describe the philosophy of mathematics in basic education learning ontologically, epistemologically, and methodologically. In order to obtain data that can be recognized for its reliability, the data selection process in this

research includes several stages based on the steps according to Newman & Gough (2020), which include: (1) developing research questions; (2) determining the conceptual framework; (3) establishing inclusion and exclusion criteria; (4) formulating search strategies; (5) synthesizing the results of the literature review and answering research questions. After formulating the research questions, the next step is to determine the conceptual framework. The conceptual framework in this research refers to the thinking of Ernest (2016). The next stage is to determine the inclusion and exclusion criteria, where the inclusion criteria include several aspects such as literature review data being accredited by SINTA in national journals, published in the range from 2016-2023, not being book reviews, proceedings, article reviews, book chapters, etc., and articles published in both English and Indonesian. The data collection technique in this research involves analyzing various literature from the Google Scholar database. This choice is made because Google Scholar has the most extensive and comprehensive database (Rafika et al., 2017), thus obtaining data or information related to the researched problem. After collecting all articles for the systematic review, the elimination process is carried out to determine the final stage. The elimination process involves selecting articles based on the title and abstract's relevance to the research topic. A search using keywords such as "mathematics learning," "ontology," "epistemology," "methodology," "mathematics learning + ontology," "mathematics learning + epistemology," "mathematics learning + methodology" yielded 376 articles related to these keywords. After the elimination process based on the relevance of titles and abstracts, 26 articles were obtained. The final step of the elimination process is to examine the entire content of the articles. Based on the overall content's relevance to the research questions and topic, 19 articles were selected for the systematic review. The data analysis technique in this research consists of data reduction, data display, and conclusion drawing/verification.

## RESULT AND DISCUSSION

Philosophy of mathematics is a perspective that composes and unites the components and pieces of mathematics based on several basic foundations. Ernest (2016) states that to analyze teaching practices, learning and related issues, aspects that are the scope of the philosophy of mathematics such as ontology, epistemology, and methodology in the context of mathematics education can be used and explored. According to Gee (199), the ontology of mathematics questions whether mathematics can be explained as a reality or not, while the epistemology of mathematics examines this discipline through various

aspects of knowledge such as possibilities, origins, nature, limits, assumptions, and foundations. Along with that, mathematical methodology focuses on research into specific methods applied in the field of mathematics.

**Ontological Mathematics**

Mathematics is not only a discipline that deals with numbers and calculations but also has its ontology and epistemology. Ontological mathematics is a scope within the philosophy of mathematics that questions mathematical statements as the real world or not. The study of the ontological foundations of mathematics involves understanding the origins of mathematics and how mathematical knowledge is formed (Fairus, et al., 2023). It also explores the nature of mathematics as a discipline and its usefulness in various contexts (Defi, et al., 2021).

Ontology is a knowledge model that defines the relationship and classification of several concepts in a particular domain (Zahro, et al., 2016). In the context of education, ontology can be used to represent information in the field of education (Kusuma, et al., 2021). Mathematical ontology views the position of mathematics through the truth of empiricism and the absolute truth of mathematics itself (Parnabhhakti, et al., 2020). In addition, ontology can also be used to analyze learning obstacles that arise in certain concepts in mathematics (Musyrifah, et al., 2022). Therefore, educators need to understand the ontological foundation of mathematics which in turn can be used as a philosophical consideration in carrying out mathematics teaching in schools (Zalukhu, et al., 2023).

The ontological foundation of mathematics means a philosophical study to find out the origin of everything such as the history of mathematics and the nature of mathematics in knowledge (Dharma, 2020). The ontological foundation of mathematics is a very important topic in the field of mathematics and philosophy. The science of ontology provides a strong methodological foundation for the development of mathematical models (Farid et al., 2022). It is often misunderstood that the development of mathematical models is subjective, but in fact, the science of ontology provides a powerful framework for understanding the nature of mathematical concepts and their relationships.

The ontological study of mathematics is a philosophical thought related to the reality and existence of mathematical entities themselves (Sadewo, et al., 2022). So within the ontological scope of mathematics, the connection in learning is seen through the teacher's efforts in linking the context of abstraction in mathematics to real reality. In line with the opinion of Fajri, et al (2022) that learning mathematics should be integrated into the form of the reality of life or real-life problems of everyday life around students.

The relationship between ontology and mathematics learning is a complex and multifaceted one. Ontology, as applied to mathematics, emphasizes rigor, logic, symmetry, and consistency of representation across scientific subfields, incorporating only established, non-contradictory knowledge. Mathematics, in turn, is seen as providing a counterexample to methodological and ontological naturalism (Sterpetti, 2018). The use of ontology in mathematics learning can aid in the correct conceptualization of mathematical fields, providing a powerful tool to explore mathematical problems and give meaning to mathematical concepts and their relationships. Furthermore, the development of ontologies for learning resources, tasks, learner models, and teaching strategies has been seen as essential in the learning domain (Heiyanthuduwage et al., 2016).

The disjunction between curriculum mathematics education and the ethos of the school has been identified as an ontological issue, highlighting the importance of aligning educational practices with the philosophical underpinnings of mathematics (Tweed, 2021). Moreover, the integration of learning designs and learning object content through an ontology-based approach has been proposed, emphasizing the significance of ontologies in integrating different aspects of mathematics learning.

In the context of mathematics education, the ontological commitment to mathematical objects has been discussed, suggesting that if mathematics plays an explanatory role in the right way, it carries an ontological commitment to mathematical objects (Heron, 2020). This highlights the deep philosophical implications of mathematics learning and the ontological assumptions underlying the teaching and learning of mathematics. Furthermore, the use of ontology in instructional material development has been explored, emphasizing the role of ontology in structuring knowledge and relationships in a particular domain (Ismail et al., 2018).

In philosophy, the scope of the ontological view of mathematics is mathematics as a tool of the mind, mathematics as a language, mathematics for nature science & social science, mathematics of space and time, and the role of modern mathematics. So we can understand that the ontological scope of mathematics regarding mathematics as a tool of the mind means that the use of mathematics as a thinking tool in producing knowledge that is useful for life in finding solutions to real-life problems. Mathematics as a language, not language in the context of a means of communication but in the sense that the role of mathematics as a language is more universal regarding the similarity of the definitions of theorems, lemmas, and postulates that do not change meaning wherever we are. the role of mathematics as nature science & social science, which shows that mathematics is an exact

science that has aesthetic properties. Then mathematics is space and time and the role of modern mathematics shows that mathematics space and time mathematics exist even though the existence of mathematics cannot be shown. This is what leads to the study of ontology includes metaphysical matters but has absolute truth (Sadewo, 2022).

**Epistemology of Mathematics**

The word epistemology comes from the Greek, namely episteme which means knowledge, understanding, and partner, and logos which means reason and argument. Epistemology according to Immanuel Kant is understanding the conditions of possible understanding. Meanwhile, epistemology according to Plato is an attempt to understand what must be known and how useful knowledge is for the seekers. So, it can be concluded that epistemology is a study in philosophy that mainly seeks an understanding of knowledge, its origins, causes, and how knowledge works.

Mathematical epistemology is a branch of philosophy that deals with mathematical knowledge. This branch specifically examines the basic aspects of mathematical knowledge such as the source, nature, limits, and truth of knowledge along with the characteristics of mathematics which include abstraction, space, time magnitude, symbolism, form, and pattern. Epistemologically, mathematics is based on ratio thinking or reasoning, in mathematics we do not need to know the experiential reality outside us to conclude mathematical problems, but we simply rely on our rational knowledge.

Epistemology plays an important role in mathematics education, influencing teaching practices and learner outcomes. Teachers with strong epistemological beliefs tend to encourage inquiry and argumentation in the classroom, using strategies such as debates, making and critiquing arguments, and group-based projects that facilitate the synthesis of ideas (Schraw, et al., 2006). Teachers recognize the importance of learners actively constructing their mathematical knowledge and understanding.

Personal epistemology, or an individual's beliefs about knowledge and knowing, also has a significant impact on learning in mathematics education. Research shows that personal epistemology influences how learners approach and engage with mathematical tasks, as well as their ability to transfer mathematical knowledge to new contexts (Schommer-Aikins and Duell, 2013). For example, learners with a more constructivist view of knowledge are more likely to engage in productive problem-solving strategies and demonstrate a deeper understanding of mathematical concepts (Tamba and Cendana, 2021).

Moreover, the integration of conceptual and everyday knowledge with mathematics requires learners to activate appropriate epistemological resources (Redish & Kuo, 2015). This highlights the importance of helping learners develop a dynamic understanding of epistemology, where they can effectively navigate between different ways of knowing and apply appropriate strategies in mathematical problem-solving.

Epistemology is not only relevant to learner learning but also to mathematics education curriculum design and instructional practice. In engineering education, for example, epistemology influences how educators design and deliver materials, as well as how they assess learners' understanding and mastery of engineering concepts (Ghazali, et al., 2021). Similarly, in school mathematics education, teachers' epistemological beliefs play a role in designing learning environments that support learners' mathematical development (Karataş and Yilmaz, 2021).

The epistemological foundation of mathematics means a person's strategy to obtain knowledge, sources, and scope of knowledge, and understand the process of the emergence of knowledge itself (Nurhayani, 2012). In mathematical epistemology, mathematical knowledge is a target to be examined or investigated (Gie, 1999).

Epistemology of mathematics is a study of knowledge about mathematics such as branches of mathematics, numbers and symbols, patterns in mathematics, mathematics part of science, abstraction of modern mathematical knowledge; and mathematical theorems (Sadewo, 2022; Atmaja, 2020). Epistemologically, mathematics is also seen as part of science, where to obtain this knowledge must go through a learning process (Putawa, 2022; Zalukhu, et al., 2023).

The role of epistemology in learning mathematics is significant, as it shapes students' beliefs about the nature of mathematical knowledge and the learning process (Tamba & Cendana, 2021). Epistemological beliefs play a crucial role in shaping students' attitudes toward mathematics, their learning approaches, and their academic achievement(Lee & Yuan, 2012). Furthermore, these beliefs impact the design of learning environments and teaching practices in mathematics education (Karataş & Yilmaz, 2021). Research has demonstrated a positive correlation between students' epistemological beliefs and their performance in mathematics assessment Additionally, students' epistemological beliefs are associated with their preferences for different forms of assessment in mathematics (Iannone & Simpson, 2019).

Epistemology is vital in shaping students' learning experiences in mathematics classrooms, influencing how they engage with mathematical concepts and the strategies

they use to solve mathematical problems (Wheeler & Montgomery, 2009). Teachers' understanding of their own epistemological beliefs and their explicit teaching of mathematical epistemology can enhance students' understanding of the foundations of mathematics (Schommer-Aikins et al., 2015). Moreover, students' epistemological beliefs about mathematics can change over time, indicating the dynamic nature of these beliefs and their potential impact on learning outcomes (Hakim et al., 2016). Furthermore, epistemological beliefs are relevant not only to students but also to teachers. The epistemological beliefs of in-service mathematics teachers significantly contribute to the design of effective learning environments for students. Understanding teachers' epistemological beliefs is crucial for informing professional development initiatives and instructional practices in mathematics education.

In mathematics epistemology, a mathematics teacher must have a good understanding of the philosophy of mathematics and its application in learning (Bintoro, et al., 2021). In short, epistemology is a fundamental aspect of mathematics education that influences teaching practices, learner learning, and curriculum design.

Teachers with sophisticated epistemological beliefs can encourage inquiry and argumentation, while learners' epistemologies shape their approach to mathematical tasks and their ability to transfer knowledge. Developing a dynamic understanding of epistemology is essential for learners to effectively integrate everyday knowledge with mathematics. In addition, epistemology informs curriculum design and instructional practices in a variety of educational contexts, such as engineering education and secondary school mathematics. By recognizing the role of epistemology in mathematics education, educators can create more effective learning environments that foster deep mathematical understanding and problem-solving skills. In summary, the role of epistemology in learning mathematics is multifaceted, influencing students' attitudes, learning approaches, and academic performance. It also has implications for instructional design, teacher professional development, and the overall learning environment in mathematics education.

**Methodological Mathematics**

Methodological mathematics is part of the scope of the philosophy of mathematics which focuses on studying or investigating something using special methods used in mathematics (Parnabhhakti, et al., 2020; Surajiyo, 2022).

Methodological mathematics itself includes 3 things (Sinaga, et al., 2021), namely as follows.

1) The deductive method is a method of thinking in concluding general principles which are then applied to something special.
2) The inductive method is the opposite of the deductive method, namely concluding special principles which are then applied to something special.
3) The dialectical method is a method of thinking that concludes three stages, namely thesis, antithesis, and synthesis, or based on major premises and minor premises to then produce new conclusions.

Further explanation of the deductive method is explained by Sadewo, et al (2022) that thinking in finding the solution of the deductive method is divided into two, namely (1) the analytic method which can be interpreted as a method that goes from the unknown to the known; (2) the synthetic method is a method that goes from the known to the unknown.

Speaking of mathematical methodology will not be separated from the method offered by Socrates, a Greek philosopher (469-399 BC). Socrates stated that mathematical methodology is "an approach by which one seeks the truth via a process of questions and answers" and "...a process of inductive questioning used to successfully lead a person to knowledge through small steps", which can be interpreted that the inductive method is a method in the form of discussion, dialog, and questions and answers regarding simple to complex inductive questions to seek knowledge or truth. (Lubis, 2022; Ekwandani et al., 2022; Zalukhu, et al., 2023). The Socratic method is built on the assumption that learners already have knowledge and that the right questions can cause this knowledge to appear in the minds of learners. Then, the questions in the Socratic method are used to validate learners' knowledge of an object in depth (Simangunsong, 2021).

This truth in mathematics cannot be separated from the characteristics of mathematics itself, one of which is that mathematics has a deductive mindset. Mathematics must be proven deductively, which means that the truth of a statement is obtained from previous statements that have been proven correct. This mindset is based on things that are general and then specific even though the discovery is inductive the generalization must still be proven deductively.

The method of proof in the methodological scope of mathematics is a way that we can do in finding solutions to mathematical problems or find and proving a mathematical concept to get a valid answer. In solving problems through mathematical methodology, whether it is by deductive methods, inductive methods, or dialectical methods in proving

and solving problems must have valid arguments, and credibility, and use logical and mathematically structured methods.

## CONCLUSION

The relationship, position, and role of the philosophy of mathematics in mathematics learning are integral to understanding the foundational aspects and conceptual framework of mathematical education. The philosophy of mathematics establishes a connection between the abstract nature of mathematical concepts and their practical application in the learning process. It plays a crucial role in shaping the way mathematical knowledge is approached, interpreted, and transmitted in educational settings.

The position of the philosophy of mathematics in mathematics learning is central to providing a theoretical underpinning for the teaching and learning of mathematical concepts. It delves into questions of ontology, epistemology, and methodology, exploring the nature of mathematical objects, how mathematical knowledge is acquired, and the methods employed in teaching and learning mathematics.

The role of the philosophy of mathematics in mathematics learning extends beyond theoretical considerations. It guides educators in developing effective teaching strategies, encourages critical thinking, and helps students grasp the underlying principles of mathematical concepts. Moreover, it contributes to the alignment of educational practices with the fundamental philosophical principles of mathematics, ensuring coherence between curriculum objectives and the ethos of mathematical education.

In summary, the philosophy of mathematics holds a significant relationship, occupies a central position, and plays a crucial role in shaping the approach, interpretation, and transmission of mathematical knowledge in the context of learning. It provides the theoretical foundation for mathematical education, guiding educators and learners alike in navigating the intricate landscape of mathematical concepts and their practical applications.

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