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A Systematic Review of Instructional Interventions Applied to Primary School Students with Mathematics Learning Difficulties

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ABSTRACT

This study was undertaken to systematically analyze instructional interventions employed to enhance the mathematical performance of elementary school students with Math Learning Difficulties (MLD). Over 20 years (2003-2023), 34 articles that met the inclusion criteria were included in the analysis. The articles in the study were analyzed in terms of methodological and intervention characteristics. Methodological characteristics were analyzed in two categories: participant characteristics and tests for identifying students. Intervention characteristics were analyzed in six categories: grade level, instructional intervention, implementer, implementation method, intervention duration, and mathematics learning area. It was found that the articles examined generally targeted students with MLD, and standardized achievement tests were used to identify students. The articles reviewed determined that third grade students were studied as participant students and strategy teaching was frequently used as an intervention programme. In the reviewed studies, the instructional interventions applied to students with math learning difficulties were implemented mainly by expert implementers in small-group teaching. It was observed that the number of sessions for instructional interventions ranged from 4 sessions to 96 sessions, with an average intervention duration of 16.91 hours. Finally, it was determined that the instructional interventions in the analyzed studies mainly focused on the learning domain of numbers and operations as the mathematics learning area.

Key words: Math Learning Difficulties, Dyscalculia, Instructional Intervention, Systematic Review

INTRODUCTION

Math Learning Difficulties (MLD) is a mathematical difficulty that occurs with problems in acquiring the concept of numbers, memorizing arithmetic facts, making fluent and accurate calculations, and mathematical reasoning (American Psychiatric Association [APA], 2013). Students with MLD have difficulties in counting, operations, money calculation, clock concept, measurement, problem-solving, and mental processes that they frequently encounter daily (Cortiella & Horowitz, 2014). They also exhibit academic characteristics such as difficulty in basic arithmetic skills, using their fingers while calculating, and being slow in responding to arithmetic operations (Karadeniz, 2020; Kurnaz & Sarı, 2020). Students with MLD need to learn mathematics subjects both to cope with the problems they face in daily life and to continue their education academically.

Many students in schools have difficulties with mathematical skills. At the same time, students show low achievement in mathematical literacy skills. In this sense, when the international literature on the prevalence of MLD is analyzed, different rates are observed in other studies. MLD is observed in 5% to 7% of school-age children (Geary, 2015). Nevertheless, it's worth noting that approximately 3-8% of school-age children face challenges with cognitive tasks related to number concepts, counting, and basic arithmetic skills (Nelson & Powell, 2018). In addition, DSM-V (APA, 2013) states that between 5% and 15% of school-age children have at least one learning disability that prevents the acquisition of numerical competence (Monei & Pedro, 2017). Considering the rates of students with MLD (Cortiella & Horowitz, 2014), there is a need for scientifically based effective intervention programs, especially for supporting students academically and improving their mathematical literacy skills (Kalaç, 2016).

It is known that students with math learning difficulties have an average or above-average intelligence level (Kurnaz & Sarı, 2020; Monei & Pedro, 2017). Individuals with MLD consist of students who learn slowly and differently rather than not learning at all. Although MLD is a permanent condition, early diagnosis, and targeted interventions are needed for students to continue their education without interruption

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and to develop effective solutions to the challenges they encounter in their everyday lives (Nelson & Powell, 2018). Students with MLD mathematics performance can be improved with appropriate and specific interventions that can be developed for different grade levels (Lucangeli et al., 2019).

An examination of international literature reveals that instructional interventions have been developed for individuals with MLD in mathematics education (Ennis & Losinski, 2019; Powell et al., 2020; Wu et al., 2020). Such instructional interventions complement students' mathematics instruction. To present scientific evidence regarding these interventions, syntheses of findings are commonly employed, as noted by Myers et al. (2022). In this regard, syntheses serve to amalgamate preexisting knowledge and research outcomes pertaining to a specific subject, as explained by Cooper et al. (2019). Expressing and presenting effective intervention programs will ensure that students with MLD are supported academically in daily and school life (Hellstrand et al., 2019; Wu et al., 2020). Combining instructional intervention studies in the literature can contribute to teachers' recognition of students with learning disabilities and adopting adapted instructional interventions.

When the previous literature was examined, systematic review studies were conducted to examine the instructional interventions developed for instruction mathematics to individuals with MLD at different educational levels (Nelson et al., 2022; Powell et al., 2021). In these studies, different interventions such as computer-based instruction (Hellstrand et al., 2019; Wu et al., 2020), problem-based instruction (Powell et al., 2021), strategy instruction (Hatulainen et al., 2016), explicit instruction (Aunio et al., 2021) and SBI (Jitendra et al., 2016) were synthesized to support mathematics achievement of students with MLD (Nelson et al., 2022). Although different intervention programs have been developed for students with MLD, the heterogeneous nature of this group necessitates further studies.

Previous syntheses have examined intervention programs by mathematics learning areas. For example, systematic review studies have focused on the learning domains of numbers (Lin & Powell, 2021), fractions (Wang et al., 2019), problem-solving (Powell et al., 2020), measurement, and algebra (O'Shea et al., 2017). Despite these studies, it remains unclear which learning domains are intensively researched and which are not. In addition, it remains unclear which content areas are studied more frequently at the primary school level.

Studies synthesizing intervention programs according to instructional levels focused on middle school (Nelson et al., 2022) and high school (Marita & Hord, 2017) level students. In addition, studies were conducted in which all education levels were considered together in the K12 classification (Nelson et al., 2022). In this direction, limited studies were found at the primary school level (Powell et al., 2020). This study synthesized performance differences between students with MLD with and without reading difficulties (RD). Therefore, there is a need to synthesize interventions targeting students with MLD at the primary school level. Systematic review studies contribute to the scientific literature, increase knowledge, and facilitate access to reliable and evidence-based information (Baker & Weeks, 2014). It also supports scientific decision-making in various fields. Therefore, it is of great importance for researchers and decision-makers.

In the literature, different types of complex findings have been observed regarding which instructional interventions effectively improve students' mathematics performance with MLD. In this respect, the complex literature must be combined and analyzed systematically. The systematic review study will reveal the general trend in the field, and the existing literature will be discussed comprehensively. Consolidating these studies and elucidating the overarching trends within the field can serve as valuable guidance for researchers and practitioners when selecting instructional interventions for students with MLD during intervention efforts. In addition, these interventions can also support the mathematical literacy skills of students with MLD.

In previous research syntheses, no systematic review studies focused only on primary school mathematics interventions. Generally, intervention syntheses have focused on more than one level of education (e.g., elementary and secondary school or elementary, secondary, and high school). This study presents a comprehensive analysis of interventions developed for students with MLD at the primary school level. Over 20 years, we examined what instructional interventions were developed and implemented for elementary school students with MLD and how they were distributed.

Purpose and Research Questions

This study encompasses two primary objectives. The first objective is to conduct a systematic analysis of the instructional interventions employed to enhance the mathematical performance of primary school students with learning disabilities. The second objective is to ascertain whether the impact of instructional interventions on the mathematics performance of primary school students varies based on moderator variables. In this context, the research questions are presented below:

1. How is the distribution of the reviewed articles in terms of methodological characteristics (participant characteristics and tests used to identify students)?
2. How is the distribution of the analyzed articles in terms of intervention characteristics (grade level, instructional intervention, implementer, implementation method, intervention duration, and mathematics learning area)?

METHOD

Literature Review Procedure

The review of studies in this research encompassed publications released between January 2000 and March 2023. Several factors influenced the choice of this date range as the starting date. Firstly, curriculum studies for instruction mathematics to individuals with MLD in the early 2000s (NCTM, 2006) can be stated as the first factor. The second factor is the steady increase in special education research syntheses in the last 20 years (2000-2020) (Talbott et al., 2018).

Firstly, a comprehensive electronic search was conducted using Scopus, Wiley Online, Sage Journals, Google Scholar, Science Direct, Taylor & Francis Online, Web of Science and Springer Link databases. The electronic search was conducted using the advanced search feature of the databases. In the first line of the advanced search, the keywords "math learning disabilities", "math learning difficulties", "dyscalculia" was used. In the second line, the keywords "intervention or treatment", "mathematics intervention", "mathematics instruction", "instruction strategies", and "instructional intervention" were used. In the third and last row, the keywords "mathematics education" and "mathematics achievement" were used.

Inclusion and Exclusion Criteria

Participants consisted of primary school students (Grade 1-5) with learning difficulties in mathematics. This criterion includes students with IEP (Individualized Education Programme) goals in mathematics who have specific learning difficulties and are diagnosed with MLD. It also includes students at risk for MLD. Studies that applied instructional interventions in teaching mathematics to students with MLD assessed students' mathematics performance after the intervention. Studies in which the mathematics learning area targeted by instructional interventions was clearly defined. Studies published between 2000 and 2023 in a peer-reviewed journal in English. Studies that met the criteria were included in the study.

Studies in which students with difficulties other than MLD (e.g. students with intellectual disability and autism spectrum disorder) were selected as participants. Studies in which an instructional intervention program was implemented for an outcome other than mathematics performance (e.g. anxiety, attitude, and motivation). Studies not published in English are excluded.

A total of 836 studies were initially identified through database searches. After removing duplicates (241 studies), 638 articles' abstracts were reviewed. Of these, 389 articles that didn't meet the inclusion criteria were excluded. The full texts of the remaining 249 articles were analyzed, with some studies being excluded at this stage due to unavailability of full texts. After the full-text analysis, 221 articles that met the inclusion criteria were identified. Subsequently, 193 studies were excluded based on exclusion criteria, leaving a total of 28 studies. Apart from the database searches, we conducted a manual review of journals that focus on LD. Through this manual review, we identified an additional 43 intervention studies related to LD. After examining the full texts of these 43 studies, 17 studies with inaccessible full texts were excluded. The remaining studies were subjected to exclusion criteria, leading to the inclusion of 6 more studies. In summary, a total of 34 studies were included in the analysis as a result of both database searches and manual searches in specialized journals focused on learning disabilities. The PRISMA diagram summarizing the search process is presented in Figure 1.

Coding Protocol

The researchers created a code sheet to extract pertinent information from the articles identified during the review process. Two authors were responsible for coding all the studies using this code sheet. The first researcher had prior experience in developing code guides for systematic reviews and meta-analyses, while the second author had expertise in creating coding schemes for qualitative research and literature syntheses. In the first stage, coding was done by the first researcher, and the second researcher provided feedback. In the second stage, coding was done by the second researcher, and the agreement between the two researchers was calculated.

The researchers coded each study under methodological and intervention characteristics headings. Methodological characteristics were coded as "participant characteristics" and "tests used to identify students." Intervention characteristics were coded as "grade level", "instructional intervention", "implementer", "implementation method", "intervention duration" and "mathematics learning area."

Participant characteristics were coded as MLD and students at risk of MLD. The tests used to determine the participant students were coded as described in the articles.

Included studies were coded by grade level, considering the grade of the participating students (Grades 1-5). Studies were coded according to the implementer, considering by whom (e.g., researcher, teacher, special education specialist) the instructional interventions were applied to the participating students.

Studies were coded as individual, small group (3-7 people), and whole classroom (more than eight people) according to the type of intervention.

The studies were coded according to the duration of the intervention, considering how long the intervention programs were applied to the participant students (i.e., the number of sessions and the duration of each session in hours). Studies were coded according to the mathematics learning area, considering the mathematical content area targeted by the intervention program (e.g., numbers, problem-solving, geometry, measurement, algebra).

The studies were coded according to the instructional interventions, considering the content of the educational components presented below. The selection of these educational components was informed by the findings of previous meta-analyses, specifically, the studies conducted by Dennis et al. in 2016 and Zheng et al. in 2013. Instructional interventions were coded by considering the instructional strategies whose contents are given below. Instructional interventions were examined in terms of their suitability to the instructional strategies whose descriptions were provided, and it was determined which strategy they were suitable for.

1. Explicit instruction: The wording in the description of the teaching strategy reflects the characteristics of explicit teaching (e.g., teacher- or researcher-directed teaching and the application of probes).
2. Technology: The intervention description includes descriptions of the use of technological devices such as computers and other media to support education.

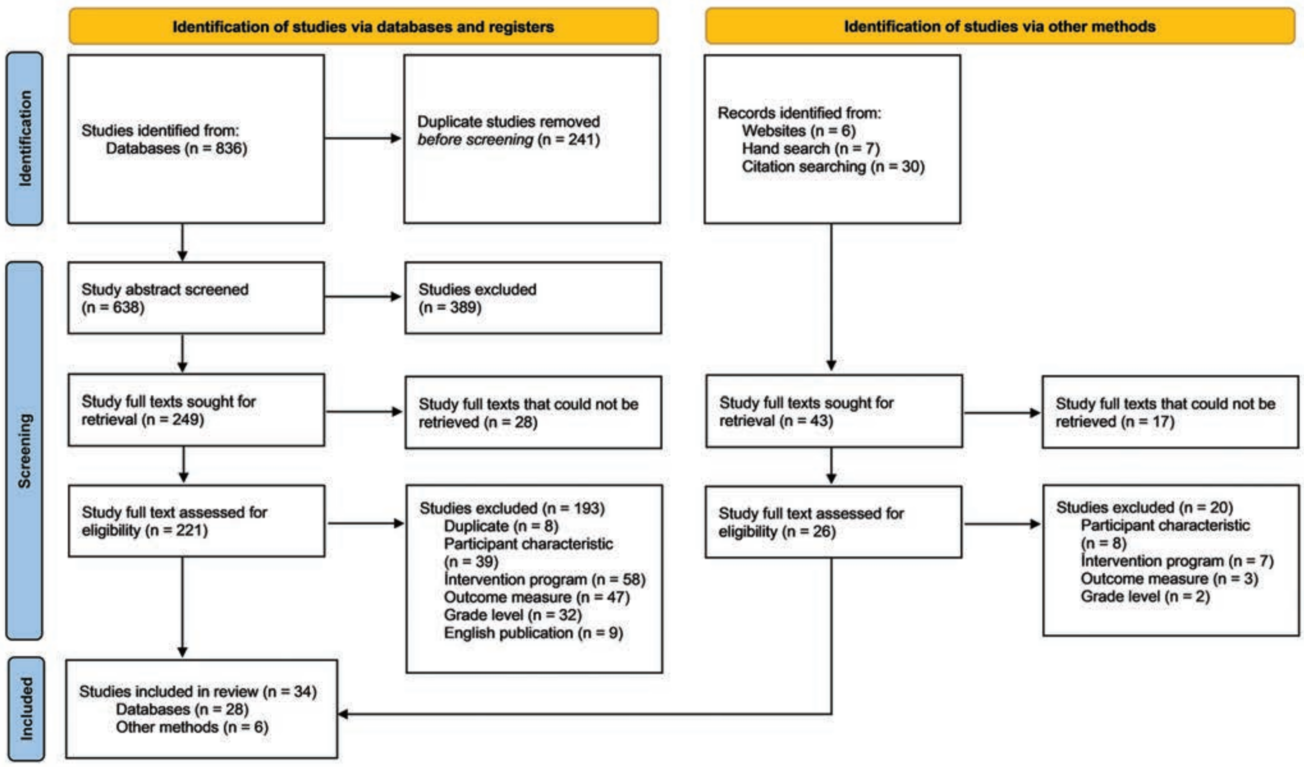

Figure 1. The PRISMA Diagram Summarizing the Search Process (Page et al., 2021)

3. Strategy cues: The intervention description includes statements such as strategy use in teaching, multi-stage procedures, verbal expressions, application of metacognitive strategies, questioning, and thinking aloud by the teacher or researcher.
4. Peer interaction: In the intervention description, there are explanations about the use of peer interaction in implementing and evaluating the instruction.
5. Instructional feedback: In the intervention description, there are explanations stating that participant students were given feedback and correction during the teaching process.
6. Visual aids: The intervention description explains the use of graphs, tables, diagrams, concept maps, visual aids, and representations to support the mathematics teaching process.
7. Foundational skills: The intervention description contains statements regarding the teaching and practice of basic skills such as calculation and fluency to participating students.
8. Schema instruction: In the intervention description, there is a teaching that provides a specific structure or framework to support and organize the learning processes of the participating students. It also includes explanations of the basic schemas used in solving word problems.
9. Instruction to transfer: In the intervention explanation, there is teaching that aims to develop students' ability to use the knowledge and skills they have learned in different contexts, situations, or areas. This teaching transfers the knowledge learned and generalizes it to real life.
10. Manipulatives: In the intervention description are statements about providing students with concrete materials, manipulatives, and other instructional materials during teaching.
11. Behavioral reinforcement: The intervention description contains statements about providing positive consequences or rewards to participating students to encourage or increase desired behaviors. In this type of teaching, praise or reinforcement is provided to participating students.
12. Self-regulated learning: The intervention description includes students' ability to set learning goals, choose learning strategies, monitor their progress, and make assessments.

Coding Reliability

To ensure the reliability of coding, the second author autonomously coded a randomly selected set of 20 articles, constituting 58.82% of the total. Following this, the first author undertook a comparison of the codes to evaluate inter-coder reliability. Inter-coder reliability was determined using the formula: Inter-coder reliability (%) = (Number of agreements)/(Number of agreements + Number of disagreements) × 100. This method for calculating inter-coder reliability aligns with the approach outlined by Miles and Huberman (1994). Inter-coder reliability across all codes was calculated as 92% (78%-100%). All discrepancies between the two coders were resolved by discussion. The final coding is presented in Table 1.

Table 1. Characteristics of studies (n=34)

Study characteristics	*f*	%
Participant characteristic		
MLD	25	73.52
At risk MLD	9	26.47
Identification of difficulty		
Standardized Achievement Test (SAT)	28	73.68
Intelligence Test (IT)	5	13.15
Curriculum Based Assessment (CBA)	2	5.26
Other (RTI, Dyscalculia screener)	3	7.89
Grade		
1	8	13.79
2	13	22.41
3	18	31.03
4	9	15.51
5	10	17.24
Implementers		
Researcher	11	29.72
Classroom Teacher	9	24.32
Specialized Interventionist	8	21.62
Special Education Teacher	5	13.51
Master's or Doctoral Students	2	5.40
Other (Music and Math Teacher)	2	5.40
Setting		
Small-Group (3-7)	17	48.57
Whole Class	12	34.28
Individual	6	17.14
Total sessions		
<10	4	11.11
10-20	15	41.66
21-30	2	5.55
31-50	10	27.77
>50	4	11.11
NR	1	2.77
Total hours		
<10	13	36.11
10-20	11	30.55
21-30	6	16.66
31-50	3	8.33
>50	1	2.77
NR	2	5.55
Mathematical content		
Numbers and Operations	17	36.17
General Skills	16	34.04
Problem Solving	9	19.14
Fractions	4	8.51
Algebra	1	2.12
Geometry	0	0
Measurement	0	0

RESULTS

The findings of these studies are presented under two headings as findings related to methodological characteristics and intervention characteristics. The Appendix presents the detailed characteristics of the studies included in the systematic review.

Within the scope of the first research question, findings related to the methodological characteristics of the studies included in the analysis were included. The results regarding the participant characteristics and the tests used to identify the students were presented in this context.

The studies included in this review were categorized as MLD and at-risk MLD according to participant characteristics and included 25 studies (73.52%) targeted students with MLD. Different methods and strategies were used to identify students with MLD and MLD risk in each of the included studies. This may be because the diagnosis of MLD varies from country to country, and there are no standard diagnostic criteria for MLD. In addition, the fact that each student with MLD exhibits different individual characteristics may also be cited as a reason for this situation.

In the included studies, standardized achievement tests (*f*=28; 73.68%) were commonly used to identify students with MLD and students at risk of MLD. In addition, intelligence tests (*f*=5; 13.15%), curriculum-based assessment (*f*=2; 5.26%), and response to intervention model were used to identify students (See Table 1). While determining the MLD in standardized achievement tests, generally (*f*=22; 57.89%), the cases of scoring below a certain percentile (e.g., 25%, 30%, 35%, 40%) predetermined by the authors (i.e., cut-off score) were taken into consideration (See the Appendix). Again, in standardized achievement tests, students with MLD were identified if they scored below a specific standard deviation (*f*=3) and below the class average (*f*=3), in addition to the cut-off score. On the other hand, there were only four studies (e.g., Nazari et al., 2022; Wu et al., 2020) that used different assessment tools together to identify students with MLD and students at risk of MLD.

Within the scope of the second research question, findings related to the intervention characteristics of the studies included in the analysis were presented. In this context, the findings related to the distribution of the studies included in the analysis according to grade level, instructional intervention, implementer, intervention type, intervention duration, and mathematics learning area were presented.

It can be said that the studies included in the analysis show a close distribution according to the grade level. In the analyzed articles, 3rd-grade students (*f*=18; 31.03%) were mostly preferred as the study group. The least preferred group as the study group was 1st-grade students (*f*=8; 13.79%). This situation may be because basic academic skills such as reading and mathematics begin to be acquired at the first-grade level. In addition, the fact that the first grade is an early grade for identifying students with MLD and MLD risk can be shown as a reason for this situation. When the Appendix is analyzed, in some of the studies included (*f*=11; 32%), students at different grade levels were selected together as the study group (e.g., 3rd and 4th-grade students).

The distribution of the studies included in the analysis according to instructional interventions is presented in Table 2. The included studies were analyzed by considering the instructional components expressed in the coding process.

When Table 2 is analyzed, it can be said that the instructional interventions addressed in the studies differed. In the included studies, strategy instruction (*f*=16; 27.11%) was frequently used. Researchers utilized instructional components such as verbal expressions, metacognitive strategies, and questioning in teaching mathematics to students with MLD and MLD risk. In addition, explicit instruction (*f*=10; 16.94), technology-assisted instruction (*f*=9; 15.25), and visual aids (*f*=8; 13.55) were also used extensively. The least preferred intervention program in the studies was manipulatives. In the studies included in the analysis, programs such as peer-supported instruction, instructional feedback, and behavioral reinforcement were not used at all. In addition, in some of the studies (*f*=19; 55.88%) (e.g., Koponen et al., 2018), more than one intervention program was applied. Instructional interventions such as technology-assisted

Table 2. Distribution of studies according to instructional interventions

	Instructional interventions											
Study	EI	TL	SC	PI	IF	VA	FS	SI	IT	MP	BR	SL
Mononen & Aunio (2014)	x						x					
Hellstrand et al. (2020)		x										
Hatulainen et al. (2016)			x									
Wu et al. (2020)		x	x									
Clarke et al. (2014)	x											
Dennis et al. (2015)	x					x						
Flores (2009)						x						
Miller & Kaffar (2011)			x			x						
Aunio et al. (2021)	x					x						
Ennis & Losinski (2019)			x									x
Lucangeli et al. (2019)		x	x									x
Wang et al. (2019)												x
Mohd Syah et al. (2015)		x										
Zhang & Zhou (2014)		x							x			
Bryant et al. (2014)	x											
Swanson et al. (2013)			x									
Nelson et al. (2013)		x	x									
Käser et al. (2013)		x	x									
Butterworth & Laurillard (2010)		x										
De Nigris et al. (2019)			x				x					
Kaufmann et al. (2003)						x						
Areces et al. (2017)						x						
Lambert & Spinath (2014)	x						x					x
Rodriguez et al. (2019)			x									
Powell et al. (2022)								x	x			
Powell & Driver (2015)	x											
Powell et al. (2020a)	x		x					x				
Powell et al. (2020b)	x		x					x				
Westenskow & Moyer-Packenham (2016)						x				x		
Schumacher et al. (2018)						x						
González-Castro et al. (2016)		x	x					x				
Koponen et al. (2018)	x		x				x					
Nazari et al. (2022)			x				x					
Ziadat (2022)			x									
Total	10	9	16	0	0	8	5	4	2	1	0	4

EI=explicit instruction; TL=technology; SC=strategy cues; PI=peer interactional; IF=instructional feedback; VA=visual aids; FS=foundational skills; SI=schema instruction; IT=instruction to transfer; MP=manipulatives; BR=behavioral reinforcement; SL=self-regulated learning instruction and strategy instruction are the most frequently used interventions together. At the same time, explicit instruction and strategy instruction can also be counted among the interventions used together.

When the distribution of the studies included in the analysis was analyzed (Appendix), instructional interventions were implemented by different people. Instructional intervention programs were frequently applied to students with MLD by researchers (*f*=11; 29.72%). Classroom teachers (*f*=9; 24.32%), specialist interventionists (*f*=8; 21.62%), and special education teachers (*f*=5; 13.51%) were also commonly involved in the implementation of instructional interventions. This finding indicates that specialists are generally involved in the implementation of instructional interventions for students with MLD.

When the studies are analyzed according to the way instructional interventions are applied to students with MLD, the most frequently used application method is small-group teaching (*f*=17; 48.57%). Apart from small-group teaching, there are also studies that consider whole-class teaching (*f*=12; 34.28%). Unlike small group and whole class teaching, individual applications were limited. In the survey conducted by Hellstrand et al. (2020), whole-class and small-group teaching were considered together.

When the studies included in the analysis were analyzed according to the number of sessions, more than half of all studies (*f*=19; 53%) included less than 20 sessions. The number of sessions varies between 4 sessions and 96 sessions. Instructional interventions applied to students with MLD mostly consisted of 10-20 sessions (*f*=15; 41.66%). When the studies included in the analysis were analyzed according to the intervention duration, the intervention durations varied between 2 hours and 96 hours, and the average intervention duration was 16.91 hours. The time of instructional interventions applied to students with MLD was mostly planned to be less than 20 hours (*f*=24; 66.66%).

When the studies included in the analysis are analyzed according to mathematics learning area, it is seen that instructional interventions are shaped by considering different learning areas. Instructional intervention programs frequently focused on numbers and operations (*f*=17; 36.17%) and basic arithmetic skills (*f*=16; 34.04%). In addition, only one study (Bryant et al., 2014) was conducted on the algebra learning domain. There was no study on the geometry learning domain in the analyzed studies.

DISCUSSION

In the articles analyzed according to participant characteristics, it was determined that mostly students with MLD were identified as participants. It was determined that the number of articles targeting students at risk of MLD was low in the analyzed articles. The difference in the methods used to identify students at risk of MLD causes the number of articles to remain limited.

This study revealed that standardized achievement tests generally identify students with MLD (e.g., Ennis & Losinski, 2019; Wang et al., 2019). In addition, students who score below a certain percentile (e.g., 25%, 30%, 35%, and 40%) in standardized achievement tests are commonly identified as students with MLD. In this context, it was observed that different percentiles (such as 11%, 14%, and 16%) were used by researchers in other studies. Similar findings were reported in studies on identifying students with MLD in the literature (Powell et al., 2020; Nelson & Powell, 2018). In the study conducted by Powell et al. (2020), standardized achievement tests were used to identify students with MLD in most studies examined. The study conducted by Nelson & Powell (2018) determined that cut-off scores ranging from 10% to 50% were used to identify students with MLD. There is a difference between the studies on the cut-off scores used to identify students with MLD. In a few studies included in this systematic review (e.g., Käser et al., 2013), researchers defined students below the class average as students with MLD. Since students with below-average achievement in one grade will not be compared with those with below-average achievement in another, identification based on the average may pose a problem (Powell et al., 2020). Likewise, the differences in cut-off scores and tests make it difficult to compare students' mathematics achievement with MLD. In this respect, researchers need to collaborate on the definition of MLD and the identification of students with MLD in terms of comparability of results (Powel et al., 2020; Nelson & Powell, 2018).

This study determined that the articles using different assessment tools together to identify students with MLD (Areces et al., 2017; Nazari et al., 2022) were limited. However, assessments using multiple assessment tools to identify students with MLD provide more accurate results (Nelson & Powell, 2018). This study used a single assessment tool in most of the articles examined. In addition, different assessment methods were used to identify students with MLD and MLD risk in each of the papers read. Because there is no consensus on this issue (Nelson et al., 2022), in experimental studies examining the effectiveness of instructional interventions, it should be kept in mind that students identified with different diagnostic criteria may respond answer to the carbon interventions (Nelson et al., 2022; Nelson & McMaster, 2019). Identifying students with MLD and at risk of MLD using different assessment tools may pose a problem in determining the effectiveness of instructional intervention programs. Therefore, it is essential to report information that will help researchers and practitioners make this decision when deciding which instructional interventions to implement for instruction mathematics to individuals with MLD (Nelson et al., 2022). On the other hand, considering there is no consensus on identifying students with MLD (Nelson & Powell, 2018), researchers need to clearly define the participant group (Nelson et al., 2022). In particular, the methods of identifying students at risk of MLD should be explained in detail.

In the articles, researchers mostly preferred third-grade students as participant students. In addition, it was found that instructional interventions generally focused on a single grade level, and there were a limited number of articles (Rodriguez et al., 2019; Koponen et al., 2018) in which different grade levels were addressed together. Studies have reported that instructional interventions have a more substantial effect on students at early ages and in lower grades, as the content of mathematics subjects will increase and become more complex as the level of instruction increases (Jitendra et al., 2017; Chodura et al., 2015; Gersten et al., 2009). The third grade is seen as a critical year for learning difficulties. Because, at this grade level, the content of mathematics subjects becomes complex (Karabekiroğlu, 2012). In addition, the risk symptoms of math learning difficulties are evident at the third-grade level (Fletcher et al., 2018). Therefore, students in all primary school grade levels should be supported with appropriate instructional interventions, especially in the third grade.

The articles examined determined that strategy instruction was frequently used as an instructional intervention program. Strategy instruction includes instructional components such as verbal expressions, metacognitive strategies, and questioning. In addition, explicit instruction, technology-assisted instruction, and visual aids (graphs, tables, diagrams, concept maps, visual aids, and representations) were also commonly used in instructional intervention programs. Explicit teaching refers to direct teaching directed by the teacher or researcher. In explicit instruction, the teacher guides the learning with various probes. Systematic review studies on instructional intervention programs that effectively improve the mathematics achievement of individuals with MLD have yielded findings similar to those of the present study. For example, Marita and Hord (2017) and Powell et al. (2021) emphasized the importance of explicit instruction for an effective mathematics intervention. In addition, visual aids were found to be necessary for mathematics intervention in different review studies (Powell et al., 2021; Watt et al., 2016).

It was observed that there were articles in which different instructional interventions were used together (e.g., Lucangeli et al., 2019; González-Castro et al., 2016). In this context, it was determined that the most frequently used instructional strategies were technology-supported and strategy instruction. The systematic review studies found that studies focusing on a specific teaching intervention were limited (Nelson et al., 2022). In this context, it was determined that systematic review studies focusing on technology and schema-supported instruction are common (Nelson et al., 2022). Through schema-supported instruction, students can learn the basic schemas used in problem-solving. In a study (Lee et al., 2020) examining the instructional components that are effective in teaching algebra, it was found that visual aids and explicit instruction are more effective when used together than when used separately. However, it is unclear which is more important than the other and how strategies are used together in studies where different instructional intervention programs are used together (Powell et al., 2021). Researchers working on this issue should focus on studies to eliminate such complexity (Powell et al., 2021).

As a result of this systematic review, it was found that researchers, classroom teachers, and expert interventionists were mostly involved in the implementation of instructional interventions for individuals with MLD. Practitioners with knowledge in instruction mathematics to individuals with MLD and students at risk of MLD who know the students best are referred to as expert practitioners. This situation is promising for instruction mathematics to individuals with MLD. Because the implementation of mathematics teaching to students with MLD by an expert team will ensure effective results (Powell et al., 2021). In previous studies, it has been reported that it is necessary to get support from experts to implement instructional interventions for students with MLD. For example, in the systematic review study conducted by Powell et al. (2020), researchers and graduate students were preferred as intervention implementers in approximately 90% of the studies included in the review. Implementation of instructional interventions by researchers may increase implementation reliability but may lead to a lack of information about educators who can implement the intervention other than researchers (Powell et al., 2020).

The reviewed articles utilized small-group teaching to implement instructional interventions for students with MLD. Remarkably, individual instruction was limited. This situation may have been preferred to benefit from the positive effects of students with the same characteristics experiencing the learning process together, or it may be because it is more difficult for practitioners to allocate time for each student individually. Intervention programs that have been effective in the mathematics achievement of students with MLD have generally been conducted as small-group instruction intertwined with whole-class instruction (Powell & Fuchs, 2015).

The articles analyzed determined that the instructional interventions applied to students with MLD were mostly 20 sessions or less. In addition, it was determined that the intervention time of instructional interventions was mostly less than 20 hours. The average intervention time of instructional interventions was calculated as 16.91 hours. More research is needed to determine how much time students with MLD need to learn any mathematics subject (Powell et al., 2021). It is thought that the session and hour information on instructional interventions will help educators plan the education of students with MLD (Powell et al., 2021).

In the articles analyzed, it was observed that instructional interventions mostly focused on numbers and operations learning domain and basic arithmetic skills as a mathematics learning area. It is expected that instructional interventions concentrate on numbers and operations learning area. Because numbers and operations learning area constitute the basis of primary school mathematics teaching, on the other hand, MLD is defined as a mathematical deficiency that occurs in basic arithmetic skills (APA, 2013). Moreover, considering that basic arithmetic skills are prerequisites for other skills (Nelson et al., 2022), it is not surprising that instructional interventions focus on basic skills. At the same time, it is often emphasized in the literature that learning basic mathematical skills positively affects learning later mathematical skills (Nelson et al., 2022; Powell et al., 2021). One of the important skills that students should acquire in primary school is mathematical literacy. Mathematical literacy skills are among the skills that students should acquire in 21st-century skills and curricula. In this context, researchers can examine the instructional interventions developed to support the mathematical literacy skills of students with MLD.

In addition, this study determined a limited number of studies on the algebra learning domain (e.g., Bryant et al., 2014) and no studies on geometry and measurement learning domains. Nelson et al. (2022) conducted a systematic review and found few studies on fractions and algebra learning domains. A similar finding was obtained in the study conducted by Powell et al. (2011), in which mathematics intervention programs for secondary school students with MLD were determined. As mentioned earlier, the study determined that the number of instructional intervention studies that considered geometry and algebra learning domains remained limited. The fact that it is difficult for teachers to teach algebra to students can be cited as a reason for the limited number of studies conducted on this subject (Lee et al., 2020). Since algebra teaching forms the basis for subsequent mathematics subjects, researchers can conduct more studies on the effectiveness of early algebra studies in primary school. In addition, geometry teaching supports students in analytical thinking and problem-solving. Measurement learning area in mathematics plays a fundamental role in daily life. Therefore, strengthening measurement skills can positively affect the daily lives and academic achievement of students with MLD and MLD risk. Researchers can conduct more studies considering geometry and measurement learning domains in this respect.

Limitations and Directions for Future Research

This systematic review study has various limitations. The study's limitations are stated in this section, and suggestions for future researchers are presented.

This study was undertaken to identify the instructional interventions employed to enhance the mathematics performance of primary school students with MLD within the reviewed articles. In line with the results, it was determined that there is a need for more experimental studies. Future researchers can analyze more experimental studies by scanning through different databases. In addition to article studies, thesis, and book chapters can also be included in the analysis. Determining the characteristics of impact interventions for individuals with MLD or MLD risk can support teachers who use these methods in their classrooms. In addition, researchers can conduct meta-analysis studies, including experimental studies, to determine effective instructional intervention programs in mathematics teaching.

In this study, it was decisive that different diagnostic vehicles were used to identify students with MLD. The articles reviewed shared limited information on how students were identified with these diagnostic tools. To interpret the study results correctly, it is necessary to clearly state how students with MLD are identified. In this sense, the process of identifying students with MLD can be expressed in detail by researchers who will work on this subject.

The use of different identification methods by each researcher in identifying students with MLD negatively affects the comparability of the results. In addition, it becomes difficult to accurately identify students in evaluations using different methods (Nelson & Powell, 2018). In this context, standardized identification methods agreed upon by researchers can be developed to identify students with MLD.

Instructional intervention programs Implemented to enhance the mathematical performance of individuals with MLD have focused on number instruction as mathematics content, and studies on geometry, algebra, and measurement instruction have been limited. In line with this result, future researchers can conduct systematic review studies focusing on instructional interventions used in elementary school geometry and measurement instruction.

Educators and researchers must know the topics students with MLD have difficulty with to provide accurate and effective intervention programs (Nelson & Powell, 2018). Future researchers can conduct experimental studies to determine the difficulties students with MLD have in which learning domain.

Implications for Practice

Previous studies have shown that explicit instruction, technology-assisted instruction, and visual aids are used when students with MLD have learning difficulties in mathematics. Previous studies have found that these strategies positively affect student learning (Gersten et al., 2009). Policymakers, researchers, and administrators can organize professional development programs for teachers about instructional intervention programs that are effective in instruction mathematics to individuals with MLD.

CONCLUSION

Our results showed that the analyzed articles predominantly focused on students MLD. In these articles, the researchers used standard achievement tests to identify students with MLD. It was concluded that different percentiles were used in standard achievement tests. In addition, it was concluded that the researchers used different assessment criteria to identify students with MLD and a single assessment method was used instead of multiple assessments.

The findings indicate that third-grade students were preferred as participant students, and strategy instruction was frequently used as an intervention program in the articles examined. In addition, it was found that explicit instruction, technology-supported instruction, and visual aids were among the commonly used instructional interventions.

As our research findings indicated, the instructional interventions applied to students with MLD were mostly applied by expert practitioners (e.g., researcher, expert interventionist, classroom teacher), and the application was carried out in the form of small group teaching rather than individual teaching. The average number of sessions of instructional interventions was 28.75, and the average intervention duration was 16.91.

Finally, the review of the related literature indicated that instructional interventions mostly focused on the learning domain of numbers and operations and basic arithmetic skills as the mathematics learning area. In addition, it was determined that there were limited studies on algebra and geometry learning domains.

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Note: The asterisks (*) show the studies included in the analysis.

APPENDIX

Appendix. Literature matrix

Study	Participant characteristic	Identification of difficulty	Grade	Instructioanal interventions	Implementers	Setting	Total sessions	Total hours	Math content	Group
Mononen & Aunio (2014)	At risk MLD	<25th percentile on AMS-2	2	T1: Explicit instruction (EI)	Classroom teacher	Small-group	12	9	T1: Counting skills and conceptual place value knowledge	T1: 11 CON1:13 CON2: 64
Hellstrand et al. (2020)	At risk MLD	<20th percentile on Mathematical test	1	T1: Computer-assisted interventions (CAI)	Classroom or special education teachers	Whole class and small-groups	16	6	T1: Number knowledge and basic skills in arithmetic	T1: 29 CON1: 27 CON2: 278
Hatulainen et al. (2016)	At risk MLD	<(−1 SD) on AMS-1	1	T1: Cognitive based interventions (CBI)	Special education teachers	Small-group	12	9	T1: Mathematical skills	T1: 18 CON1: 18 CON2: 122
Wu et al. (2020)	MLD	>80 on Intelligence quotient (IQ) and Raven matrices; <20% on average mathematics score	2-5	T1: Computerized cognitive remediation therapy (CCRT)	Researcher	Individual	40	20	T1: Number learning and graphical reasoning	T1: 35 CON: 35
Clarke et al. (2014)	At risk MLD	RTI		T1: Tier II; explicit and systematic instructional design	Classroom teacher	Small-group	60	30	T1: Number and operations; number sense	T1: 44 CON: 45
Dennis et al. (2015)	MLD	<25th percentile on AIMSWeb	2	T1: Tier II; explicit and systematic teaching	Classroom teachers	Small-group	50	25	T1:Addition and subtraction; place value, numerical order and quantity comparison	T1: 8 CON: 8
Flores (2009)	At risk MLD	Curriculum-based assessment	3	T1: CRA	Researcher	Small-group	12	6	T1: Subtraction	T1: 6
Miller & Kaffar (2011)	MLD	IDEA and Minnesota criteria; Kaufman test of educational achievement	2	T1: CRA; strategy instruction	Classroom teacher	Individual	16	16	T1: Addition (counting and fluency)	T1: 10 CON: 10
Aunio et al. (2021)	At risk MLD	<30th percentile on early numeracy test	1	T1: Explicit instruction; CRA	Special education teachers	Whole class	15	12	T1: Early arithmetic skills	T1: 40 CON1: 32 CON2: 195
Ennis & Losinski (2019)	MLD	<25th percentile on STAR Math; <50% on SRSS-IE	5	T1: Self-regulated strategy development (SRSD)	Researcher	Small-group	14	5	T1: Add/Subtract Fractions	T1: 8
Lucangeli et al. (2019)	MLD	<(-1 or -2 SD) on standardized mathematics tests (AC-MT 6–11)	2-5	T1: CAI; Self-regulatory training	Specialist psychologist	Whole class	16	16	T1: Calculation and problem-solving skills	T1: 34 CON: 34
Wang et al. (2019)	MLD	T1: <25th percentile on [WRAT]-4 T2: <31nd percentile on [WRAT]-4	3	T1: Base condition T2: Embedding Self-Regulation Instruction (Tier II)	Classroom teacher	Whole class	35	21	T1: Fractions	T1: 24 T2: 23 CON: 26

(Contd...)

Appendix. *(Continued)*

Study	Participant characteristic	Identification of difficulty	Grade	Instructioanal interventions	Implementers	Setting	Total sessions	Total hours	Math content	Group
Mohd Syah et al. (2015)	MLD	<35th percentile on standardized mathematics tests	1	T1: CAI (computer play)	Classroom teacher	Individual	5	5	T1: Addition; subtraction; counting	T1: 25 CON: 25
Zhang & Zhou (2014)	MLD	<35th percentile on midterm examination scores	5	T1: Web-based learning system	Researcher	Individual	6	2	T1: Memory, understanding, application, composite, and thinking	T1: 72 CON: 70
Bryant et al. (2014)	MLD	<25th percentile on KeyMath–3	2	T1: Tier III intervention (systematic; explicit)	Experienced mathematics interventionist	Small-group	50	25	T1: numbers and operations; algebraic thinking	T1: 12
Swanson et al. (2013)	MLD	<25th percentile on TOMA	2-3	T1: Strategy training; working memory	Doctoral students; certified teachers	Whole class	40	20	T1: Word problem solving	T1: 42 CON: 100
Nelson et al. (2013)	MLD	<25th percentile on standardized mathematics assessment	3-4	T1: Computer-delivered practice-based intervention T2: Mnemonic strategy intervention	Expertise in elementary math intervention	Whole class	4	2	T1: Multiplication	T1: 30 T2: 30 CON: 30
Käser et al. (2013)	MLD	Below-average performance in the standardized arithmetic test HRT	2-5	T1: Computer-based training system	Researcher	Whole class	30	10	T1: Addition; subtraction; counting	T1: 33 CON: 30
Butterworth & Laurillard (2010)	MLD	Dyscalculia Screener	3	T1: Digital games (CAI)	Specialist teacher	Small-group	NR	NR	T1: Counting	T1: 8
De Nigris et al. (2019)	At risk MLD	Assessment of Computing Skills AC-MT 1-5	2	T1: Cognitive treatment	Classroom teacher and therapist	Individual	96	96	T1: Numbers and operations	T1: 1
Kaufmann et al. (2003)	MLD	Below-average performance on a mathematic achievement test	3	T1: Numeracy intervention program; CRA	Researcher	Small-group	72	18	T1: Basic arithmetic skills	T1: 6 CON: 18
Areces et al. (2017)	MLD	DAM; average intelligence on WISC-IV; DISC-IV	1-5	T1: Integrated Dynamic Representation (IDR)	Researcher	Whole class	12	NR	T1: Basic arithmetic skills; problem solving	T1: 40 CON: 40
Lambert & Spinath (2014)	MLD	<16th percentile on standardized mathematics achievement test	2-5	T1: Self-instruction; direct instruction	Trained psychologists or educators	Whole class	48	40	T1: Basic arithmetic skills; problem solving	T1: 26 CON: 20

(Contd...)

Appendix. *(Continued)*

Study	Participant characteristic	Identification of difficulty	Grade	Instructioanal interventions	Implementers	Setting	Total sessions	Total hours	Math content	Group
Rodriguez et al. (2019)	At risk MLD	<9th or < 14th Arithmetic Test	3-4	T1: NMT; Cognitive strategy instruction	Music teacher	Small-group	16	11	T1: Numerical cognition; working memory	T1: 21 CON: 21
Powell et al. (2022)	MLD	<25th percentile on SDWP and TWPB	3	T1: Word-problem intervention	Researcher	Small-group	39	20	T1: Word problem solving	T1: 56 CON: 20
Powell & Driver (2015)	MLD	<11th percentile on Assessment of Addition Fluency	1	T1: Addition + vocabulary tutoring T2: Addition tutoring	Classroom teacher	Whole class	T1: 15 T2: 15	T1: 4 T2: 4	T1: Addition; Subtraction	T1: 35 T2: 35 CON: 28
Powell et al. (2020a)	MLD	<25th percentile on SDWP	3	T1: Meta-cognitive strategies and explicit instruction	Experienced mathematics interventionist	Small-group	45	23	T1: Word problem solving	T1: 51 CON: 60
Powell et al. (2020b)	MLD	<25th percentile on SDWP	3	T1: PMEQ T2: PM-alone	Experienced mathematics interventionist	Small-group	48	24	T1: Word problem solving	T1: 40 T2: 45 CON: 53
Westenskow & Moyer-Packenham (2016)	At risk MLD	<40% on Equivalent Fractions Test	5	T1: Physical and virtual manipulative	Researcher	Small-group	10	8	T1: Fractions	T1: 43
Schumacher et al. (2018)	MLD	<35. percentile on TUF-4	5	T1: TransMath fraction intervention T2: Traditional learning program	Mathematics Teacher	Small-group	76	45	T1: Fractions	T1: 4 T2: 5 CON: 5
González-Castro et al. (2016)	MLD	Curriculum-based assessment	1-3	T1: IDR computer program	Expert educator	Whole class	45	38	T1: Word problem solving	T1: 15 CON: 15
Koponen et al. (2018)	MLD	<20th percentile on Calculation Fluency Measures	2-4	T1: Multi-Component Strategy Training	Special education teacher	Small-group	24	18	T1: Counting skills; calculation fluency	T1: 69 CON: 69
Nazari et al. (2022)	MLD	<(−1 SD) on IRAN Key-Math Test; WISC-IV	3-4	T1: Process-based executive function intervention	Researcher	Whole class	17	9	T1: factual and procedural arithmetic knowledge	T1: 15 CON: 15
Ziadat (2022)	MLD	Diagnosed with mathematical difficulties	3	T1: Sketchnote + working memory T2: Sketchnote	Researcher	Individual	T1: 4 T2: 20	T1:2 T2:10	T1-T2: Word problem solving	T1: 20 T2: 20 CON: 20

AMS = Assessment of Mathematics Skill; RTI = Response to Intervention; CRA = Concrete Representational-Abstract; EI = Explicit Instruction; SRSS-IE = Student Risk Screening Scale–Internalizing/Externalizing; WRAT = Wide Range Achievement Test; ToMA = Test of Math Abilities; DAM = Dyscalculia and Mathematics Difficulty; DISC = Diagnostic Interview Schedule for Children; NMT = Numeracy Musical Training; SDWP = Single-Digit Word Problems; TWPB = Texas Word Problems-Brief; PM = Physical Manipulatives; VM = Virtual Manipulatives; TUF = Test for Understanding of Fractions; IDR = Integrated dynamic representation; T = Treatment; CON = Control; MLD = Math Learning Difficulties; NR = Not Reported; SD = Standard Deviation; PMEQ = Pirate Math Equation Quest; PM-alone = Pirate Math without Equation Quest