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| Research Article / Araştırma Makalesi |

# A Psychometric Analysis of The Mathematics Learning Disability Screening Scale Developed Through DSM-5

# DSM-5 Aracılığıyla Geliştirilen Matematik Öğrenme Güçlüğü Tarama Ölçeğinin Psikometrik Analizi

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**Keywords**
1.Mathematical learning disability
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3.Validity
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## Abstract

*Purpose:* This study, it was aimed to develop a valid and reliable measurement tool by evaluating the psychometric properties of the Mathematics Learning Disabilities Screening Scale (MLDSS) for elementary and secondary school students. In this context, a measurement tool that is culturally and linguistically appropriate for the Turkish context and overcomes the limitations of translated scales was developed.

*Design/Methodology/Approach:* The study was conducted as a scale development study within a survey research design. The scale's items were developed based on DSM-5 criteria and an extensive literature review. The sample consisted of 644 students, identified by their teachers, from 120 schools across Türkiye's seven geographical regions. The psychometric properties of the scale were evaluated using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA), along with internal consistency (Cronbach's Alpha) and test-retest reliability analyses.

*Findings:* The EFA results revealed a three-factor structure (Number Sense, Calculation, and Mathematical Reasoning) that explained 68.5% of the total variance. The CFA confirmed this structure, with goodness-of-fit indices indicating an excellent model fit (e.g., CFI = .95, IFI = .95, RMSEA = .069, $\chi^2/df$ = 2.41). The scale demonstrated high internal consistency (Cronbach's Alpha = .93) and strong test-retest reliability (r = .90).

*Highlights:* The mathematics learning disability screening scale is a valid and reliable instrument developed for elementary and secondary school students. Its three-factor structure is consistent with modern theories of mathematics learning disabilities and its strong psychometric properties make it a valuable tool for educators and experts in early identification and intervention planning.

## Öz

*Çalışmanın amacı:* Bu çalışmada, ilkokul ve ortaokul öğrencileri için Matematik Öğrenme Güçlüğü Tarama Ölçeği'nin (MLDSS) psikometrik özellikleri değerlendirilerek geçerli ve güvenilir bir ölçme aracının geliştirilmesi amaçlanmıştır. Bu kapsamda, Türkiye bağlamına kültürel ve dilsel olarak uygun, çeviri ölçeklerin sınırlılıklarını gideren bir ölçme aracı geliştirilmiştir.

*Materyal ve Yöntem:* Araştırma, tarama modeline uygun bir ölçek geliştirme çalışması olarak yürütülmüştür. Ölçek maddeleri DSM-5 kriterleri ve kapsamlı literatür taramasına dayalı olarak geliştirilmiştir. Örneklem, Türkiye'nin yedi coğrafi bölgesindeki 120 okuldan, öğretmenleri tarafından belirlenen 644 öğrenciden oluşmaktadır. Ölçeğin psikometrik özellikleri, Açımlayıcı Faktör Analizi (AFA), Doğrulayıcı Faktör Analizi (DFA), iç tutarlılık (Cronbach Alfa) ve test-tekrar test güvenirlik analizleri kullanılarak değerlendirilmiştir.

*Bulgular:* AFA sonuçları, toplam varyansın %68.5'ini açıklayan üç faktörlü bir yapı (Sayı Hissi, Hesaplama ve Matematiksel Akıl Yürütme) ortaya koymuştur. DFA, bu yapıyı doğrulamış ve uyum indeksleri mükemmel bir model uyumuna işaret etmiştir (örneğin, CFI= .95, IFI= .95, RMSEA= .069, $\chi^2/df$ = 2.41). Ölçek, yüksek düzeyde iç tutarlılık (Cronbach Alfa = .93) ve güçlü test-tekrar test güvenirliği (r = .90) göstermiştir.

*Önemli Vurgular:* Matematik öğrenme güçlüğü tarama ölçeği, ilkokul ve ortaokul öğrencileri için geliştirilmiş geçerli ve güvenilir bir araçtır. Üç faktörlü yapısı, modern matematik öğrenme güçlüğü teorileriyle uyumlu olup güçlü psikometrik özellikleri sayesinde eğitimciler ve uzmanlar için erken tanılama ve müdahale planlamasında değerli bir araç olma potansiyeli taşımaktadır.

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# INTRODUCTION

A mathematical learning disability (MLD) is characterized by persistent and significant difficulties in comprehending mathematical concepts, applying operations, and solving problems. These challenges are not related to an individual's overall cognitive ability but are typically caused by disruptions in specific cognitive functions (Asfuroğlu & Fidan, 2016; Geary, 2004). Consequently, students with MLD may struggle with understanding mathematical ideas, performing calculations accurately and efficiently, and applying mathematical knowledge to real-world situations (Akın & Sezer, 2010; Deruaz et al., 2020). These persistent difficulties can undermine a student's self-confidence, heighten anxiety, and negatively impact their motivation, making early and accurate identification crucial for providing effective educational interventions (Mutlu, 2019; 2024).

This study was designed to remedy the notable lack of culturally appropriate assessment tools for Mathematical Learning Disability (MLD) in Türkiye. Although many international scales exist, a heavy reliance on direct translations of these foreign instruments has led to critical concerns about their cross-cultural validity. It is questionable whether such tools can accurately measure the same constructs in Turkish students. In response to this specific gap, the present research focused on developing a new Turkish MLD rating scale. The primary objective was to create and psychometrically validate an assessment tool, tailored to the local context, that can effectively and reliably identify primary and secondary school students who may have MLD.

## Theoretical Framework

### Mathematical Learning Disability

MLD is a specific learning disorder defined as a structural deficit in "number sense"—an innate neurological system that supports an individual's basic skills in perceiving, comparing, and using numerical quantities (Butterworth, 2010; Von Aster & Shalev, 2007). This core deficit leads to a heterogeneous profile, manifesting differently both cognitively and academically among individuals. MLD can cause various problems, extending beyond understanding abstract mathematical concepts to include challenges in remembering and applying procedures (Cirino et al., 2015; Geary, 2013; Olkun, 2015; Filiz & Güneş, 2023). This diversity highlights the critical importance of early diagnosis. Interventions are particularly effective at a young age when the brain is highly malleable, as they can more effectively shape the learning process and increase the likelihood of significant improvements in students' mathematical skills (Mutlu et al., 2021; Uçar & Duman, 2024; Tosto et al., 2015). Despite these challenges, students with MLD can learn when supported by appropriate instructional interventions, for which an accurate diagnosis is a prerequisite. The development of a reliable diagnostic tool, as undertaken in this study, is therefore essential for facilitating these effective interventions.

The varied nature of Mathematical Learning Disability (MLD) is reflected in its diverse definitions within the literature. Some researchers, like Butterworth (2010), define it based on persistent struggles with numbers and operations, while others, such as Price and Ansari (2013), conceptualize it as a deficit in neurological skills. A more comprehensive view from Kaufman et al. (2011) describes MLD as a combination of deficits across behavioral, cognitive, neuropsychological, and neural domains. Despite these different perspectives, the common characteristic is a significant and enduring difficulty with understanding, recalling, and applying mathematical concepts or correctly using operational rules. To create a unified conceptualization for this research, the current study synthesizes these viewpoints through the lens of the diagnostic criteria from DSM-5 and ICD-10.

### Diagnostic Criteria for Mathematics Learning Disabilities

Globally, the diagnostic approach to MLD is guided by the standards set forth by the American Psychiatric Association (APA) in the DSM-5 and the World Health Organization (WHO) in the ICD-10 (APA, 2013; Kißler et al., 2021; Pham & Riviere, 2015; Tannock, 2013). These frameworks outline three core cognitive dimensions of the disability: number sense, calculation skills, and mathematical reasoning. As defined by Kaufmann & Von Aster (2012), number sense involves challenges in understanding fundamental mathematical ideas, magnitudes, and symbols. Concurrently, deficits in computational skills refer to an inability to execute basic arithmetic or a high frequency of errors. The third dimension, mathematical reasoning, pertains to difficulties with the application of mathematical knowledge to problem-solving.

A diagnosis of MLD must consider its emergence from an interplay of cognitive and academic factors, necessitating an evaluation of number sense, arithmetic, and problem-solving. Both number sense (which includes skills like counting and number comparison) and basic arithmetic (addition, subtraction, multiplication, and division) are widely viewed as critical markers for identifying the disability (Mutlu, 2019; 2024). These particular skills are foundational, forming the bedrock for higher-level mathematics (Gersten & Chard, 1999). Consequently, students who struggle with fundamental numerical skills often fail to achieve arithmetic fluency—the ability to perform calculations with speed and accuracy (Molise & Luneta, 2024). Since individuals with MLD often show difficulties throughout the problem-solving process (Monei & Pedro, 2017), it is essential that problem-solving capabilities are also a component of the diagnostic examination.

## Assessment of Mathematics Learning Disabilities

The assessment of MLD is complicated by its frequent co-occurrence with other learning disabilities, which necessitates the use of specialized diagnostic tools. While traditional intelligence and academic achievement tests are often employed for this purpose (Geary, 2004; Eteng-Uket, 2023; Geary & Hoard, 2005), their effectiveness can be inadequate. These tests are prone to being skewed by socioeconomic factors and often neglect the emotional and environmental dimensions of the disability (Gersten et al., 2005; Mazzocco & Myers, 2003; Yoong et al., 2023), thereby highlighting a clear need for more sensitive instruments. In response to these limitations, a wide array of alternative tools has emerged in the literature. Several instruments focus on screening, such as the Number Sets Test for identifying risk in young children (Geary et al., 2009), a computer-based tool from Butterworth (2003) for students aged 6-14, and Loughborough University's "dyscalculium" screener (Eteng-Uket, 2023). More specific diagnostic instruments include the Neuropsychological Test Battery (NUCALC), which evaluates number processing and calculation (von Aster & Shalev, 2007), and the TEDIMATH test for diagnosing arithmetic disorders (Grégoire et al., 2004, as cited in Eteng-Uket, 2023). Other researchers have designed computer-based tests for basic mathematical and psychological processes (Cangoz et al., 2013; Karagiannakis & Baccaglini-Frank, 2014). Despite this progress, many of these tools, as well as methods like discrepancy analysis and behavioral observation, are criticized for lacking standardization, having psychometric weaknesses, and maintaining too narrow a focus (Cangoz et al., 2013; Eteng-Uket, 2023; Mutlu & Akgün, 2017). This critique is reinforced by the findings of Mutlu and Akgün (2017), who determined that all common diagnostic approaches have significant limitations when used alone. Given the profound impact of MLD on a child's development and the difficulty of early diagnosis, creating a reliable, effective, and teacher-friendly screening tool is a vital step toward supporting students and educators.

Beyond these general assessment challenges, a specific problem exists in Türkiye. While numerous MLD assessment tools are available internationally, there is a scarcity of scales that are culturally and linguistically validated for the Turkish context. Many existing scales are direct translations, which raises concerns about their cross-cultural validity—specifically, whether they measure the same cognitive constructs in individuals from different cultures (Cangoz et al., 2013; Geary, 2004; Mutlu & Akgün, 2017; Filiz, 2021). This concern is substantiated by research indicating that the cognitive manifestations of learning difficulties can differ across language groups (e.g., English vs. Turkish learners) (Altunkaya, 2017; Güngör & Yeşilyurt, 2023).

While there have been recent efforts to develop assessment scales in Türkiye, the demand for such tools has not been satisfied. This gap is attributable to the demanding nature of scale validation and the difficulty of creating a comprehensive assessment that reflects the complex, multidimensional aspects of MLD. In response, this study's primary purpose is to develop the Mathematics Learning Disability Screening Scale (MLDSS), a valid, reliable, and culturally-sensitive tool for the Turkish context. The broader goals of this work are to refine the definition of the MLD population in Türkiye, highlight current inadequacies, and provide a critical resource for teachers and researchers that aids in the early identification and support of at-risk students. The entire study is structured around answering two fundamental research questions about the proposed scale:

1. Does the Mathematics Learning Disability Screening Scale (MLDSS) demonstrate validity in measuring the symptoms of students with mathematics learning disabilities?
2. Does the Mathematics Learning Disability Screening Scale (MLDSS) demonstrate reliability in measuring the symptoms of students with mathematics learning disabilities?

## METHOD

### Research Design

This study evaluates the psychometric properties of the Mathematics Learning Disability Screening Scale (MLDSS), which was developed for elementary and secondary school students. Accordingly, this research is a scale development study conducted within the framework of a survey research design. Survey research designs involve collecting data on characteristics such as attitudes and behaviors from a large sample to describe the current state of a population (Fraenkel et al., 2015; McMillan & Schumacher, 2014). This study involved administering the scale to elementary and secondary school students, followed by an examination of its reliability, validity, factor structure, and other psychometric parameters. Specifically, an Exploratory Factor Analysis (EFA) was first conducted to identify the underlying structure of the scale. Subsequently, a Confirmatory Factor Analysis (CFA) was performed to validate this structure. The results of these analyses are reported sequentially.

### Participants

To achieve a sample that was representative of the target population, this study employed cluster sampling, a probability-based technique (Fraenkel et al., 2015). The procedure for this method involved identifying appropriate sampling units (clusters) and subsequently selecting participants at random from within those units (Karagöz, 2023). The data collection effort spanned all seven of Türkiye's geographical regions, with two provinces chosen from each, totaling fourteen. The process began by identifying primary and secondary schools with a high incidence of students with learning disabilities. From these schools, teachers who instructed a student with a formal diagnosis of a learning disability were invited to take part in the study. Teachers who volunteered were then tasked with completing the rating scale for a single student under their supervision.

In total, 644 teachers from 120 schools participated, completing the scale for 644 students who had been diagnosed with a learning disability. The ages of the students ranged from 9 to 12. To ensure high representativeness, data were collected from an equal or near-equal number of students from each grade level. According to the literature on factor analysis, sample sizes of 100 are considered weak, 200 fair, 300 good, 500 very good, and 1,000 excellent (Field, 2013). Given the number of participants in this study (N=644), the sample size can be considered very good for conducting a factor analysis. Detailed demographic information about the participants is presented below.

**Table 1. Demographic characteristics of the participants**

| Variable | Category | EFA Sample | | CFA Sample | |
|---|---|---|---|---|---|
| | | Frequency | Percentage | Frequency | Percentage |
| Gender | Female | 206 | %60 | 175 | 58.3 |
| | Male | 138 | %40 | 125 | %41.7 |
| | Total | 344 | %100 | 300 | %100 |
| Grade | 3 | 90 | %26.1 | 78 | %26 |
| | 4 | 82 | %23.9 | 71 | %23.7 |
| | 5 | 84 | %24.4 | 82 | %27.3 |
| | 6 | 88 | %25.6 | 69 | %23 |
| | Total | 344 | %100 | 300 | %100 |

## Procedure

This section outlines the steps followed in the development of the scale. The process adhered to the standard procedures for scale development as reported in the literature (DeVellis & Thorpe, 2022; Simms, 2008). The examination of the psychometric properties of the MLDSS developed in this study followed these established standards.

First, the construct of MLD and its components were defined. To this end, the MLD literature was analyzed in detail, along with the diagnostic criteria for learning disabilities (LDs) and MLD from DSM-5 and ICD-10. A three-dimensional heterogeneous structure reflecting the nature of MLD was identified. This structure was classified under three categories (see Fig 1): Number Sense, Calculation, and Mathematical Reasoning.

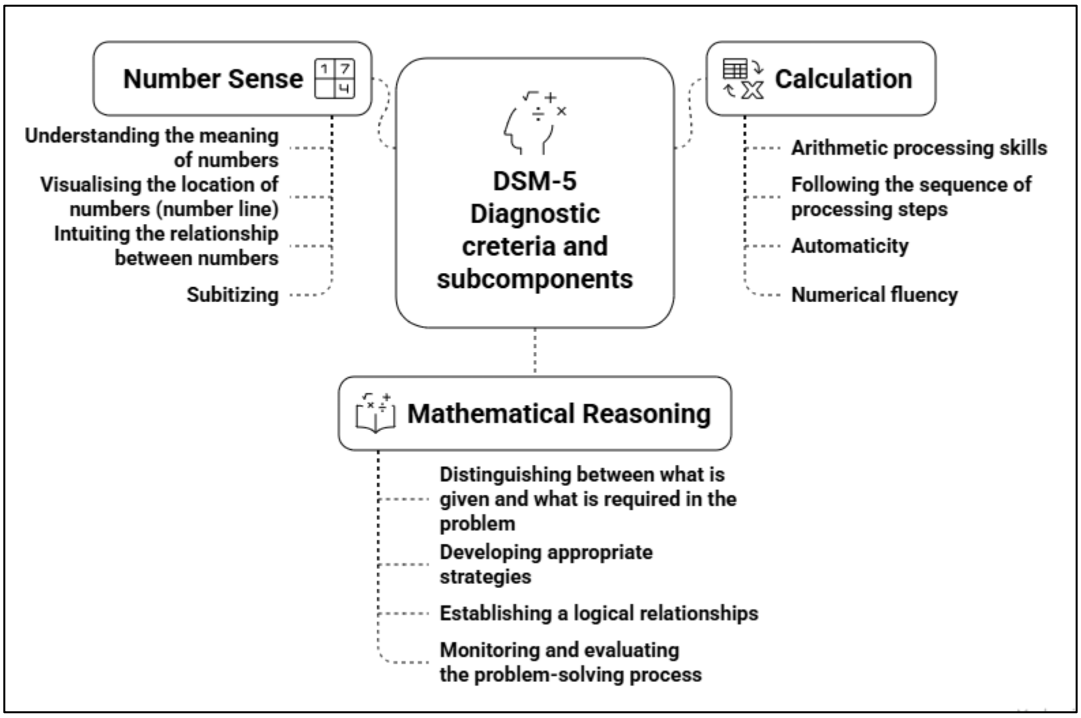


**Figure 1. DSM-5 Diagnostic criteria and subcomponents**

The second phase of the procedure involved creating the draft scale, a process guided by the three sequential stages of item writing, expert review, and a pilot study (Tavşancıl, 2014). Initially, to build a comprehensive profile of MLD, an initial pool of 62 items was generated through a thorough literature search of electronic databases, including TÜBİTAK ULAKBİM (Turkish Academic Network and Information Center), Web of Science, Scopus, Google Scholar, and Science Direct (APA, 2013; Geary et al., 2009; Hellstrand et al., 2024; etc.). This pool was then refined to 51 items after redundant items were eliminated. To establish content validity, the 51-item draft was reviewed by an expert panel consisting of a psychologist, a special education specialist, a mathematics teacher, and two MLD researchers. The panel evaluated the scale's scope and sub-dimensions, as well as the clarity, wording, and psychometric appropriateness of each item. Although the experts' overall feedback was positive, confirming the scale's theoretical soundness and suitability, they recommended several changes. Consequently, items with similar wording (M 23, 33, 48) and those that did not align with DSM-5 criteria and the literature (M 1, 2, 3, 5, 8, 11, 12, 13, 15, 16, 20, 24, 25) were removed. This review process resulted in a final 35-item version, for which a five-point Likert-type rating scale ("never" to "always") was adopted for responses. This final version was then administered in a pilot study to 20 teachers (10 primary school, 10 mathematics) outside of the main study group, and the successful pilot confirmed the items were clear and understandable, preparing the scale for full administration.

Third, before completing the MLDSS, all participating teachers were directed to attend an online training session prepared by the researchers. This two-hour training was conducted via videoconference on Microsoft Teams and was recorded and shared with the teachers via Google Drive. The training aimed to inform teachers about MLD and to encourage their active participation in the data collection process. The content covered topics such as the definition and diagnosis of MLD, a review of the MLDSS items, instructions on how to administer the scale, and teaching methods and interventions for students with MLD. Additionally, a pre-assessment session was held to address any challenges faced by the teachers (e.g., accessing or filling out the Google Form). The scale was administered online using Google Forms, and teachers were given a two-month period to observe and evaluate the performance of their students.

The fourth and final procedural step was to conduct validity and reliability analyses of the MLDSS, for which data were gathered from two separate samples: 344 teachers for an Exploratory Factor Analysis (EFA) and 300 for a Confirmatory Factor Analysis (CFA). EFA, performed in SPSS 25, was utilized to identify the underlying factor structure, analyze how items grouped into sub-dimensions, and examine their loadings and inter-factor correlations (DeVellis, 2003). Following this, CFA, conducted in AMOS 23, was used to confirm whether the proposed factor structure was supported by the data from the second sample, a key step in establishing construct validity (Brown, 2015; Kline, 2016). To assess reliability, the MLDSS was also re-administered to 20 teachers after two weeks to establish test-retest stability via the Pearson Correlation Coefficient, while internal consistency was measured using Cronbach's Alpha. The study concluded with a comprehensive interpretation and discussion of all findings related to the scale's psychometric properties.

## FINDINGS

### Findings Related to Validity Analysis

This section presents the findings related to the research question: "Does the MLDSS validly measure the symptoms of students with mathematical learning disabilities?" To examine the construct validity of the MLDSS, Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were employed.

#### Findings Related to EFA

To test the hypothesized three-dimensional structure of the scale, which was based on DSM-5 criteria, an Exploratory Factor Analysis (EFA) was conducted. Before beginning the main analysis, the suitability of the data for factor analysis was confirmed. The Kaiser-Meyer-Olkin (KMO) measure yielded a value of .931, indicating marvelous sample adequacy (Kaiser, 1974). Furthermore, Bartlett's Test of Sphericity was significant ($\chi^2 = 3011.274$; df = 120; $p < .001$), which confirmed that the correlations among the items were strong enough for analysis (Bartlett, 1954). Because the underlying factors were assumed to be correlated, the Direct Oblimin rotation method was selected, as is common in educational research.

The analysis then proceeded with an iterative item reduction process. The EFA was first conducted on 35 items, which initially produced a three-factor structure explaining 60.115% of the total variance. In the first refinement stage, items were removed for statistical reasons: those with low factor loadings below 0.40 (M 14, 21, 22, 29, 30, 31) and those with high cross-loadings on multiple factors (M 41, 44, 46, 49, 51). After re-running the analysis, a second refinement was performed, where items were reviewed for their theoretical contribution. Items that did not seem to measure the intended construct (M 7, 18, 34, 37, 42, 45, 50) and one additional item with a low factor loading (M 9) were also removed. This iterative process resulted in a final 16-item scale, for which a final EFA revealed a three-factor structure that explained 68.495% of the total variance. The detailed results for this final structure are presented in Table 2.

**Table 2. Factor characteristics**

| Factor | Eigenvalue | Variance (%) | Cumulative variance (%) |
|---|---|---|---|
| Number sense | 8.057 | 50.353 | 50.353 |
| Calculation | 1.882 | 11.763 | 62.117 |
| Mathematical reasoning | 1.021 | 6.379 | 68.495 |

An examination of Table 2 shows that, according to the EFA results, all three sub-dimensions of the MLDSS have eigenvalues greater than 1.0. The first sub-dimension has a particularly high eigenvalue of 8.057, explaining 50.353% of the variance. The second sub-dimension has an eigenvalue of 1.882 and accounts for an additional 11.763% of the variance. Finally, the third sub-dimension has an eigenvalue of 1.021, explaining a further 6.379% of the variance. To support the analysis of the scale's sub-dimensions, the scree plot is presented in Figure 2.

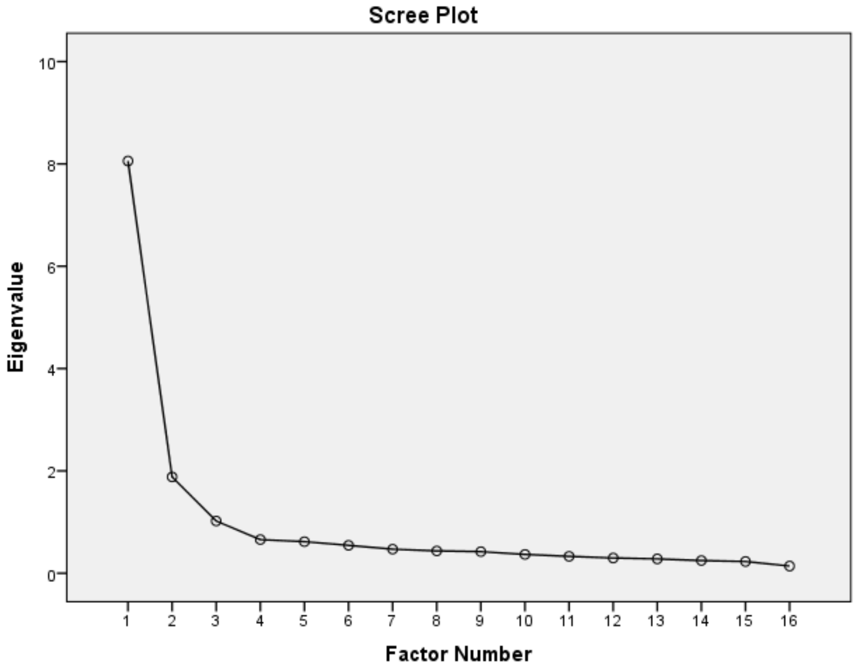


**Figure 2. Scree plot**

To determine the number of factors to retain, an inspection of the scree plot was conducted (see Fig 1). The graph shows a clear "elbow" forming between the third and fourth factors, after which the eigenvalues decrease sharply and begin to level off. This pattern indicates that the initial three factors explain a significant amount of the variance, while any subsequent factors contribute very little explanatory power. Based on this visual analysis, an optimal three-factor solution was concluded for the scale. To further substantiate this decision, the proposed structure was reviewed by a panel of experts, including two internationally recognized faculty members with expertise in MLD and one specialist in scale development. After evaluating the factors and their corresponding items, the experts endorsed the three-factor structure as theoretically sound. Therefore, the analysis proceeded with this confirmed three-factor model, and the results of the subsequent rotated factor analysis are detailed in Table 3.

**Table 3. Results of the rotated factor analysis**

| Factor Name | | Item | Communality (Extraction) | Factor Loadings 1 | 2 | 3 |
|---|---|---|---|---|---|---|
| Number Sense | M4 | Inverts or changes the order of numbers when reading and writing (for example, writes or reads 69 as 96 or 342 as 234) | 0,69 | 0,90 | | |
| | M38 | Writes numbers to the wrong digit in mathematical operations | 0,72 | 0,86 | | |
| | M35 | Difficulties in determining the place value (especially numbers with zero tens digit in three-digit numbers (for example, 305)) | 0,69 | 0,83 | | |
| | M40 | Difficulties in establishing a one-to-one relationship between number symbols and objects when counting | 0,70 | 0,81 | | |
| | M39 | Has difficulty rounding numbers to tens or hundreds (especially numbers with 5 in ones and tens digits) | 0,70 | 0,73 | | |
| | M43 | Difficulties in rhythmic counting backwards starting from any number | 0,53 | 0,68 | | |
| | M47 | Difficulties in comparing numbers (e.g. less, more) | 0,47 | 0,49 | | |
| | M32 | Difficulty in showing the position of any number on the number line | 0,54 | 0,45 | | |
| Calculation | M26 | Has difficulty in calculating the total amount when shopping | 0,82 | | -0,93 | |
| | M27 | Has difficulty in calculating change when paying for shopping | 0,83 | | -0,88 | |
| | M28 | Has difficulty in reading an analogue clock | 0,54 | | -0,53 | |
| Mathematical Reasoning | M6 | Has difficulty in using different problem solving strategies when solving problems | 0,43 | | | 0,70 |
| | M4 | Difficulties in interpreting mathematical problems | 0,49 | | | 0,70 |
| | M17 | Difficulties in mathematical thinking | 0,57 | | | 0,74 |
| | M10 | Difficulties in interpreting numerical data | 0,48 | | | 0,59 |
| | M19 | Difficulties in concretising and visualising abstract mathematical concepts (modelling) | 0,49 | | | 0,66 |

As shown in Table 3, the communalities for each item ranged from .45 to .93. The scale consists of three sub-dimensions: "Number Sense," comprising 8 items; "Calculation," comprising 3 items; and "Mathematical Reasoning," comprising 5 items. The naming of these dimensions was based on the DSM-5 classification system and expert opinions. The factor loadings for the items in the "Number Sense" sub-dimension ranged from .45 to .90. For the "Calculation" sub-dimension, the factor loadings ranged from -.93 to -.55. For the "Mathematical Reasoning" sub-dimension, the factor loadings ranged from .62 to .74. Furthermore, an inter-factor correlation analysis was conducted to determine the relationships among the scale's factors (see Table 4).

**Table 4. Inter-factor correlation analysis**

| Factors | 1 | 2 | 3 |
|---|---|---|---|
| Number Sense (1) | 1.00 | | |
| Calculation (2) | -.681 | 1.00 | |
| Mathematical Reasoning (3) | .508 | -.449 | 1.00 |

**p<.01

As detailed in Table 4, the analysis of the scale's factors showed moderate and significant correlations. Specifically, Number Sense was negatively correlated with Calculation ($r = -.681$, $p < .001$) but positively correlated with Mathematical Reasoning ($r = .508$, $p < .001$). A further negative correlation was identified between Calculation and Mathematical Reasoning ($r = -.449$, $p < .001$). The strength of these correlations sufficiently demonstrates that the sub-dimensions measure related but distinct constructs without issues of multicollinearity**.**

**Findings Related to CFA**

To evaluate the model fit from the Confirmatory Factor Analysis (CFA), this study employed a range of goodness-of-fit indices, an approach necessitated by the known limitations of the chi-square ($\chi^2$) test with large samples. Therefore, the model was evaluated against established criteria using both absolute indices ($\chi^2$/df, GFI, AGFI, SRMR, RMSEA) and comparative indices (CFI, IFI). The thresholds for acceptable fit included a $\chi^2$/df ratio below 5.0 (Wheaton et al., 1977), GFI/AGFI values above .85, SRMR/RMSEA values below .08 (Hooper et al., 2008), and CFI/IFI values above .90 (Bentler, 1995; Bollen, 1989). Table 5 provides the complete findings for these goodness-of-fit indicators.

**Table 5. CFA Goodness-of-Fit Indices for the MLDSS.**

| Fit Index | Value | Acceptable Fit | Excellent Fit | Status |
|---|---|---|---|---|
| NFI | .92 | ≥.90 | ≥.95 | Acceptable |
| NNFI | .92 | ≥.90 | ≥.95 | Acceptable |
| IFI | .95 | ≥.90 | ≥.95 | Perfect |
| CFI | .95 | ≥.90 | ≥.95 | Perfect |
| RFI | .90 | ≥.90 | ≥.95 | Acceptable |
| AGFI | .87 | ≥.85 | ≥.90 | Acceptable |
| GFI | .90 | ≥.85 | ≥.90 | Perfect |
| RMR | .044 | ≤.08 | ≤.05 | Perfect |
| SRMR | .051 | ≤.08 | ≤.05 | Perfect |
| REMSEA | .069 | ≤.08 | ≤.05 | Acceptable |
| $\chi^2$/df | 2.41 | 2.5-3 | 0-2.5 | Perfect |

An analysis of the goodness-of-fit indices presented in Table 5 indicates that the values for IFI, CFI, GFI, RMR, SRMR, and $\chi^2$/df demonstrate an excellent model fit. The values for NFI, NNFI, RFI, AGFI, and RMSEA indicate an acceptable model fit. The $R^2$ values, which represent the proportion of variance in each item explained by its factor, ranged from .11 to .59. To further examine the model's structural fit, the path diagram illustrating item-total correlations and the corresponding t-values was inspected. The path diagram for the first-order CFA is presented in Figure 3.

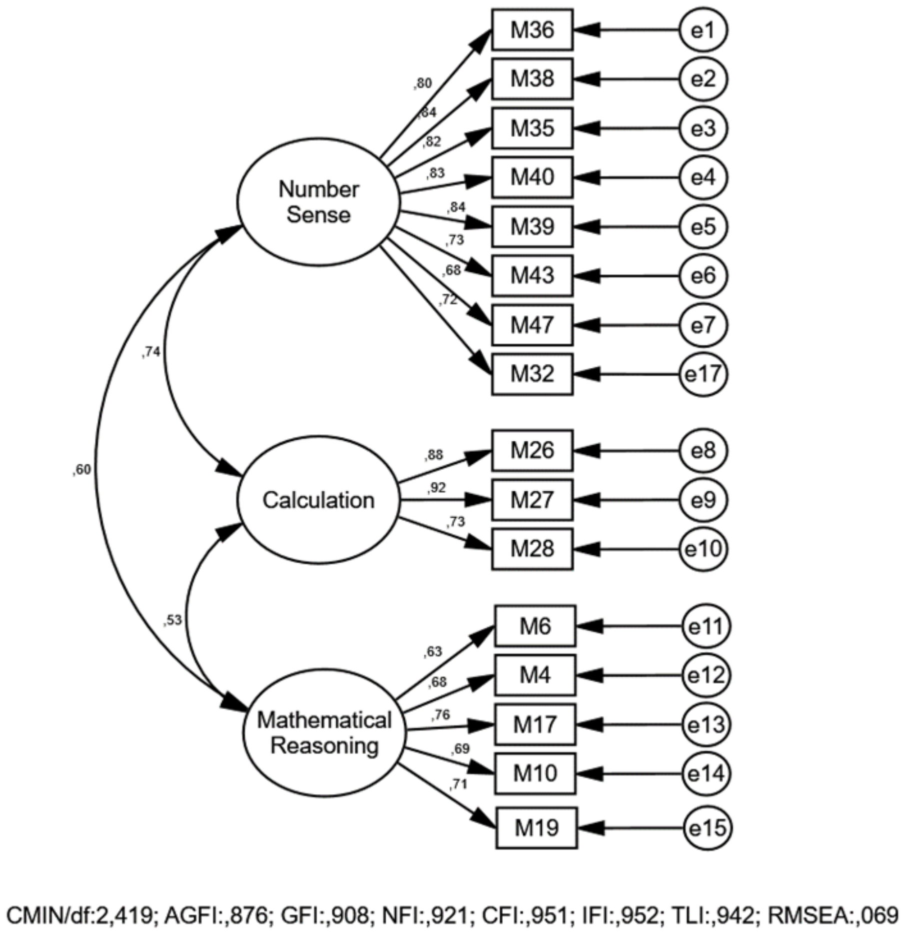


**Figure 3. Path diagram**

The path diagram in Figure 3 illustrates that all items loaded strongly onto their respective factors, with standardized coefficients ranging from .63 to .92. Because all factor loadings also had significant t-values ($p < .01$), the findings indicate that the scale's items are effective and distinct measures of their underlying constructs.

## Findings Related to Reliability Analysis

The reliability of the MLDSS was confirmed through two separate analyses. First, the scale's internal consistency was found to be excellent, as measured by Cronbach's Alpha. The alpha for the total scale was .93 in both the EFA and CFA samples, with high coefficients also observed for the sub-dimensions in each sample (EFA sample: .89, .89, and .84; CFA sample: .92, .87, and .82 for Number Sense, Calculation, and Mathematical Reasoning, respectively). Second, the scale's stability was affirmed through a test-retest analysis with 20 teachers across a 15-day period. This yielded strong Pearson correlation coefficients for all sub-dimensions—Number Sense (.90), Calculation (.92), and Mathematical Reasoning (.88)—as well as for the total scale score (.90), indicating its consistency over time.

## DISCUSSION AND CONCLUSION

This study was designed to develop the Mathematics Learning Disability Screening Scale (MLDSS), a valid and reliable instrument based on DSM-5 diagnostic criteria for identifying elementary school students at risk for mathematics learning disabilities (MLD). The findings demonstrate that the developed scale possesses strong psychometric properties, showing both high validity and reliability. These results align closely with current international and national literature, indicating that the MLDSS offers a significant contribution to the field.

The construct validity analysis confirmed a three-dimensional theoretical structure for MLD, comprising number sense, calculation, and mathematical reasoning. This multidimensional framework corroborates the scientific consensus that MLD arises from fundamental deficits in interrelated yet distinct skill areas, rather than from a single, monolithic problem. This structure is conceptually consistent with findings from other international instruments. For example, the "Dyscalculia Test" developed in Nigeria by Eteng-Uket (2023) also focuses on three core domains: number sense, arithmetic operations, and working memory. In contrast, a mathematics achievement test developed for elementary school students in Hong Kong approached MLD assessment through more curriculum-based domains such as mathematical fluency, arithmetic, and problem-solving (Kwan, 2020). The MLDSS is uniquely positioned within this landscape as a tool that targets not only the academic manifestations of MLD but also its cognitive roots, particularly by treating a core deficit like number sense as a distinct dimension.

The psychometric properties of the MLDSS further attest to its robustness. The scale's three-factor structure explains a total variance of 68.5%, a notably high value that indicates a strong model fit (Zahra et al., 2014). Furthermore, the high internal consistency (Cronbach's alpha = .93) and test-retest reliability (.90) underscore the instrument's stability and precision. These reliability coefficients are comparable to, and in some cases exceed, those of other well-regarded scales in both international (Geiger & Brewster, 2018; Eteng-Uket, 2023) and national literature (Okur, 2019; Deniz, 2022).

A central finding from the MLDSS development is the pivotal role of the "number sense" factor in explaining MLD. This corroborates a large body of research suggesting that a core deficit in understanding and processing numerical quantities lies at the heart of MLD. For instance, using the Number Sets Test, Geary et al. (2009) demonstrated that number sense performance was one of the strongest predictors of MLD, independent of intelligence and working memory. Similarly, Olkun et al. (2016), in their work on an MLD screening tool in Türkiye, highlighted that deficits in basic number processing skills are a elementary reason for low mathematics achievement. The ability of the MLDSS to successfully measure number sense as a discrete factor suggests it has strong potential to detect this critical cognitive deficit.

These findings also align with research demonstrating the feasibility of early and reliable identification of children at risk for MLD. Mazzocco and Thompson (2005) found that kindergarteners' performance on basic numeracy tasks could predict a later MLD diagnosis with high accuracy. This reinforces the call from researchers like Brendefur et al. (2018) for more comprehensive assessment tools that evaluate multiple underlying domains, rather than focusing solely on number concepts. The importance of this study is further highlighted by the global trend towards culturally and contextually sensitive assessment. The development of a local test in Hong Kong (Kwan, 2020) mirrors the need for the MLDSS in Türkiye, pointing to a universal recognition that such instruments must be localized. The MLDSS serves this purpose by measuring performance in specific domains directly linked to MLD (number sense, calculation, and reasoning), thereby providing a valuable profile that can inform subsequent diagnostic processes.

## RECOMMENDATIONS

The MLDSS presents significant implications for both educational practice and research.

*For Practitioners:* The scale can serve as a critical tool for teachers and school psychologists in the early identification of students at risk for MLD. By providing concrete data on a student's specific area of weakness (e.g., number sense versus calculation), the MLDSS enables the design of targeted and effective educational programs. This approach aligns with the philosophy of tools like the PMA (Brendefur et al., 2018), which advocate for interventions tailored to a student's specific needs rather than a "one-size-fits-all" approach.

For Researchers: The MLDSS can be utilized as a foundational data collection tool for studies investigating the cognitive profiles, prevalence, and longitudinal progression of MLD in Türkiye. Future longitudinal studies examining the predictive power of the MLDSS, similar to the work of Geary et al. (2009), would further solidify its diagnostic value. Moreover, conducting comparative analyses with other local instruments (e.g., Olkun et al., 2016) and establishing norms with larger, geographically diverse samples would enhance the scale's generalizability and contribute significantly to the body of knowledge in this field.

### Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship or publication of this article.

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### Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

### Researchers’ contribution rate

TF and AÇ conceived of the presented idea and jointly developed the items for the scale. TF designed the methodology and performed the statistical analyses. AÇ provided the theoretical framework and supervised the interpretation of the findings. TF prepared the Method and Findings sections, while AÇ wrote the Introduction and Discussion. Both authors managed the data collection and ethics approval processes. All authors discussed the results and contributed to the final manuscript.

### Ethics Committee Approval Information

This study was approved by the Bayburt University Social and Human Sciences Research Ethics Committee (Decision No: 28, Date: 07/01/2025).

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**APPENDIX**

**English and Turkish versions of the scale**

| Items | Never | Rarely | Sometimes | Usually | Always |
|---|---|---|---|---|---|
| **Number Sense** | | | | | |
| 36. Inverts or changes the order of numbers when reading and writing (for example, writes or reads 69 as 96 or 342 as 234) | | | | | |
| 38. Writes numbers to the wrong digit in mathematical operations | | | | | |
| 35. Difficulties in determining the place value (especially numbers with zero tens digit in three-digit numbers (for example, 305)) | | | | | |
| 40. Difficulties in establishing a one-to-one relationship between number symbols and objects when counting | | | | | |
| 39. Has difficulty rounding numbers to tens or hundreds (especially numbers with 5 in ones and tens digits) | | | | | |
| 43. Difficulties in rhythmic counting backwards starting from any number | | | | | |
| 47. Difficulties in comparing numbers (e.g. less, more) | | | | | |
| 32. Difficulty in showing the position of any number on the number line | | | | | |
| **Calculation** | | | | | |
| 26. Has difficulty in calculating the total amount when shopping | | | | | |
| 27. Has difficulty in calculating change when paying for shopping | | | | | |
| 28. Has difficulty in reading an analogue clock | | | | | |
| **Mathematical Reasoning** | | | | | |
| 6. Has difficulty in using different problem solving strategies when solving problems | | | | | |
| 4. Difficulties in interpreting mathematical problems | | | | | |
| 17. Difficulties in mathematical thinking | | | | | |
| 10. Difficulties in interpreting numerical data | | | | | |
| 19. Difficulties in concretising and visualising abstract mathematical concepts (modelling) | | | | | |

| Maddeler | Hiçbir zaman | Ara sıra | Bazen | Genellikle | Her zaman |
|---|---|---|---|---|---|
| **Sayı Hissi** | | | | | |
| 36. Sayıları okurken ve yazarken ters çevirir veya sırasını değiştirir (örneğin, 69 sayısını 96 veya 342 sayısını 234 olarak yazar veya okur) | | | | | |
| 38. Matematiksel işlemlerde sayıları yanlış basamağa yazar | | | | | |
| 35. Basamak değerini belirlemekte zorluk yaşar (Özellikle üç basamaklı sayılarda onlar basamağı sıfır olan sayılar (örneğin, 305)) | | | | | |
| 40. Sayma yaparken sayı sembolleri ile nesneler arasında birebir ilişki kurmakta zorlanır | | | | | |
| 39. Sayıları onluğa veya yüzlüğe yuvarlamakta zorluk yaşar (Özellikle birler ve onlar basamağında 5 olan sayılar) | | | | | |
| 43. Herhangi bir sayıdan başlayarak geriye doğru ritmik saymada zorlanır | | | | | |
| 47. Sayıları karşılaştırmalarda güçlük çeker (örn. daha az, daha fazla) | | | | | |
| 32. Sayı doğrusu üzerinde herhangi bir sayının konumunu göstermekte zorlanır | | | | | |
| **Hesaplama** | | | | | |
| 26. Alışveriş yaparken toplam tutarı hesaplamakta zorluk yaşar | | | | | |
| 27. Alışverişte ödeme yaparken para üstünü hesaplamada zorluk yaşar | | | | | |
| 28. Analog saati okumakta zorluk yaşar | | | | | |
| **Matematiksel Akıl Yürütme** | | | | | |
| 6. Problem çözerken farklı problem çözme stratejilerini kullanmakta zorluk yaşar | | | | | |
| 4. Matematiksel problemleri yorumlamada güçlük yaşar | | | | | |
| 17. Matematiksel düşünmede zorluk yaşar | | | | | |
| 10. Sayısal verileri yorumlamakta güçlük yaşar | | | | | |
| 19. Soyut matematiksel kavramların somutlaştırılması ve görselleştirilmesinde (modelleme) zorluk yaşar | | | | | |