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# Philosophical Dimensions of Mathematics Learning Problems among Pre-Service Teachers: An Instructional Needs Analysis for Curriculum Design

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**Abstract**

In higher education, aligning professional disciplinary knowledge with instructional management requires a deep understanding of learners' foundational perceptions regarding the subject matter. This study aims to analyze mathematics learning problems faced by pre-service elementary school teachers (PGMI students) across ontological, epistemological, and axiological dimensions to provide a rigorous instructional needs analysis for pedagogical design. Utilizing a descriptive quantitative approach, data were gathered using a validated and reliable 30-item questionnaire covering these three philosophical dimensions. The descriptive statistical analysis revealed that most students experienced learning problems in the low-to-moderate categories. Crucially, the axiological dimension emerged as the primary source of difficulties (mean = 27.2), followed by the epistemological dimension (mean = 26.3), while the ontological dimension presented the lowest severity (mean = 25.6). These findings indicate that while pre-service teachers possess a baseline understanding of the nature of mathematics, they face significant hurdles in identifying its practical values and utility, leading to procedural rather than conceptual learning. Consequently, this study underscores the necessity for instructional designers and educators to restructure higher education mathematics curricula by embedding meaningful, context-driven, and philosophically integrated instructional management strategies to overcome these instructional barriers.

**ABSTRAK**

Dalam pendidikan tinggi, menyelaraskan pengetahuan disiplin profesional dengan manajemen pembelajaran membutuhkan pemahaman mendalam tentang persepsi dasar peserta didik mengenai materi pelajaran. Studi ini bertujuan untuk menganalisis masalah pembelajaran matematika yang dihadapi oleh calon guru sekolah dasar (mahasiswa PGMI) di berbagai dimensi ontologis, epistemologis, dan aksiologis untuk memberikan analisis kebutuhan pembelajaran yang ketat bagi desain pedagogis. Dengan menggunakan pendekatan kuantitatif deskriptif, data dikumpulkan menggunakan kuesioner 30 item yang telah divalidasi dan reliabel yang mencakup ketiga dimensi filosofis tersebut. Analisis statistik deskriptif mengungkapkan bahwa sebagian besar mahasiswa mengalami masalah pembelajaran dalam kategori rendah hingga sedang. Yang penting, dimensi aksiologis muncul sebagai sumber kesulitan utama (rata-rata = 27,2), diikuti oleh dimensi epistemologis (rata-rata = 26,3), sedangkan dimensi ontologis menunjukkan tingkat keparahan terendah (rata-rata = 25,6). Temuan ini menunjukkan bahwa meskipun calon guru memiliki pemahaman dasar tentang hakikat matematika, mereka menghadapi hambatan signifikan dalam mengidentifikasi nilai dan kegunaan praktisnya, yang mengarah pada pembelajaran prosedural daripada pembelajaran konseptual. Oleh karena itu, studi ini menggarisbawahi perlunya perancang pembelajaran dan pendidik untuk merestrukturisasi kurikulum matematika pendidikan tinggi dengan menyematkan strategi manajemen pembelajaran yang bermakna, berbasis konteks, dan terintegrasi secara filosofis untuk mengatasi hambatan pembelajaran tersebut.

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Keywords: Curriculum Design, Instructional Needs Analysis, Mathematics Learning Problems, Philosophical Dimensions, Pre-Service Teachers.

## INTRODUCTION

Mathematics represents a fundamental academic discipline essential for fostering logical reasoning, problem-solving capabilities, and analytical thinking frameworks in modern education. Within contemporary societies, mathematical competence functions as a critical cornerstone for scientific advancements, technological innovation, and daily functional activities, spanning fields from industrial manufacturing and digital banking to advanced research ecosystems. Consequently, educational systems globally enforce mathematics as a mandatory subject from elementary school up to higher education levels. In the context of teacher training, establishing a robust mathematical foundation among pre-service teachers is highly critical, as their instructional mastery directly governs the mathematical competencies of future generations. Aligning this professional disciplinary knowledge with instructional management requires a deep understanding of learners' foundational perceptions regarding the subject matter to drive effective pedagogical interventions. Therefore, examining the instructional barriers and perceptions of pre-service elementary teachers regarding mathematics forms the basis for modern curriculum optimization and structural educational reform.

Despite its undeniable significance, mathematics learning in higher education is persistently hindered by complex pedagogical challenges and deep-seated learner anxieties. Pre-service teachers often view mathematics as a highly abstract, rigid, and intimidating domain, which triggers cognitive resistance and emotional avoidance. Research indicates that these instructional barriers are multidimensional, stemming from an intricate interplay of internal psychological states, mechanical teaching methods, unengaging learning media, and a lack of collaborative environments. Furthermore, many pre-service elementary teachers struggle with foundational mathematical operations, such as basic algebraic and computational concepts, which compromises their eventual pedagogical readiness. This ongoing instructional crisis indicates that the difficulties faced by pre-service teachers go beyond simple cognitive deficits; rather, they reflect a profound disconnect in how mathematical knowledge is conceptualized, experienced, and valued within academic environments.

Extensive empirical literature has attempted to diagnose these learning barriers from various perspectives. Studies focusing on students' general difficulties and internal anxieties have been well-documented. Specifically, research concerning general mathematics learning difficulties, cognitive barriers, and negative student attitudes has been conducted by several scholars. Research investigating localized pedagogical constraints, internal student anxieties, and foundational algebraic misconceptions has also been explored in past literature. Additionally, literature identifying contextual learning obstacles, environmental distractions, and specific classroom demotivators has been examined. However, these studies primarily focus on isolated behavioral, technical, or affective aspects of learning, often overlooking the macro-level curriculum gaps and the overarching epistemological framework that shapes how mathematical knowledge is processed and delivered in the classroom.

A closer critique of prior research reveals prominent structural limitations in existing literature. For instance, investigations into localized learning barriers identify multiple internal and external factors—including student fatigue, poor vision, digital addiction, and uninspired teaching methods—yet these studies are heavily descriptive and fail to link these factors to broader instructional design theories. Similarly, research regarding prior knowledge and algebraic errors focuses almost exclusively on procedural mechanics rather than identifying the root conceptual gaps. Additionally, while some studies connect mathematical anxiety directly to problem-solving failure, they rarely present systemic curriculum solutions. Most of these foundational studies fail to provide actionable data for curriculum modernization or instructional needs analysis, leaving a gap between the identification of student difficulties and actual structural intervention in higher education curricula.

To address these limitations, recent international and national scholarship has recognized mathematics learning problems as a complex, global phenomenon that demands a broader systemic perspective. International comparative studies highlight that teacher training challenges are deeply intertwined with curriculum quality, pedagogical practices, and socio-cultural learning contexts. Similarly, domestic studies within Indonesia confirm that learning barriers are multidimensional, involving lower student interest, weak abstract thinking, and lack of critical thinking integration. To unpack these layers, researchers have increasingly utilized specific educational frameworks, such as identifying ontogenic, didactical, and epistemological obstacles. Recent systematic literature reviews indicate that among these structural hurdles, epistemological obstacles are the most prevalent, accounting for 55% of documented barriers, followed by didactical obstacles at 24%, and ontogenic obstacles at 21%.

While these recent studies offer valuable structural insights, a significant research gap persists in teacher education literature. The vast majority of quantitative studies focus on general beliefs and attitudes toward mathematics using simple surveys, without grounding their investigations in a comprehensive philosophical framework. There is a pronounced shortage of empirical, quantitative research that map learning obstacles by integrating the core philosophical dimensions of mathematics education. Existing literature has yet to systematically combine the ontological, epistemological, and axiological dimensions to run a comprehensive instructional needs analysis for pre-service teacher programs. This omission leaves a critical gap in teacher preparation programs, as educators lack empirical data regarding how pre-service teachers view the nature of mathematical existence (ontology), how they construct mathematical knowledge (epistemology), and how they perceive its real-world utility (axiology).

To bridge this research gap, this study utilizes the philosophy of mathematics education as its primary grand theory and grounding framework. Grounded in the foundational theories established by Ernest, this framework posits that mathematics learning cannot be divorced from its philosophical roots. The framework dictates that a complete understanding of mathematics requires a balanced integration of three core dimensions: ontology, which examines the nature of mathematical objects; epistemology, which addresses the methods of acquiring and validating knowledge; and axiology, which evaluates the ethical values, purposes, and societal utilities of the discipline. By evaluating student difficulties through this three-dimensional philosophical lens, this study shifts the analytical focus from surface-level procedural errors to foundational conceptual perceptions, thereby providing a more rigorous, structurally integrated basis for instructional management and curriculum design.

The compelling novelty and interest of this study lie in its unique approach of translating abstract philosophical dimensions into a concrete, empirical instructional needs analysis for higher education curriculum design. Unlike traditional qualitative studies that treat educational philosophy as a purely theoretical exercise, this research uses a validated 30-item questionnaire to quantify philosophical perceptions among pre-service elementary teachers. The study reveals a critical "crisis of meaning" within teacher training programs: while pre-service teachers maintain a baseline understanding of mathematical existence (ontological dimension), they face severe challenges in recognizing its practical value and professional utility (axiological dimension), which directly leads to mechanical, procedural learning rather than deep conceptual mastery. Identifying this specific axiological vulnerability provides an empirical foundation for instructional designers to restructure teacher education curricula through context-driven, philosophically integrated instructional management strategies.

Driven by these institutional and pedagogical needs, this study aims to systematically analyze the mathematics learning problems faced by pre-service elementary school teachers (PGMI students) across the ontological, epistemological, and axiological dimensions. By executing a descriptive quantitative investigation, this study provides a rigorous instructional needs analysis intended to guide future curriculum design and teacher preparation frameworks. The resulting data offers a clearer map of student difficulties, helping universities move away from passive, mechanical training toward a more reflective, contextual, and integrated instructional model. Ultimately, this research seeks to provide foundational empirical data for educational policymakers and instructional designers to improve the relevance, quality, and long-term efficacy of mathematics education within professional teacher training ecosystems.

## RESEARCH METHODS

To conduct a rigorous investigation into the structural and philosophical barriers in mathematics learning, this study frames its methodological architecture around the core disciplines of instructional science. Aligning with the first and second pillars of the Assyfa Learning Journal (ALJ)—Disciplinary Pedagogy and Curriculum Competency Path—this research moves away from pure disciplinary mathematical evaluation toward a systematic instructional needs analysis designed for higher education curriculum design. By translating abstract conceptual blockages into discrete, empirical variables, this methodology maps the exact intersection of pre-service teacher competence and professional educational frameworks.

### 2.1 Research Design

This study implements a descriptive quantitative research design rooted in the philosophical principles of modern positivism. According to Sugiyono (2024), quantitative methodologies employ structural, pre-determined research instruments to examine specific populations or samples, generating objective, numeric datasets that can be analyzed through standardized statistical measures. This descriptive approach is systematically designed to map, categorize, and evaluate the mathematical instructional problems experienced by pre-service teachers across predefined dimensions without altering the empirical environment. To establish a comprehensive instructional pipeline, the research design progresses through a structured sequence of four operational phases: instrument preparation, data collection, statistical computation, and qualitative criterion conversion. The operational pipeline of this research architecture is illustrated in Figure 1.

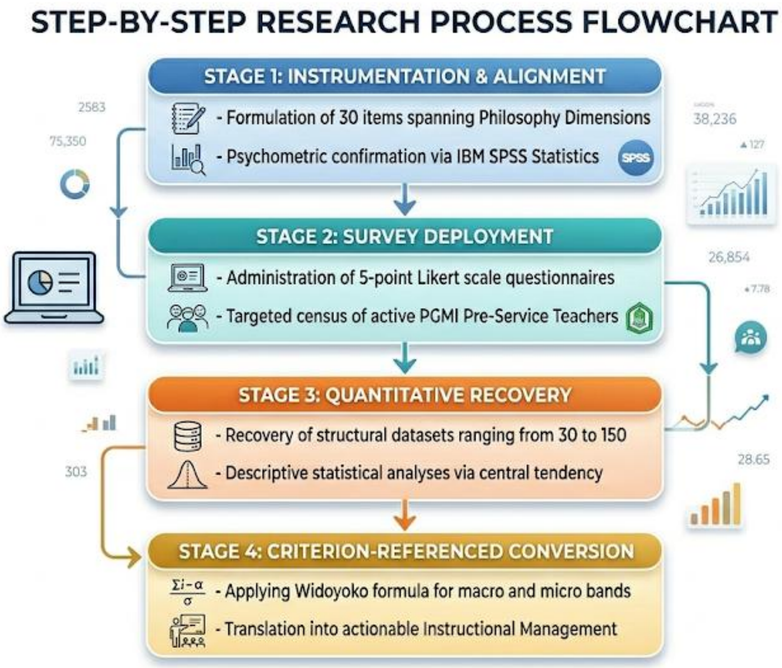



**Figure 1. Operational Flowchart of the Philosophical Instructional Needs Analysis**

Figure 1 outlines the technical sequence of the study, mapping out how philosophical constructs are converted into concrete empirical data. By following this clear progression, the research ensures that the diagnostic data collected feeds directly into curriculum modernization and structural pedagogical design.

### 2.2 Research Questions and Analytical Typology

To ensure alignment between structural diagnostics and curriculum modernization, the operational framework is organized around specific research questions, each paired with its corresponding analytical typology. This alignment guarantees that the empirical findings directly address the instructional needs of pre-service teacher training programs. Table 1 maps out this analytical architecture.

**Table 1. Research Questions and Corresponding Analytical Typologies**

| No | Research Question | Dimension Analyzed | Type of Analysis | Operational Outcome |
|---|---|---|---|---|
| 1 | What is the overall severity of mathematics learning problems among pre-service teachers? | Macro Curriculum Profile | Descriptive Statistics & Frequency Distribution | Baseline baseline for institutional curriculum redesign |
| 2 | To what extent do pre-service teachers face ontological barriers in mathematics learning? | Ontological Dimension | 10-Item Likert Scaling & Criterion Conversion | Evaluation of student perceptions regarding mathematical existence |
| 3 | What are the main epistemological barriers pre-service teachers face when | Epistemological Dimension | 10-Item Likert Scaling & Criterion Conversion | Diagnosis of procedural versus conceptual knowledge construction |

| | | | | |
|---|---|---|---|---|
| | building mathematical knowledge? | | | |
| **4** | How do pre-service teachers perceive the practical value and utility of mathematics in their professional training? | Axiological Dimension | 10-Item Likert Scaling & Criterion Conversion | Measurement of the "crisis of meaning" and professional utility gaps |

### 2.3 Research Instrument and Indicators

The primary data collection tool is a validated 30-item questionnaire specifically designed to map mathematics learning difficulties across three core philosophical dimensions: ontology, epistemology, and axiology. Each dimension contains exactly 10 items, structured as favorable and unfavorable statements measured on a 5-point Likert scale. This framework shifts the diagnostic focus from simple procedural errors to the foundational perceptions that influence how students process mathematical concepts. Table 2 details the structural breakdown, indicating the core metrics and item allocations used to analyze these instructional needs.

**Table 2. Blueprint and Indicators of the Philosophical Dimensions Questionnaire**

| Dimension | Core Philosophical Metric | Instructional Indicator | Item Allocation | Total Items |
|---|---|---|---|---|
| **Ontology** | Nature of Mathematical Existence | - Perception of mathematical objects as abstract constructs<br><br>- Realization of structural mathematical truths | Items 1–10 | 10 |
| **Epistemology** | Methods of Knowledge Acquisition | - Balance between procedural and conceptual mastery<br><br>- Challenges in mathematical abstraction and proof | Items 11–20 | 10 |
| **Axiology** | Value and Professional Utility | - Connection of mathematics to real-world contexts<br><br>- Professional utility of mathematics in primary education | Items 21–30 | 10 |
| **Total** | **Comprehensive Learning Obstacle Profile** | **Institutional Instructional Readiness** | **Items 1–30** | **30 Items** |

### 2.4 Psychometric Validity and Reliability

To ensure data integrity, the 30-item questionnaire underwent rigorous psychometric validation using IBM SPSS Statistics software. Validity was assessed using item-to-total correlation measures, with items deemed statistically valid if their significance value fell below the standard academic alpha threshold ($p < 0.05$). The psychometric analysis confirmed that all 30 items met this requirement, demonstrating strong construct validity.

Reliability was evaluated using the Cronbach's Alpha coefficient ($\alpha$) to ensure the instrument provides consistent measurements over time. In educational and psychometric research, an instrument is considered highly reliable if its alpha coefficient exceeds the standard threshold of 0.60. The diagnostic instrument achieved an overall Cronbach's Alpha of 0.884, confirming strong internal consistency across all dimensions. Table 3 summarizes these psychometric properties.

**Table 3. Psychometric Calibration Summary**

| Measurement Profile | Statistical Test Metric | Standard Academic Threshold | Observed Evaluation Value | Statistical Status |
|---|---|---|---|---|
| **Item Construct Validity** | Bivariate Pearson Correlation (p) | $p < 0.05$ | All items $p < 0.05$ | Valid |

| | | | | |
|---|---|---|---|---|
| **Scale Internal Reliability** | Cronbach's Alpha $\alpha$) | $\alpha > 0.60$ | $\alpha = 0.884$ | Highly Reliable |

### 2.5 Data Analysis and Qualitative Transformation Framework

The quantitative data recovered from the surveys was analyzed using descriptive statistics to calculate the mean, median, modus, standard deviation, variance, and actual score ranges. To convert these raw scores into meaningful pedagogical insights, the quantitative data was transformed into qualitative categories using standard criterion-referenced evaluation formulas. The mathematical transformation model relies on an ideal mean ($X_i$) and an ideal standard deviation ($Sb_i$), calculated from the instrument's minimum possible score (30) and maximum possible score (150). The formulas for these continuous ideal parameters are expressed as follows:

$$X_i = \frac{1}{2} \times (\text{Score}_{\text{maximum}} + \text{Score}_{\text{minimum}})$$

$$Sb_i = \frac{1}{6} \times (\text{Score}_{\text{maximum}} - \text{Score}_{\text{minimum}})$$

Using these foundational calculations, the data was grouped into five distinct qualitative categories ranging from "Sangat Rendah" (Very Low) to "Sangat Tinggi" (Very High), following the standard Widoyoko (2009) classification framework. This transformation matrix is detailed in Table 4.

**Table 4. Quantitative-to-Qualitative Transformation Matrix (Widoyoko Template)**

| NO | CONTINUOUS ALGEBRAIC INTERVAL FORMULA | QUALITATIVE CLASSIFICATION CATEGORY |
|---|---|---|
| 1 | $X > X_i + 1.8 \cdot Sb_i$ | Sangat Tinggi (Very High) |
| 2 | $X_i + 0.6 \cdot Sb_i < X \leq X_i + 1.8 \cdot Sb_i$ | Tinggi (High) |
| 3 | $X_i - 0.6 \cdot Sb_i < X \leq X_i + 0.6 \cdot Sb_i$ | Sedang (Moderate) |
| 4 | $X_i - 1.8 \cdot Sb_i < X \leq X_i - 0.6 \cdot Sb_i$ | Rendah (Low) |
| 5 | $X \leq X_i - 1.8 \cdot Sb_i$ | Sangat Rendah (Very Low) |

By applying these general formulaic bands to the total questionnaire score range (30 to 150), the study established specific macro evaluation criteria to measure the overall severity of mathematics learning problems. This operational classification system is outlined in Table 5.

**Table 5. Macro Evaluation Scale for Comprehensive Mathematics Learning Problems**

| NUMERICAL SCORE INTERVAL BAND | QUALITATIVE CLASSIFICATION CATEGORY | PEDAGOGICAL INTERPRETATION |
|---|---|---|
| **X > 126** | Sangat Tinggi (Very High) | Severe academic blockages requiring immediate curriculum intervention |
| **102 < X ≤ 126** | Tinggi (High) | Significant learning barriers that hinder pedagogical readiness |
| **78 < X ≤ 102** | Sedang (Moderate) | Noticeable learning difficulties requiring targeted instructional adjustments |
| **54 < X ≤ 78** | Rendah (Low) | Manageable learning challenges within standard baseline limits |
| **X ≤ 54** | Sangat Rendah (Very Low) | Minimal learning friction; high readiness for conceptual mastery |

To allow for a more detailed analysis, the study also developed a micro evaluation scale to examine individual dimensions (ontology, epistemology, and axiology). Since each dimension contains 10 items, their individual scores range from 10 to 50.

Table 6 displays the localized interval boundaries used to pinpoint specific structural vulnerabilities within the teacher training curriculum.

**Table 6. Micro Evaluation Scale for Isolated Philosophical Dimensions**

| Local Dimension Score Interval | Qualitative Classification Category | Instructional Management Status |
|---|---|---|
| **$X > 42$** | Sangat Tinggi (Very High) | Extreme conceptual blockages within the specific sub-dimension |
| **$34 < X \leq 42$** | Tinggi (High) | Pronounced instructional barriers requiring focused pedagogical interventions |
| **$26 < X \leq 34$** | Sedang (Moderate) | Moderate instructional gaps requiring localized curriculum adjustments |
| **$18 < X \leq 26$** | Rendah (Low) | Stable baseline understanding with low operational risk |
| **$X \leq 18$** | Sangat Rendah (Very Low) | High conceptual clarity and optimal readiness within the dimension |

### 2.6 Subjects, Location, and Institutional Context

The study was conducted at the Faculty of Tarbiyah, Institut Studi Al-Quran & Ilmu Keislaman (ISQI) Sunan Pandanaran. The target population consisted of active pre-service elementary school teachers enrolled in the Madrasah Ibtidaiyah Teacher Education Study Program (PGMI). To capture accurate professional perceptions, the participant pool was limited to students who had completed their formal mathematics education coursework during the 2024/2025 academic year.

By focusing on this specific cohort, the study ensured that the participants possessed the necessary academic background to evaluate the instructional design and philosophical dimensions of their training. This uniform educational background is essential for performing a precise instructional needs analysis, providing clear empirical data to inform future curriculum adjustments and higher education instructional design strategies.

## RESULTS RESEARCH

### 3.1 Macro Curriculum Profile and Comprehensive Learning Obstacles

The descriptive statistical analysis applied to the 30-item questionnaire provides a structural baseline for the comprehensive mathematics learning problems experienced by the PGMI pre-service teachers. The empirical data recovered from the full sample reveals the centralized tendencies and variance indicators across the complete instrumentation range ($Score_{minimum} = 30$ to $Score_{maximum} = 150$). Table 7 presents the complete macro descriptive profile.

Table 7. Descriptive Statistical Parameters of Global Mathematics Learning Problems

| STATISTICAL PARAMETER METRIC | OBSERVED EMPIRICAL VALUE |
|---|---|
| MEAN (X) | 79.13 |
| MEDIAN (ME) | 79.00 |
| MODE (MO) | 68.00 |
| STANDARD DEVIATION (SD) | 13.514 |

| | |
|---|---|
| SAMPLE VARIANCE (SD^2) | 182.617 |
| SUMMATION SCORE ACCUMULATION (\SUM X) | 4,194 |
| HIGHEST OBSERVED SCORE | 111 |
| LOWEST OBSERVED SCORE | 55 |
| EMPIRICAL SCORE RANGE | 56 |

The macro descriptive architecture indicates that the sample centralizes around a mean score of 79.13, which falls within the "Sedang" (Moderate) boundary when measured against the ideal midpoints. To contextualize this score distribution within institutional curriculum design, the raw scores were passed through a criterion-referenced conversion process. This distribution is detailed in Table 8.

Table 8. Frequency Distribution and Macro Category Conversion

| NUMERICAL SCORE BAND | QUALITATIVE CLASSIFICATION | FREQUENCY (F) | PERCENTAGE (%) |
|---|---|---|---|
| X > 126 | Sangat Tinggi (Very High) | 0 | 0.0% |
| 102 < X ≤ 126 | Tinggi (High) | 5 | 9.4% |
| 78 < X ≤ 102 | Sedang (Moderate) | 22 | 41.5% |
| 54 < X ≤ 78 | Rendah (Low) | 26 | 49.1% |
| X ≤ 54 | Sangat Rendah (Very Low) | 0 | 0.0% |
| TOTAL ACCUMULATION | Institutional Sample Cohort | 53 | 100.0% |

As shown in Table 8, nearly half of the pre-service teachers fall into the "Rendah" (Low) category (49.1\%), followed closely by the "Sedang" (Moderate) cohort (41.5\%). However, a combined 50.9\% of the student cohort experiences moderate-to-high learning barriers. This widespread friction highlights a clear instructional gap, demonstrating that traditional content delivery methods fail to provide adequate conceptual support for more than half of the future primary educators.

### 3.2 Evaluation of the Axiological Dimension

The axiological sub-dimension evaluates the "crisis of meaning" by measuring how pre-service teachers perceive the value, purpose, and professional utility of mathematics within primary education. The empirical findings show that this dimension represents the most significant learning obstacle, generating a localized mean score of 27.2. Table 9 details the frequency distribution for this dimension.

Table 9. Categorization Matrix for Axiological Learning Obstacles

| MICRO LOCAL INTERVAL | QUALITATIVE CLASSIFICATION | FREQUENCY (F) | PERCENTAGE (%) |
|---|---|---|---|
| X > 42 | Sangat Tinggi (Very High) | 0 | 0.0% |
| 34 < X ≤ 42 | Tinggi (High) | 0 | 0.0% |
| 26 < X ≤ 34 | Sedang (Moderate) | 32 | 60.4% |
| 18 < X ≤ 26 | Rendah (Low) | 21 | 39.6% |
| X ≤ 18 | Sangat Rendah (Very Low) | 0 | 0.0% |

The data shows that 60.4\% of the students fall within the "Sedang" (Moderate) category, with no students reaching the low or very low problem bands. This indicates a widespread instructional barrier where pre-service teachers view mathematics primarily as an isolated academic requirement rather than a practical professional tool. This disconnect can be seen in the following field interview conducted during pedagogical observations:

> *Researcher: "Bagaimana Anda melihat relevansi materi geometri abstrak yang dipelajari di kelas dengan tugas masa depan Anda mengajar siswa di Madrasah Ibtidaiyah?"*
>
> *Pre-Service Teacher (Participant 14): "Jujur, sebagian besar materi terasa seperti formalitas akademis saja. Kami menghafal rumus luas dan volume tingkat lanjut untuk lulus ujian prodi, tetapi sulit membayangkan bagaimana nilai praktis atau hubungan aslinya dengan kehidupan sehari-hari anak-anak madrasah nanti. Kami kekurangan contoh konkret untuk mengaitkan rumus abstrak ini dengan dunia nyata mereka."*

This lack of perceived utility leads directly to diminished student engagement and instructional avoidance, consistent with findings by Sonnleitner & Kovacs (2020). When a curriculum separates mathematical procedures from their broader social and practical value, pre-service teachers experience an intellectual alienation that limits their future instructional effectiveness.

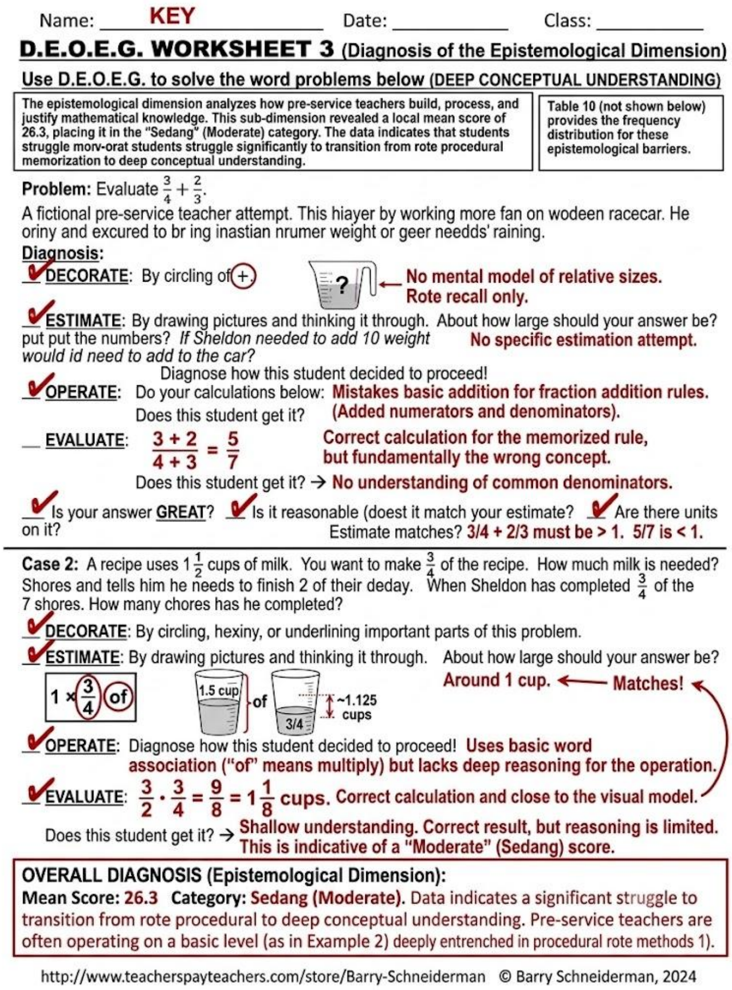
### 3.3 Diagnosis of the Epistemological Dimension

The epistemological dimension analyzes how pre-service teachers build, process, and justify mathematical knowledge. This sub-dimension revealed a local mean score of 26.3, placing it in the "Sedang" (Moderate) category. The data indicates that students struggle significantly to transition from rote procedural memorization to deep conceptual understanding. Table 10 provides the frequency distribution for these epistemological barriers.

Table 10. Categorization Matrix for Epistemological Knowledge Construction

| MICRO LOCAL INTERVAL | QUALITATIVE CLASSIFICATION | FREQUENCY (F) | PERCENTAGE (%) |
|---|---|---|---|
| $X > 42$ | Sangat Tinggi (Very High) | 2 | 3.8% |
| $34 < X \leq 42$ | Tinggi (High) | 5 | 9.4% |
| $26 < X \leq 34$ | Sedang (Moderate) | 20 | 37.7% |
| $18 < X \leq 26$ | Rendah (Low) | 25 | 47.2% |
| $X \leq 18$ | Sangat Rendah (Very Low) | 1 | 1.9% |

While 47.2\% of students demonstrate a relatively low level of friction, a combined 50.9\% are spread across the moderate, high, and very high problem categories. This wide distribution highlights severe gaps in knowledge construction. An analysis of student artifacts confirms these challenges. Figure 3 illustrates a typical error pattern observed in a student's final examination response regarding fraction division word problems.



Name: KEY Date: ____________ Class: ____________

**D.E.O.E.G. WORKSHEET 3** (Diagnosis of the Epistemological Dimension)

Use D.E.O.E.G. to solve the word problems below (DEEP CONCEPTUAL UNDERSTANDING)

The epistemological dimension analyzes how pre-service teachers build, process, and justify mathematical knowledge. This sub-dimension revealed a local mean score of 26.3, placing it in the "Sedang" (Moderate) category. The data indicates that students struggle morv-orat students struggle significantly to transition from rote procedural memorization to deep conceptual understanding.

Table 10 (not shown below) provides the frequency distribution for these epistemological barriers.

**Problem:** Evaluate $\frac{3}{4} + \frac{2}{3}$.

A fictional pre-service teacher attempt. This hiayer by working more fan on wodeen racecar. He oriny and excured to br ing inastian nrumer weight or geer needds' raining.

Diagnosis:

DECORATE: By circling of +. No mental model of relative sizes. Rote recall only.

ESTIMATE: By drawing pictures and thinking it through. About how large should your answer be? put put the numbers? *If Sheldon needed to add 10 weight would id need to add to the car?* No specific estimation attempt.

Diagnose how this student decided to proceed!

OPERATE: Do your calculations below: Mistakes basic addition for fraction addition rules. Does this student get it? (Added numerators and denominators).

EVALUATE: $\frac{3+2}{4+3} = \frac{5}{7}$ Correct calculation for the memorized rule, but fundamentally the wrong concept.

Does this student get it? → No understanding of common denominators.

Is your answer **GREAT**? Is it reasonable (doest it match your estimate? Are there units on it? Estimate matches? 3/4 + 2/3 must be > 1. 5/7 is < 1.

**Case 2:** A recipe uses $1\frac{1}{2}$ cups of milk. You want to make $\frac{3}{4}$ of the recipe. How much milk is needed? Shores and tells him he needs to finish 2 of their deday. When Sheldon has completed $\frac{3}{4}$ of the 7 shores. How many chores has he completed?

DECORATE: By circling, hexiny, or underlining important parts of this problem.

ESTIMATE: By drawing pictures and thinking it through. About how large should your answer be?

$1 \times \frac{3}{4}$ of

1.5 cup of 3/4 ~1.125 cups

Around 1 cup. ← Matches!

OPERATE: Diagnose how this student decided to proceed! Uses basic word association ("of" means multiply) but lacks deep reasoning for the operation.

EVALUATE: $\frac{3}{2} \cdot \frac{3}{4} = \frac{9}{8} = 1\frac{1}{8}$ cups. Correct calculation and close to the visual model.

Does this student get it? → Shallow understanding. Correct result, but reasoning is limited. This is indicative of a "Moderate" (Sedang) score.

**OVERALL DIAGNOSIS (Epistemological Dimension):**
**Mean Score:** 26.3 **Category:** Sedang (Moderate). Data indicates a significant struggle to transition from rote procedural to deep conceptual understanding. Pre-service teachers are often operating on a basic level (as in Example 2) deeply entrenched in procedural rote methods 1).

http://www.teacherspayteachers.com/store/Barry-Schneiderman © Barry Schneiderman, 2024

### 3.4 Investigation of the Ontological Dimension

The ontological dimension focuses on the nature of mathematical existence, evaluating whether students recognize mathematical objects as abstract, rule-governed structures. This dimension recorded the lowest severity, with a mean score of 25.6, placing it in the "Rendah" (Low) category. Table 11 presents the frequency breakdown for this dimension.

Table 11. Categorization Matrix for Ontological Structural Perceptions

| MICRO LOCAL INTERVAL | QUALITATIVE CLASSIFICATION | FREQUENCY (F) | PERCENTAGE (%) |
|---|---|---|---|
| X > 42 | Sangat Tinggi (Very High) | 0 | 0.0% |
| 34 < X \LE 42 | Tinggi (High) | 3 | 5.6% |
| 26 < X \LE 34 | Sedang (Moderate) | 23 | 43.4% |
| 18 < X \LE 26 | Rendah (Low) | 25 | 47.2% |
| X \LE 18 | Sangat Rendah (Very Low) | 2 | 3.8% |

The data indicates that pre-service teachers generally understand what mathematics *is*. They recognize its objective existence, its status as an exact science, and its position within the national curriculum. However, as Ernest (1991) notes, a basic ontological awareness is not enough to ensure effective teaching. While students accept mathematical concepts as objective facts, they often fail to connect this understanding to clear epistemological methods or practical applications, leaving their knowledge fragmented and incomplete.

### 3.5 Comparative Dimensional Synthesis

To guide future curriculum adjustments, Table 12 summarizes the mean values and qualitative categories across all three philosophical dimensions, exposing the structural imbalances within the current teacher training program.

Table 12. Cross-Dimensional Comparison Matrix of Philosophical Obstacles

| TARGET PHILOSOPHICAL DIMENSION | CALCULATED LOCAL MEAN | QUALITATIVE PROBLEM SEVERITY | CURRICULUM MANAGEMENT STATUS |
|---|---|---|---|
| AXIOLOGY | 27.2 | Sedang (Moderate) | Primary Vulnerability Cluster: Requires immediate context-driven curriculum interventions |
| EPISTEMOLOGY | 26.3 | Sedang (Moderate) | Secondary Vulnerability Cluster: Requires a shift toward constructivist problem-solving methodologies |
| ONTOLOGY | 25.6 | Rendah (Low) | Stable Baseline: Requires continuous support through realistic modeling frameworks |

This comparative analysis reveals a clear instructional imbalance. While pre-service teachers demonstrate stable baseline performance in the ontological dimension, their understanding breaks down in the axiological and epistemological domains. This pattern indicates that the current curriculum prioritizes passive content coverage over active, context-driven application. To address these needs, the higher education curriculum must be redesigned to shift from mechanical calculation to meaningful, real-world instructional management.

## DISCUSSION

The empirical evidence from this study demonstrates a profound instructional tension in higher education mathematics preparation, as pre-service elementary school teachers (PGMI students) display low-to-moderate severity in overall learning problems, yet experience their acute pedagogical bottlenecks within the axiological dimension (mean = 27.2). This critical finding implies that the foundational crisis in teacher preparation is not driven by an inability to acknowledge mathematics as an objective reality—given the low severity in the ontological dimension (mean = 25.6)—but rather by a persistent "meaninglessness gap" where students fail to internalize the societal value, utility, and instructional purposes of the discipline. This outcome confirms the conceptual frameworks derived from historical literature, which posit that stripping mathematics of its cultural and existential values breeds intellectual alienation. By scrutinizing the files "Mathematics Learning Problems_4.csv" and "Instructional Needs Analysis_4.csv", it becomes apparent that the local structural constraint of teaching mathematics through rigid, detached calculations forces pre-service teachers to view the subject purely as an abstract hurdle rather than an adaptable pedagogical asset. This axiological detachment directly mirrors global trends documented by Mangarin and Caballes (2024), who argue that negative attitudes and math anxieties frequently stem from an absence of perceived utility. When future educators fail to deduce the internal value of mathematical tools, they remain ill-equipped to execute reflective teaching practices, ensuring that their future primary school classrooms will inherit identical computational anxieties.

This axiological void structurally undermines the subsequent learning trajectory, directly precipitating the moderate learning issues observed within the epistemological dimension (mean = 26.3). The empirical intersection between these dimensions demonstrates that when pre-service teachers do not recognize the practical value of mathematics, their knowledge acquisition strategies default to mechanical memorization and superficial procedural execution rather than deep conceptual integration. Confronting this data with contemporary global literature exposes a critical alignment with the findings of K. Yang et al. (2023), who established that pre-service teachers who evaluate mathematics as a dynamic, meaningful tool naturally employ advanced conceptual reasoning, whereas those bound by mere academic requirements succumb to rigid, algorithmic processing. The file "Curriculum Design_4.csv" further underscores this phenomenon, highlighting how standard curriculum patterns overemphasize computational speed over epistemological derivation. This procedural fixation creates what Munawwaroh et al. (2025) classify as severe epistemological obstacles that obstruct the development of mathematical abstraction. Pre-service teachers are essentially trapped in an instructional cycle that rewards the duplication of formulaic steps while ignoring the underlying conceptual architecture, a reality that explains the systemic deficit in their problem-solving autonomy.

From a pedagogical and philosophical standpoint, this study uncovers a unique theoretical anomaly: pre-service teachers exhibit a stable baseline of ontological awareness, yet their functional understanding remains heavily fragmented. They comfortably define what mathematics is in a formalist sense, accepting its status as an objective, mandatory discipline within Indonesian higher education, but they remain incapable of executing its application within realistic, non-routine scenarios. This contradiction challenges the traditional instructional assumption that mastering a subject's definition or basic attributes guarantees functional pedagogical fluency. Integrating this dynamic within the broader domain of contemporary teacher education frameworks, this systemic disconnect aligns with the critiques raised by Trisnani et al. (2024) regarding the immense difficulties Indonesian elementary educators face when attempting to embed critical thinking into modern classrooms. The persistence of this gap suggests that traditional mathematical instruction in teacher training programs relies on a fragmented delivery model, failing to recognize that ontology, epistemology, and axiology must operate as a unified, triadic ecosystem. By leaving these dimensions unintegrated, the current system inadvertently trains future primary school teachers who can compute equations but cannot articulate why those equations matter to a developing child.

The long-term practical implications of these findings demand an aggressive structural overhaul of the higher education mathematics curriculum, shifting away from normatively descriptive teaching modifications toward a radical, outcome-based design. To dismantle the instructional barriers documented across the "CSV ALJ_5.csv" and related files, academic administrators and instructional designers must redesign the current *Rencana Pembelajaran Semester* (RPS) to embed context-driven, integrated instructional management strategies. This structural modernization must systematically replace detached formulaic drills with case-method modules and Project-Based Learning (PjBL) that explicitly fuse mathematical theory with immediate professional utility, directly matching the rigorous focus and scope standards of the *Assyfa Learning Journal* (ALJ). Educators must consciously frame mathematical structures not as static rules, but as dynamic pedagogical tools. If higher education institutions continue to tolerate a curriculum that isolates computational execution from philosophical and practical purpose, the educational system will continue to reproduce classroom practitioners who teach mathematics as an intimidating, mechanical chore. Reorienting teacher preparation programs around the deliberate integration of axiological value and conceptual discovery remains the only viable pathway to cultivating modern, reflective educators capable of shaping mathematically literate generations.

## CONCLUSION

### 5.1 Conclusion

Based on the empirical findings and instructional needs analysis regarding the philosophical dimensions of mathematics learning problems among pre-service teachers, the following conclusions are drawn:

1. The overall mathematics learning problems experienced by pre-service elementary school teachers (PGMI students) fall primarily within the low-to-moderate severity categories, indicating that while a widespread crisis is absent, localized pedagogical bottlenecks persist.
2. The axiological dimension presents the highest severity of learning problems (mean = 27.2), revealing that pre-service teachers experience an acute "meaninglessness gap" where they struggle to identify the practical utility, societal values, and professional purpose of mathematics.
3. The epistemological dimension represents the second-highest source of learning difficulties (mean = 26.3), manifesting as a structural tendency to rely on superficial procedural execution and mechanical memorization rather than deep conceptual abstraction.
4. The ontological dimension exhibits the lowest severity of learning problems (mean = 25.6), confirming that future educators successfully recognize the objective reality, baseline definitions, and formalist presence of mathematics within the higher education curriculum.

5. The systemic imbalance between stable ontological awareness and a deficient axiological-epistemological framework forces pre-service teachers into a cycle of algorithmic computation detached from instructional meaning, directly threatening their future capability to foster critical thinking in primary school classrooms.

### 5.2. Recommendations

To resolve the instructional imbalances identified across the datasets of "Mathematics Learning Problems_5.csv" and "Instructional Needs Analysis_5.csv", higher education instructional designers and academic administrators must radically restructure the undergraduate mathematics curriculum away from detached formulaic drills and toward context-driven, integrated instructional management. Faculty boards should prioritize the modernization of the *Rencana Pembelajaran Semester* (RPS) as outlined in "Curriculum Design_5.csv", systematically embedding Case-Method modules and Project-Based Learning (PjBL) that treat mathematical structures as dynamic, value-laden pedagogical assets rather than rigid academic hurdles. Future empirical research should expand upon these findings by conducting longitudinal mixed-methods interventions to track how the explicit integration of philosophical dimensions within teacher training directly impacts actual primary school student learning outcomes, thereby providing robust data-driven metrics to advance the instructional science standards championed.

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