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A Bibliometric and Systematic Review of the Studies on the Mathematics Learning Disabilities (Dyscalculia)

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Abstract: This study aimed to bring studies in the field of dyscalculia to the literature as a single study. In addition, it was also aimed to provide researchers with the opportunity to access many studies at the same time. In this research, a systematic and bibliometric review was preferred to present many studies in a single study. A total of 147 studies were obtained from the Web of Science database. Out of 147 studies, 46 studies without method section were excluded and 101 studies were analysed. The studies were analysed with the help of the Excell and VosViwer programs. It was observed that most of the studies were carried out in 2016 and 2018. It was seen that ANOVA (SPSS) was mostly preferred among the data analysis methods. It was revealed that the most preferred method in the studies was experimental research, while the least preferred method was action research, correlational research and case study. When the articles were analysed according to data collection tools, it was observed that there was not only a single tool in general and data were obtained using multiple tools together. The age of the individuals included in the research was found to be between 8 and 10 years old and between 60 and 90 individuals. It was found that at least 1 and at most 183 of the individuals included in the study were diagnosed as having dyscalculia risk. When the published articles on dyscalculia were examined according to dyscalculia diagnosis and intervention methods, it was seen that the standardized mathematics achievement test was used the most, and mAMAS, MaLT and HGRT joint analysis, Raven's Standard Progressive Matrices Test and individual ability test were used the least. According to the bibliographic data, the relationship between the collaboration between authors and bibliographies of the studies on dyscalculia was examined. As a result of this examination, it was seen that the first three authors who collaborated the most are Geary and Hoard. In addition, it was revealed that the three largest articles with the highest number of citations and bibliographical relationship and the largest network were Mazzocco (2011), Landerl (2009) and Wilson (2015).

Keywords: *Dyscalculia, Learning Disability, Math Learning Disabilities, Systematic Review, Bibliometric Review*

1. INTRODUCTION

Mathematics has emerged and evolved as a result of human needs, becoming a fundamental tool in many fields. Throughout this process, it has laid the groundwork for various sciences and serves as a core instrument across numerous domains. Currently, mathematics teachers teach and explain mathematics to all individuals to improve their quality of life, highlighting its significant role in daily life. Moreover, mathematics is essential not only in daily activities

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but also in numerous professional, academic, and scientific areas (Olkun et al., 2015). However, despite recognizing the importance of mathematics, some individuals struggle to learn and apply it effectively.

Educational plans are made to facilitate the process of learning mathematics for individuals and are taught gradually with this plan. The Ministry of National Education [MoNE] (2019) (highlighted specific goals in the mathematics curriculum, such as enabling individuals to express problem-solving steps, engage in logical reasoning, and identify relationships between objects and people as well as among objects themselves. From K-12 grade, students learn how numbers represent objects and how they relate to each other, how number structures and systems are concealed, and how numbers and operations can be used to solve problems (National Council of Teachers of Mathematics, 2000, p. 32). However, in this process, some students do not perform at the same level as their peers and exhibit below-average learning performance. These students face difficulties in acquiring arithmetic skills. There are many reasons why some individuals cannot learn mathematics or acquire arithmetic skills.

These reasons may include insufficient education, intellectual disabilities, socio-cultural differences, emotional disorders, sensory impairments, or a condition known as dyscalculia, which is a specific learning difficulty in mathematics (Mutlu & Akgün, 2017). The International Classification of Diseases was defined dyscalculia as a discrepancy between an individual's level of intelligence and their mathematical performance that cannot be explained by low social environment, intellectual disability, or inadequate education (World Health Organization, 1992). The American Psychiatric Association’s Diagnostic and Statistical Manual of Mental Disorders (DSM-5) defines dyscalculia as a learning disorder characterized by difficulties in performing accurate and rapid calculations and in learning basic arithmetic operations. In Türkiye, dyscalculia is referred to as “arithmetic difficulty,” “mathematics learning difficulty,” or “mathematics learning disorder” (Bintaş, 2007; Köroğlu, 2018; Mutlu, 2016; Sezer & Akın, 2011; Soylu, 2020).

Research conducted to determine the prevalence of dyscalculia in school-aged children shows a range between 3% and 7% (Mutlu, 2020). This indicates that the incidence of dyscalculia is more widespread than previously estimated or known. Therefore, raising awareness about dyscalculia, its diagnosis, and particularly early diagnosis for early intervention, is critical (Shalev, Manor & Gross-Tsur, 2005). This study aims to reveal the trends in research on dyscalculia, identify the types of studies needed, and contribute to increasing awareness. Thus, this research is expected to contribute to the literature in this field.

Upon reviewing previous literature on dyscalculia (Butterworth, 2003; Filiz, 2023; Gersten et al., 2009; Jitendra & Xin, 1997; Lafay, Osana & Valat, 2019; Miller, Butler & Lee, 1998; Monei & Pedro, 2016; Powell, 2011), it is observed that most of these studies focused primarily on experimental research (Butterworth, 2003; Filiz, 2023; Gersten et al., 2009; Jitendra & Xin, 1997; Lafay, Osana & Valat 2019; Miller, Butler & Lee, 1998; Monei & Pedro, 2016). One reason for this focus is the analysis of the effectiveness of intervention methods applied to individuals with dyscalculia (Filiz, 2023; Monei & Pedro, 2016). When examining the time limitations in these studies, it is observed that the majority of the publications were restricted by the year they were included (Filiz, 2023; Monei & Pedro, 2016; Miller, Butler & Lee, 1998; Butterworth, 2003). Furthermore, similar to this study, some reviews on dyscalculia utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method (Filiz, 2023; Lafay, Osana & Valat, 2019). In addition, some reviews only included studies published in English (Butterworth, 2003; Filiz, 2023).

In recent years, there has been an increase in research on dyscalculia. However, systematic reviews and bibliometric studies remain scarce. This study systematically reviews and presents a bibliometric analysis of the studies in the field of dyscalculia. Additionally, it aims to guide researchers in determining the number and age of participants in future studies, identifying the tools for diagnosing and intervening with individuals at risk of dyscalculia and consolidating the findings of various studies into a single contribution to the literature. In line with these objectives, the following research questions were explored:

1. What is the distribution of the articles included in the study in terms of their publication years, data analysis methods, research methods and designs, and data collection tools?

2. What is the distribution of the articles included in the study in terms of participant age, participant number, the number of individuals with dyscalculia, and the methods used for diagnosing and intervening in dyscalculia?

3. What are the collaboration relationships among the authors of the articles included in the study, and what are the relationships among their references?

4. What are the commonalities in the findings of the articles included in the study?

2. METHODOLOGY

2.1. Research Method

This study aims to guide researchers by compiling the studies related to dyscalculia from the Web of Science database. Therefore, the systematic review approach, which is used to examine and synthesize all the studies published in a specific field according to predetermined criteria, was adopted for this review study (Davis et al., 2014; Snyder, 2019). This systematic review was conducted based on PRISMA guidelines. PRISMA is a checklist-based flow diagram that provides information on how to conduct a systematic review (Liberati et al., 2009).

The Cochrane Collaboration, an organization that synthesizes medical research findings, defines systematic reviews as comprehensive overviews of primary research that aim to answer a specific research question by identifying, selecting, synthesizing, and evaluating high-quality relevant research studies based on predetermined criteria (Uslu, 2023). Additionally, systematic reviews compile all relevant results related to a specific research question based on the preselected criteria (Harris et al., 2014). A thorough literature review on a particular subject advances knowledge and provides a strong foundation for future research on the topic. This method identifies existing research as well as areas that require further investigation (Barn, Barat & Clark, 2017).

Systematic review studies are prepared in seven stages:

1. Defining the research question,
2. Conducting a search using specific keywords,
3. Evaluating and analyzing the quality of the evidence,
4. Presenting and summarizing the evidence,
5. Discussing the evidence,
6. Writing the systematic review,
7. Subjecting the review to external peer review and publication (Centre for Reviews and Dissemination [CRD], 2008; Grimshaw et al., 2003; Hemingway & Brereton, 2009; Higgins & Green, 2011; Support Unit for Research Evidence [SURE] & Cardiff University, 2010; The Cochrane Public Health Group, 2011; cited in Karaçam, 2013).

In addition to the systematic review, a bibliometric analysis was also conducted in this study. Bibliometric analysis is widely used to reveal relationships between scientific studies. This method enables data visualization using bibliometric mapping techniques. The rationale for the combined use of systematic review and bibliometric analysis is to present data with statistically measurable outcomes through systematic review while uncovering relationships between authors and studies through bibliometric analysis. Today, many software programs such as CiteSpace II (Chen, 2006), Network Workbench (NWB) Tool (Börner et al., 2010), and VOSviewer (van Eck & Waltman, 2010) are used for bibliometric mapping. In this study, the VOSviewer (www.vosviewer.com) software program was used.

VOSviewer is an open-access program used to create large bibliometric maps. It can visualize maps based on citations and common data to represent keywords in studies (van Eck & Waltman, 2010).

Web of Science is one of the most comprehensive databases. It is widely used by researchers to conduct research and examine topics related to their fields (Xu et al., 2022; Yan & Liu, 2021). Therefore, the studies to be mapped using VOSviewer in this study were accessed through the Web of Science (WoS) database.

2.2. Data Sources of the Study

The data in this study were obtained from articles published in various journals on "mathematics learning disability (dyscalculia)" in the Web of Science database between January 1, 2003, and August 30, 2024, using the keywords “dyscalculia” and “mathematics learning disability.”

Additionally, searches were conducted using the keywords "dyscalculia" and "math learning disability" in the Web of Science database. A total of 1477 studies were identified, and those related to mathematics, education, and mathematics education were included. These studies were used in both the systematic review and the bibliometric analysis.

2.3. Procedure

The inclusion criteria were determined by considering the PRISMA method during the systematic review process. The PRISMA method assists authors in conducting a well-structured systematic review by providing a minimum set of items to be included in line with the objectives of the study.

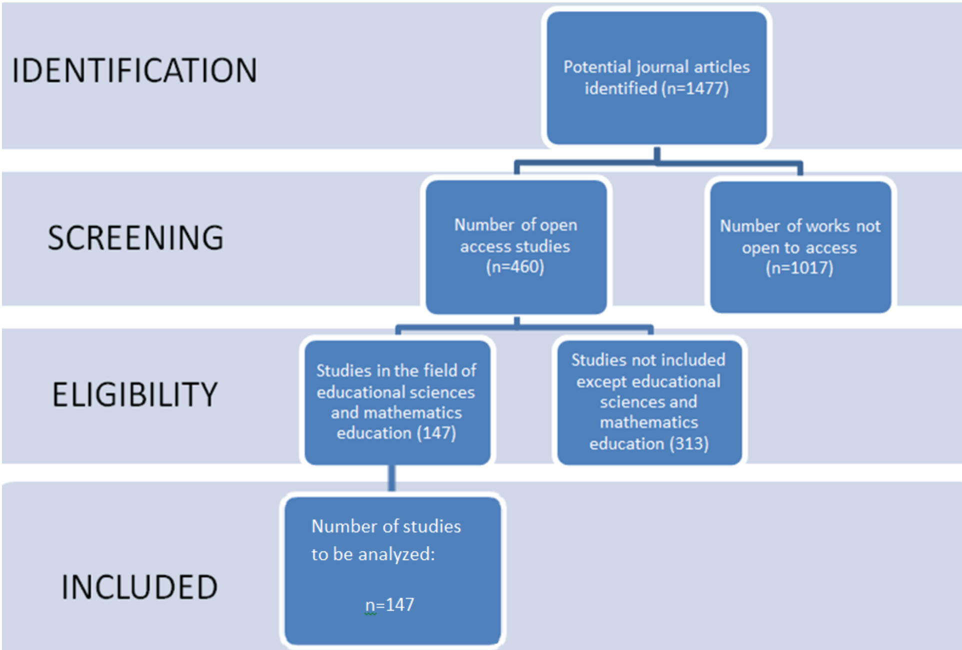


Figure 1. *Stages of Study Inclusion Using the PRISMA Method*

In the bibliometric analysis, the classification of the results was based on keywords. By imposing restrictions, the common citation network, the relationship between authors, and the number of articles were determined from the dataset. Data were collected using an “Advanced Search” in the WoS database. The search was conducted with the code (TS=("dyscalculia" OR "math learning disability")), where “OR” was used to retrieve all results for either keyword. This allowed for a broader scope.

The stages of data collection in the bibliometric analysis are as follows:

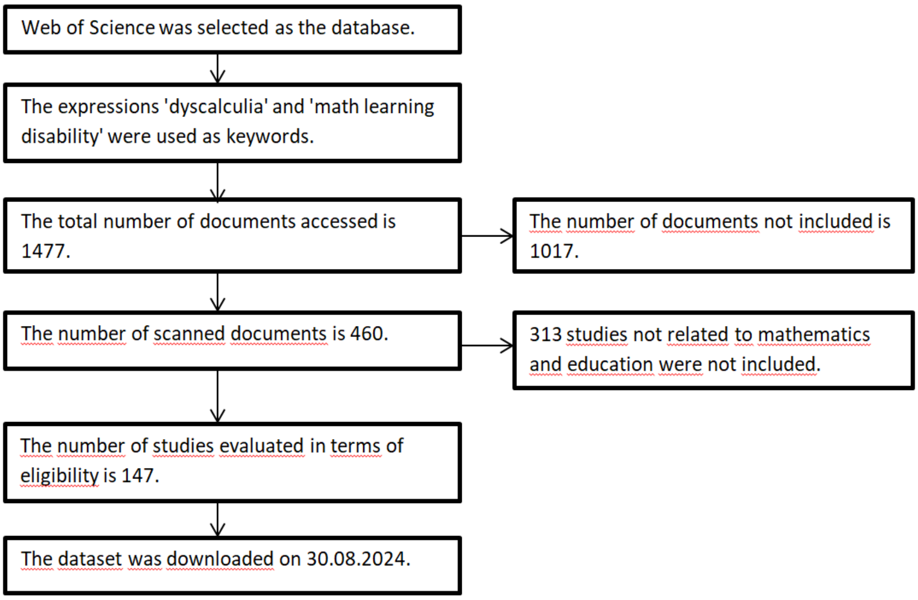


Figure 2. *Stages of Data Collection for Bibliometric Analysis*

2.4. Data Analysis

There are two main methods used in bibliometric studies: the first is performance analysis, which aims to assess the citation impact of various variables in scientific research, and the second is science mapping, which aims to reveal the conceptual and social structure of scientific research (Gutiérrez-Salcedo et al., 2017). Depending on the purpose of the research, either one or both of these methods can be used in bibliometric studies (Öztürk, 2021).

In this study, the distribution of the articles was analyzed by the authors. The citation analysis was conducted on the collected data. For this purpose, VOSviewer software was used to generate citation (publication, author, source, country) and co-citation (reference, author) network maps.

In VOSviewer, maps are created based on networks and visualized, and the findings from these maps can be explored (van Eck & Waltman, 2010). In VOSviewer, the analysis results are presented in three visualization modes: Layered Visualization, Network Visualization, and Density Visualization. Network Visualization represents collaboration or relationship networks; Layered Visualization groups elements according to specific criteria, and Density Visualization shows the frequency density of elements (Çevik, 2021).

In VOSviewer, each connection between two elements has a strength represented by positive numbers. There are no multiple connections between the two elements, and it indicates the relationship between analysis units. Maps based on network data contain only elements representing a specific term (e.g., countries, keywords, etc.). Elements are grouped into clusters. Elements with close relationships are represented in the same colour and are located closer to each other (Çevik, 2021; van Eck & Waltman, 2010).

During the systematic review analysis, data from Excel files were used to organize the desired features for review, with headings created for each study, and listed accordingly. Studies were coded (e.g., A1, A2, etc.) and compiled into a list.

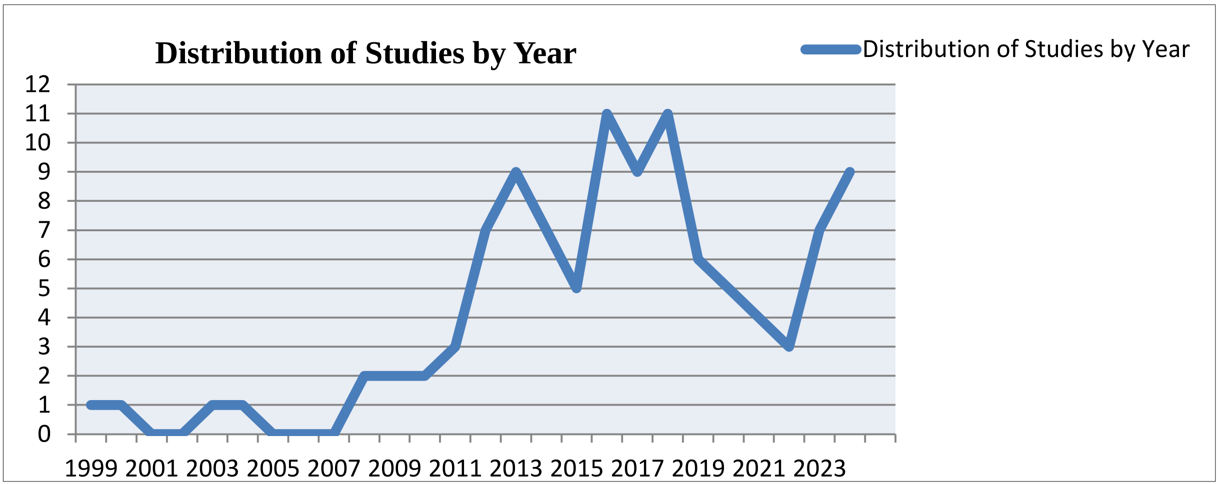
3. FINDINGS

In this section, the findings related to the research questions are presented, combining the data obtained from the systematic review and bibliometric analysis.

In the review, 46 studies that met the inclusion criteria but lacked a methods section were identified. Since these studies did not include information on research methods, data analysis methods, data collection tools, participant numbers, the number of dyscalculic individuals, participant ages, or diagnostic methods, only the distribution by publication year was considered. For all other questions, the remaining 101 studies were analyzed.

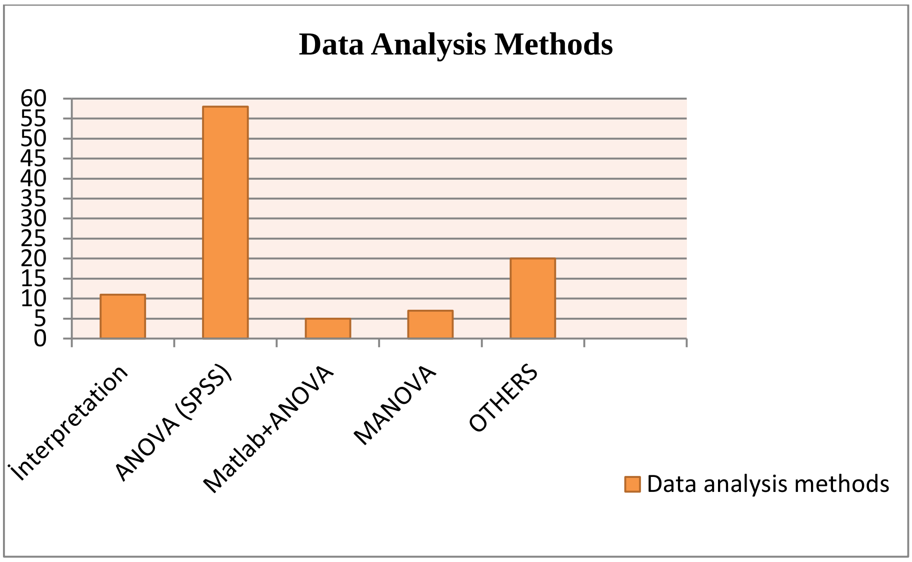
Each study was examined according to the research questions, and the findings are presented in tables. The distribution of studies by publication year is shown in Table 1.

Table 1. *Distribution of Included Studies by Publication Year*



Based on the inclusion criteria, the publication years of the selected studies show that the majority of studies were conducted in 2016 and 2018, with no studies published in 2001, 2002, 2005, 2006, and 2007. According to the table, 30.7% of the studies were conducted in 2016 and 2018. The data indicate an increase in studies over time compared to earlier years.

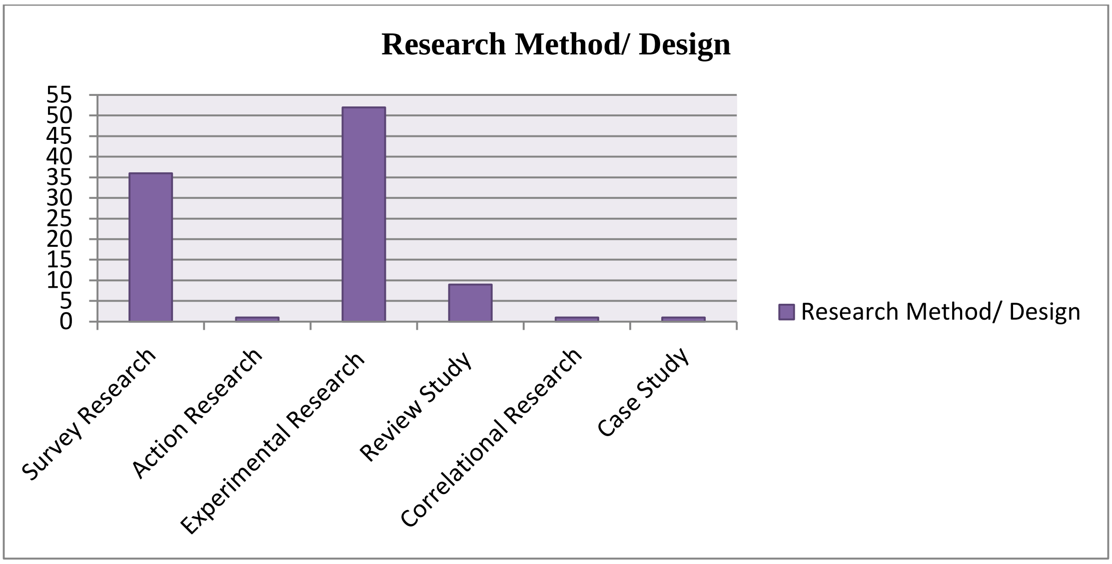
Table 2. *Distribution of Included Studies by Data Analysis Methods*



When examining the data analysis methods used, it is observed that most studies favoured ANOVA (SPSS) for analysis. A total of 58 studies used ANOVA, 11 used the author's interpretation for analysis, 7 employed MANOVA, and 5 used both Matlab and ANOVA. In addition to ANOVA, author's interpretation, MANOVA, and Matlab + ANOVA, other methods were also used. These studies were categorized as "Other" in the analysis. There are 20 studies classified as "Other," and the methods used in these studies include:

- Multivariate analysis method
- Comprehensive Meta-Analysis (CMA) statistical program
- modGraph
- Hyper RESEARCH
- Offline coding
- BrainVoyager
- RE-AIM
- E-prime
- ROC analyses

Table 3. *Distribution of Included Studies by Research Methods and Designs*



When examining the research methods and designs preferred by researchers, it is observed that the most frequently used method is experimental research, found in 52 studies. In addition, there is one study each conducted using action research, correlational, and case study designs.

This indicates that researchers mostly preferred experimental research when working with individuals with dyscalculia. The reason for this could be the ongoing need for improvement and development in diagnosing and defining dyscalculia, as well as the lack of definitive data on the subject.

When examining the distribution of data collection tools used in the studies, it is observed that different tools were often used, with multiple tools employed simultaneously. The data collection tools used in the studies is as follows:

Table 4. *Distribution of Included Studies by Data Collection Tools*

Article Code	Data Collection Tool
A1	Arithmetic test
A2	NUCALC battery
A3	Basic number screening test + Student interview
A4	Eric, Academic Search Complete, Psych Info, Education Search Complete, Psychological and Behavioral Sciences (Review Study)
A5	Video recording (interview)
A6	Number sense test + Arithmetic test
A7	Computer-assisted screening test
A8	AMANS self-report survey + Mathematics Assessment for Learning and Teaching tests + The Hodder Group Reading Tests II
A9	AC-MT Test for the evaluation of calculus disorders + Wechsler III for IQ evaluation
A10	Diagnosis, measurement and achievement test
A11	Raven’s Standard Progressive Matrices test + Color Stroop task
A12	Working memory test

A13	Mathematics Assessment for Learning and Teaching tests + Hodder Group Reading Test II
A14	Dialnet, ERIC, Google Scholar, Revista de Neurología and PsycINFO, PubMed (Review study)
A15	Interview, observation, and document analysis
A16	CORSI-Block Tapping test + ZAREKI-R test
A17	The Wechsler Individual Achievement Test + The wechsler Abbreviated Scale of Intelligence (WASI)
A18	The Woodcock-Johnson–III TEST + Corsi block-tapping test
A19	The Mathematics Assessment for Learning and Teaching test (standardized math test) + the Hodder Group Reading Test II (standardized reading test) + the Wechsler Intelligence Scale (IQ) + Parent’s Daily Skills Report (Likert scale)
A20	Computer-assisted dot-number tests
A21	Westermann spelling test + Kaufman Assessment Battery for Children
A22	Symbolic comparison test + IQ test + mathematics achievement test
A23	Mathematics fluency, calculation, reading fluency, verbal working memory, visual-spatial WMan, and full-scale IQ composite scores tests
A24	Word reading subtest + reading comprehension subtest + Wechsler Achievement Test
A25	WJ-R Calculation subtest (Woodcock & Johnson, 1990) + the Wechsler Abbreviated Scale of Intelligence (IQ)
A26	Arithmetic Subtest
A27	Working Memory Test + Wechsler Kısaltılmış Zeka Ölçeği the Working Memory Test Battery for Children + Pair Cancellation test from Woodcock-Johnson III + Rapid Letter Naming subtest of the Comprehensive Test of Phonological Processing
A28	Symbolic Magnitude Comparison Test + Flemish Student Monitoring System + Mathematics/Reading Achievement Tests
A29	ERIC ve EBSCOhost (Review Study)
A30	Visual Numerical Discrimination Tasks + Raven’s Matrices
A31	Dyscalculia screener
A32	Wechsler Individual Achievement Test + Word Reading Test + Reading Comprehension Test
A33	Writing, Arithmetic, and Reading Skills Test + Mathematics Anxiety Scale + Raven's Colored Progressive Matrices + Zareki-R (for Numerical Cognition) + Brazilian Institute of Market Research Scale + Wisconsin Card Sorting Test – WCST
A34	Symbolic Numerical Magnitude Comparison + IQ Test
A35	Mathematics Achievement Test + Cattell Culture Fair Intelligence Test + Standardized Reading Test
A36	Raven’s Standard Progressive Matrices + Standard Arithmetic Test + Standard Reading Test
A37	Academic Search Complete, Educational Resources Information Center (ERIC), Science Direct, Springer Link, Taylor & Francis Online, Scopus, ULAKBIM National Databases (UVT), Web of Science, Sage Journals, Wiley Online Library Full Collection, and Google Scholar Databases (Review Study)
A38	Standardized Mathematics Test + Reading Test + IQ
A39	MathEduc Database (Review Study)
A40	Standardized Mathematics Achievement Test – Math Up to 10
A41	PsycINFO, Google Scholar, and Educational Resources Information Center (ERIC) (Review Study)
A42	Subtests of Wechsler Individual Achievement + Word Reading Subtests + Spelling Subtest + Numerical Operations Subtest + Normal Behavior Scale + Memory Test

A43	Web of Science (Review Study)
A44	Vocabulary Subtest of Woodcock-Johnson IV Achievement Test + Sight Word Efficiency Subtest + Anxiety Scale + Attention Test + Arithmetic Test
A45	Survey
A46	The Pictorial Test
A47	Arithmetic Subtest
A48	Parent’s Opinion + Observer’s Opinion
A49	Raven's Colored Progressive Matrices + Wechsler Individual Achievement Test
A50	Wechsler Intelligence Scale for Children – Third Edition (WISC-III) + Arithmetic Number Fact Test + Dutch Standardized Reading Test
A51	Arithmetic test
A52	Series Completion Classification, Matrices, and Topologies Test
A53	Conners’ Parent Rating Scale + Word Reading Efficiency Test + Woodcock-Johnson III Reading Fluency Test + Peabody Individual Achievement Test – Reading Comprehension Subtest + GOAL Formative Literacy Assessment Test + WISC-III-PI Multiple Choice Knowledge + Vocabulary Multiple Choice Subtests + Non-verbal Tests, WISC-III-UK Picture Completion Test + Raven’s Standard + Advanced Progressive Matrices
A54	Raven's Colored Progressive Matrices + Wechsler Abbreviated Scale of Intelligence (Wechsler) + Vocabulary and Matrix Reasoning Subtests
A55	Rekenen-Wiskunde (School Mathematics Achievement Test) + The Tempo Test Automatiseren [Rapid Arithmetic Test] + Dutch Number Sense Assessment Test + Continuous Naming and Word Reading Test + Raven’s Standard Progressive Matrices
A56	The Arithmetic Number Facts Test (Tempo Test Rekenen) + The Kortrijk Arithmetic Test Revision + IQ TEST
A57	Numerical and Symbolic Test
A58	KeyMath--Revised achievement test + Developmental Test of Visual Perception--second edition + the Woodcock-Johnson--Revised (WJ-R)
A59	Selected Subtests of the Woodcock-Johnson Cognitive Abilities Test – Third Edition (WJ-III COG)
A60	Wechsler Preschool and Primary Scale of Intelligence + Dutch Version of Wechsler Intelligence Scale for Children + Snijders-Oomen Non-Verbal Intelligence Test + The Tempo Test Arithmetic + Raven’s Standard Progressive Matrices
A61	Wide Range Achievement Test Third Edition + Wechsler Abbreviated Scales of Intelligence
A62	Phonological Ability Test + WISC-IV + Panamath Test
A63	The Wechsler Intelligence Scale for Children – 3rd Edition – Dutch Version (WISC-III) + Color Picture Test + Reading and Spelling Test + The Tempo Toets Rekenen + Arithmetic Test
A64	Two Sub-Achievement Tests from Woodcock-Johnson III + Math Fluency Subtest + Reading Fluency Subtest + Short Intelligence Test
A65	WIAT-II + Working Memory Test Battery for Children (WMTBC)
A66	The Test for the Diagnosis of Mathematical Competences + Magnitude Comparison + The Kortrijk Arithmetic Test Revised + The Arithmetic Number Facts Test + Wechsler Intelligence Scale for Children
A67	TEMA-3 (Test of Early Mathematics Ability)
A68	Numerical Domino Game + Color Domino Game + Dutch Version of Wechsler Preschool and Primary Scale of Intelligence + Dutch Version of Wechsler Intelligence Scale for Children – Third Edition (WISC-III) + Snijders-Oomen Non-Verbal Intelligence Test – Revised
A69	Wechsler Individual Achievement Test (WIAT-II) + Word Reading Accuracy Test + The Woodcock-Johnson Tests of Cognitive Abilities (WJ-III)

A70	Wechsler Preschool and Primary Scale of Intelligence – Third Edition (WPPSI-III) + Test for the Diagnosis of Mathematical Competencies (TEDI-MATH)
A71	The German Version of the Culture Fair Intelligence Test + Standardized Reading Fluency Test + Standardized Spelling Test + Standardized Arithmetic Fluency Test
A72	School Achievement Test + The Corsi Block Task + Culture Fair Intelligence Test + German Mathematics Test + German Spelling Test
A73	Raven’s matrices
A74	Raven’s Colored Progressive Matrices Test + Efficiency Test + Arithmetic Test
A75	The Dutch Wechsler Intelligence Scale for Children–III + The Tempo Test + Working Memory Test Battery for Children + Spelling Test Rekenen (TTR; Arithmetic Number Facts Test) + The Kortrijkse Rekentest Revisie (KRT-R; Kortrijk Arithmetic Test Revision) + Eén-Minuut-Test (EMT; One Minute Reading Test)
A76	Wechsler Individual Achievement Test-II–Abbreviated [WIAT-II) + Wechsler Preschool and Primary Scale of Intelligence-III (WPPSI-III)
A77	Wechsler Intelligence Scale for Children-III + Woodcock–Johnson PsychoEducational Battery–Revised
A78	Early numerical achievement test + Kortrijk Arithmetic Test Revised + IQ
A79	Cochrane, PubMed, PsycINFO, and ERIC (Review Study)
A80	Wechsler Preschool and Primary Scale of Intelligence – Third United Kingdom Edition (WPPSI-III) + Parent Order Processing Survey
A81	The TEDI-MATH + The Revised Kortrijk Arithmetic + The Wechsler Intelligence Scale for Children
A82	The LVS Mathematics Test+the clock reading test+ Raven’s Standard Progressive Matrices
A83	Computer-Assisted Test + The Tempo Test Arithmetic
A84	Amath Test (Arithmetic) + Addition, Subtraction, and Verbal Problem Solving Test + The Block Repetition Forward (BRF) and Block Repetition Backwards (BRB) Tests
A85	Peabody Individual Achievement Test (PIAT) Reading Recognition Subtest + Time-Limited Word Reading Test + The Wide Range Achievement Test, Revised + Wechsler Intelligence Scale for Children, Revised (WISC-R)
A86	The Raven’s + Wechsler Abbreviated Scale of Intelligence (WASI) + Wechsler Individual Achievement Test–II–Abbreviated + Number Sets Test + The Working Memory Test Battery for Children + Coloured Progressive Matrices
A87	The Wechsler Intelligence Scale for Children–III + the Mathematics Reasoning subtest of the + the Woodcock-Johnson PsychoEducational Battery–Revised + Wechsler Individual Achievement Test
A88	Computer-Assisted Test + Basic Numerical Processing Tests + Dots and Number Comparison Task + Cognitive Abilities Test 3 + Spatial Processing Tests + The Corsi Block Task + Cognitive Ability Test + Raven’s Progressive Matrices
A89	Dutch WISC-III + The arithmetic number facts test + The Kortrijk arithmetic test revision
A90	eTest for the Diagnosis of Mathematical Competencies (TEDIMATH) + the Cognitive Developmental Skills in Arithmetics + The Arithmetic Number Facts Test + The Time Competence Test
A91	WISC-IV, Arithmetic Test
A92	Semi-Structured Interview
A93	IQ and Standard Test, Math Test and Word Test, Raven’s Matrices IQ
A94	Number Writing Speed, Number Combinations (NC), Multi-Digit Mental Calculation (MMC), and Number Sense Skills (NSS) Test
A95	MathEduc Database

A96	Computer-Assisted Arithmetic Test/Mathematics Test
A97	Qualtrics Survey
A98	Wechsler Intelligence Scale for Children-IV (WISC-IV)/ Raven Colored Progressive Matrices-CPM or Progressive Matrices-PM
A99	Standardized Numerical Test/ZAREKI-R
A100	Woodcock-Johnson IV Academic Achievement Test, Calculation Subtest
A101	Wechsler Intelligence Scales

It is noted that the use of a single data collection tool was rare; instead, data were often collected using multiple tools simultaneously.

Table 5. *Distribution of Included Studies by Participant Age*

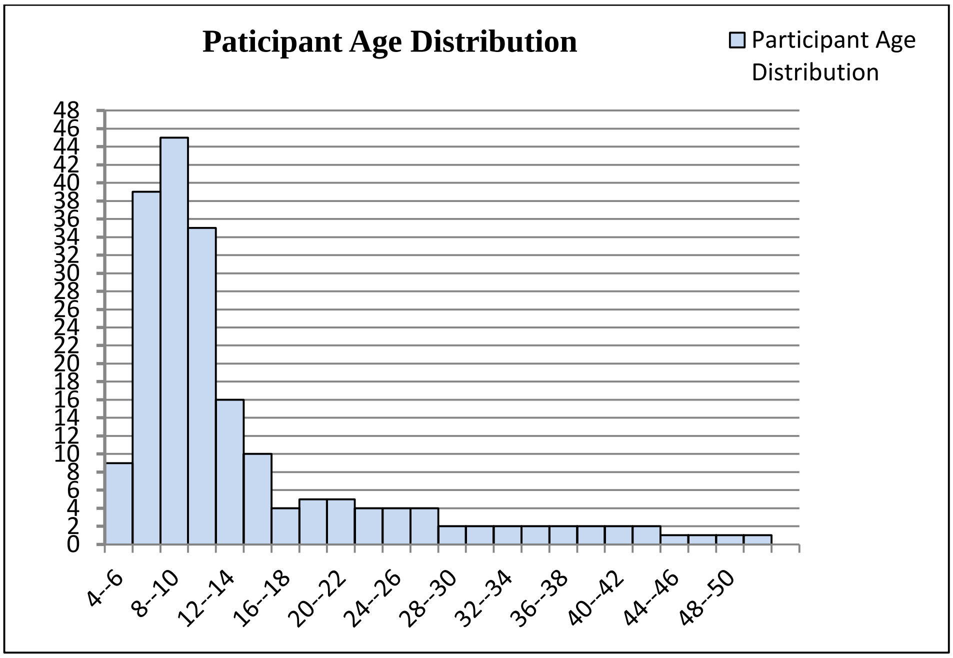
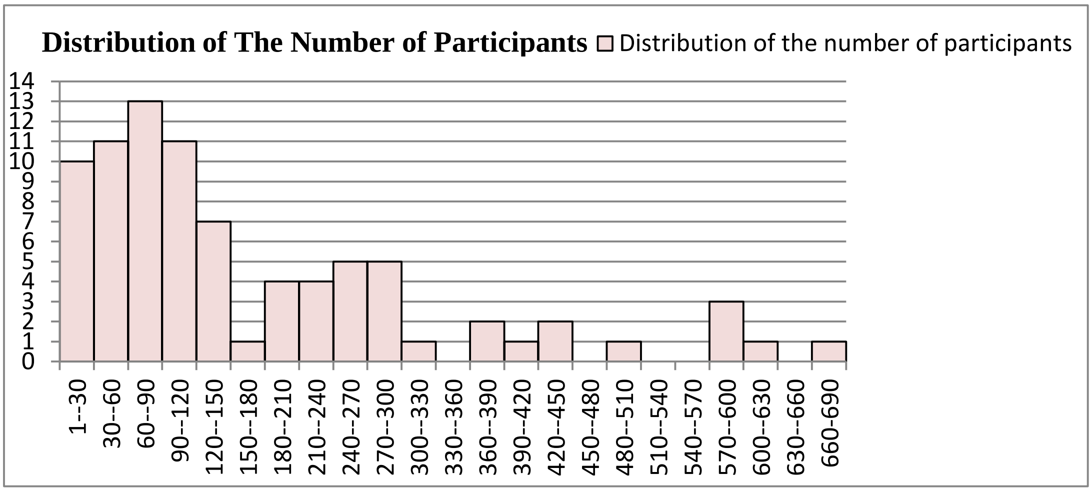


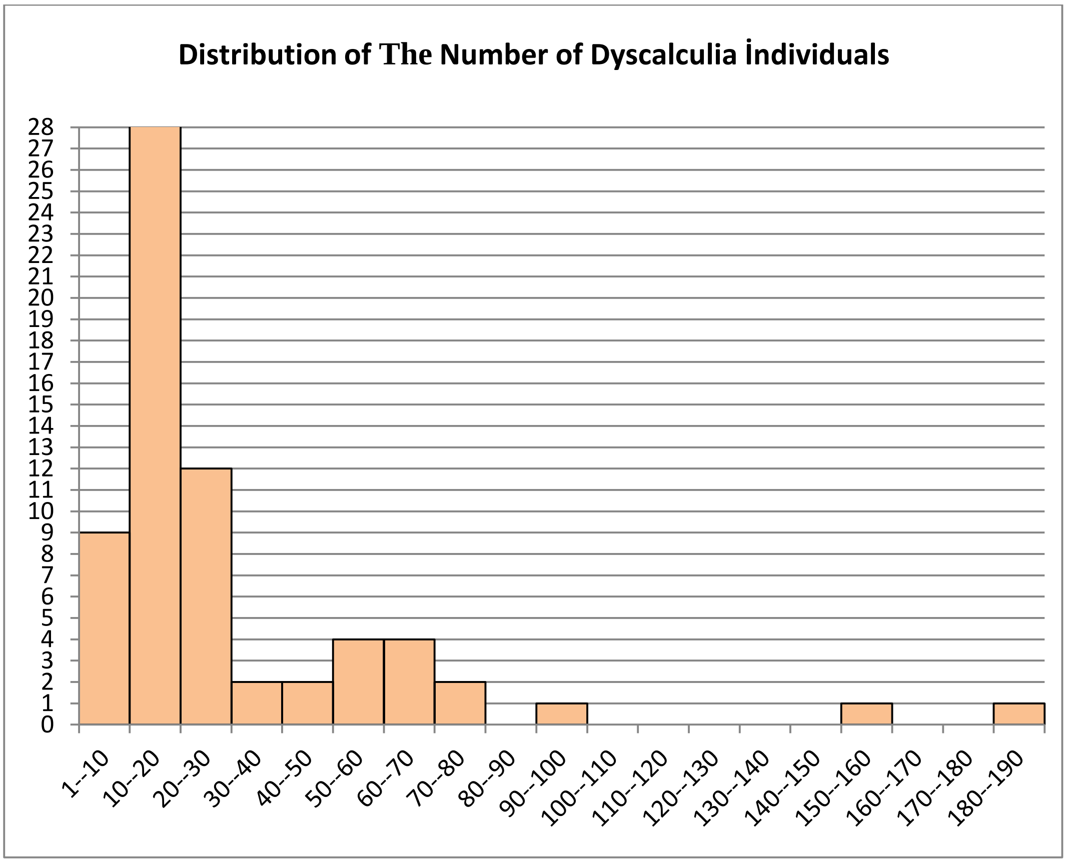
Table 5 shows the age ranges of the participants included in the studies and the corresponding number of studies for each range. The most common age group for studies in the field of dyscalculia was 8 to 10 years, with 45 studies conducted in this age group. Another frequently studied age group was 6 to 8 years, with 39 studies. It is also observed that studies involving individuals over the age of 16 were relatively few. Table 5 shows that the total number of studies is 200. This is due to some studies, such as A10, including participants from multiple age groups (e.g., 8-12 years), and this range is split into two intervals (8-10 and 10-12) in the table. As there are several studies like A10, the total number of data points from the 101 studies increases to 200.

Table 6. *Distribution of Included Studies by Number of Participants*



In Table 6, the values range from 1 to 690 participants. This is because the data in other studies represent extreme outliers, with participant numbers ranging from 877, 942, 1004, 1023, 1454, 1588, 1757, to 6121. Based on Table 6 and the data obtained, the most common range of participant numbers was between 60 and 90. It was also determined that at least 1 participant and as many as 6121 participants were included in the studies.

Table 7. *Distribution of Included Studies by Number of Dyscalculic Participants*



In the studies included in this review, various tests were applied to identify individuals at risk of dyscalculia, and the number of dyscalculic individuals was determined. Table 7 presents the number of dyscalculic individuals identified in different studies. In 28 studies, the number of dyscalculic individuals ranged between 10 and 20. Among these studies, 2 identified only 1 individual, while 1 study identified 183 individuals.

Table 8. *Distribution of Included Studies by Dyscalculia Diagnosis and Intervention Methods*

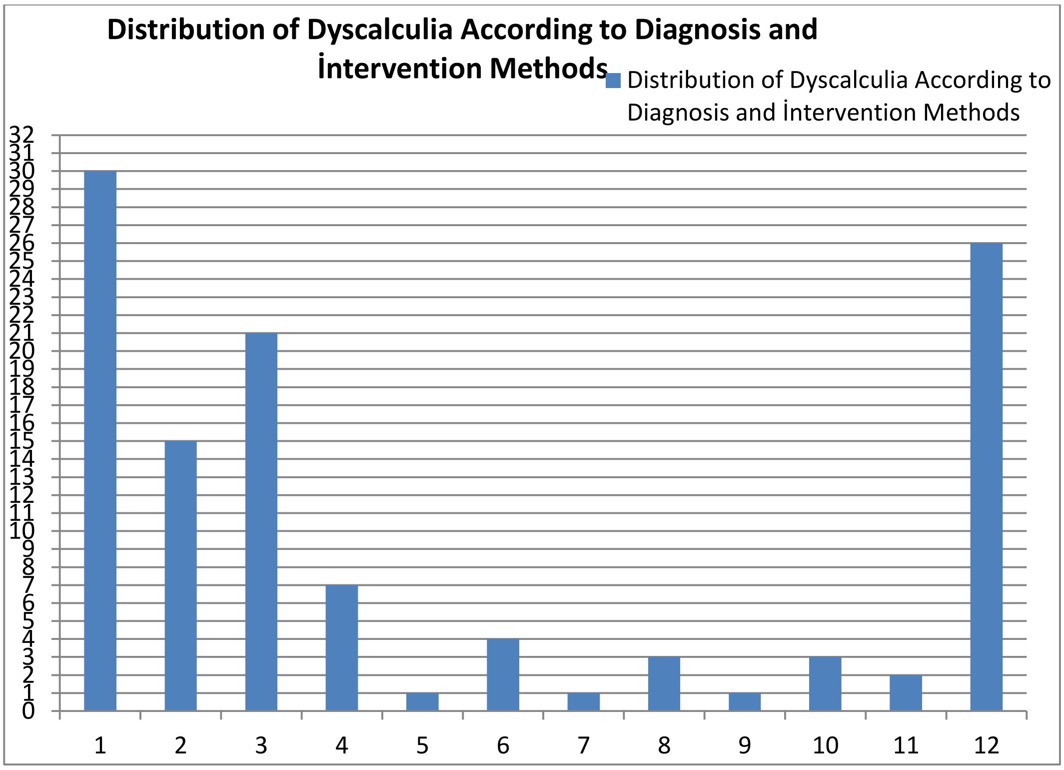


Table 8 provides the numerical distribution of tests used for diagnosing and intervening in dyscalculia. The names of the dyscalculia diagnosis and intervention tools are represented by the following codes in the table:

1 = Standardized mathematics achievement test;

2 = Wechsler Intelligence Scale for Children (WISC-R test);

3 = IQ test;

4 = dyscalculia screening test;

5 = mAMAS, MaLT, and HGRT joint analysis;

6 = computer-assisted dyscalculia screening tool;

7 = Raven’s Standard Progressive Matrices Test;

8 = Direct inclusion based on RAM guidance;

9 = Individual ability test;

10 = Woodcock Johnson-III Standardized Achievement Test;

11 = Zareki-R test;

12 = No diagnostic tool used.

Although there were a total of 101 studies, Table 8 shows 114 diagnostic and intervention tools used. This is because, for example, in A18, both the IQ test and a standardized mathematics achievement test were used, and both were included in the data. Due to several similar cases, the number of data points increased. When examining Table 8, it is observed that the most commonly used tool was the standardized mathematics achievement test, while the least used tools were mAMAS, MaLT and HGRT joint analysis, Raven's Standard Progressive Matrices Test, and individual ability tests.

In this study, bibliometric data from the Web of Science database were visualized using VOSviewer. Each point on the map represents an author, and each cluster represents a group of authors who have collaborated.

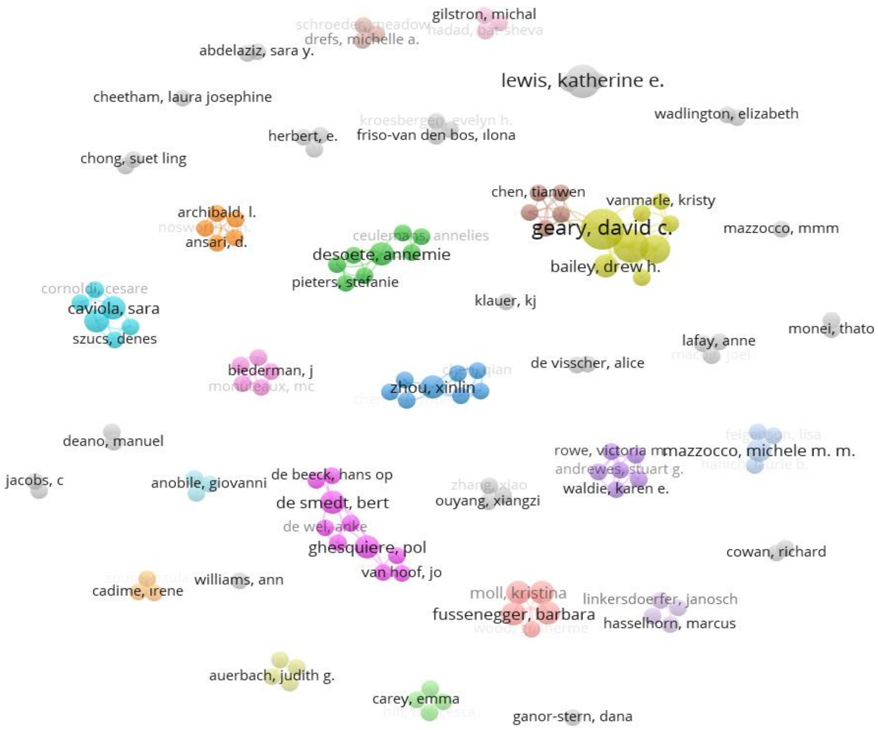


Figure 3. *Collaboration and Co-authorship among Authors*

In this figure, the same-coloured clusters represent groups of authors who have collaborated on the same studies. A total of 35 clusters were identified. The size of the circles indicates the level of collaboration, with the three authors who collaborated the most being David C. Geary and Mary K. Hoard. These authors hold significant positions within their collaboration networks.

In Figure 4, each point represents an author and the year of their study, illustrating the connections among their references.

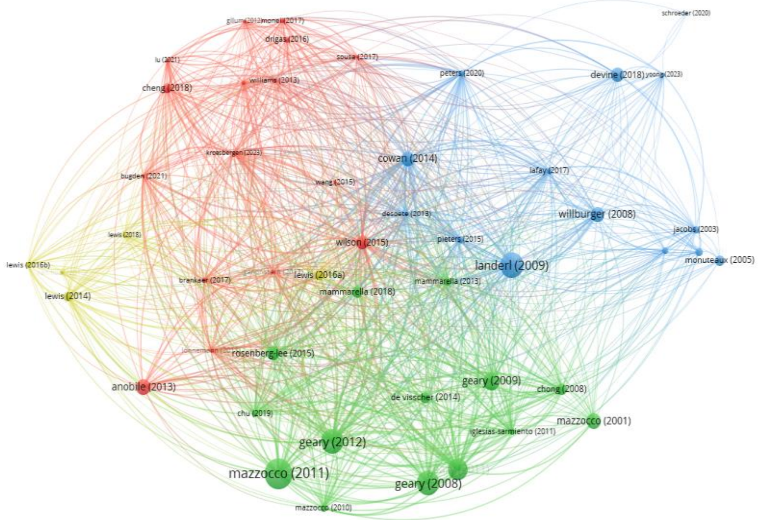


Figure 4. *Common Citation Network*

Figure 4 presents an analysis of the citation relationships between the articles on dyscalculia. It visualizes the studies that have influenced one another or been influenced by others. A common citation network was created to show the articles that cite each other. The articles with the highest number of citations and the largest network clusters are Mazzocco (2011) in green, Landerl (2009) in blue, and Wilson (2015) in red.

The 110 studies included in this review were analyzed to identify common results. The findings are summarized in Table 9.

Table 9. *Common Results of the Studies*

Author- Year	Similarly
Chan (2013)	Dyscalculic individuals performed worse in symbolic tasks compared to controls.
Van Hoof et al. (2010)	Significant differences were found between dyscalculic and control groups in IQ and standardized mathematics achievement tests.
Kucian et al. (2018)	The significant difference between dyscalculic and normal individuals could be normalized at the neuronal level through number-line training.
Morsanyi (2018)	Dyscalculic individuals performed worse in number sense tests compared to normal individuals.
Mazzocco (2011)	A significant difference was found in symbolic tests, with dyscalculic individuals scoring lower.
Tang (2017)	While testing non-verbal intelligence, normal individuals performed better than individuals with learning difficulties and dyscalculia, with the lowest IQ scores belonging to the dyscalculic group.
Budgen (2016)	Dyscalculic individuals had significant deficiencies in both mathematical and reading performance compared to normal individuals.
Murphy (2013)	No significant difference was found between dyscalculic individuals and those with other learning difficulties in number tests, but there was a significant difference between dyscalculic individuals and normal students.
Brankaer (2017)	Dyscalculic individuals consistently performed lower across all class groups.

Szucs (2018)	Significant differences were found between dyscalculic and normal individuals in spatial and arithmetic tests.
Gilmore (2011)	Dyscalculic individuals performed worse than those with other learning difficulties in approximate number tasks, though no difference was found in number recognition.
Moll & Gobel (2016)	Dyscalculic individuals scored lower on IQ tests than those with attention deficits and control groups. A significant relationship was found between IQ and reading tests.
Desoete (2014)	A study comparing response times between control and dyscalculic groups found significant differences in the speed-accuracy relationship, with control groups showing a higher correlation.
Brankaer (2011)	symbolic comparison tests revealed high accuracy rates and significant differences were found between the dyscalculic and normal groups.
Brankaer (2013)	Dyscalculic individuals performed worse than their peers in both symbolic and non-symbolic tests.
Devine (2018)	A significant difference was found between low-mathematics-achievement individuals and normal individuals, while dyscalculic individuals showed a complete disconnect from the correlation.
Skagerlung (2016)	Dyscalculic individuals performed significantly worse in general number comparison tests compared to normal individuals.
Pellerone (2013)	When examining the time factor, dyscalculic individuals were found to give fewer correct answers within less than one second.
Zygouris (2017)	Dyscalculic individuals performed significantly worse than normal individuals in all tests conducted.
Chan (2013)	No significant difference was found in the effect of gender on dyscalculic individuals.
Devine (2013)	A significant gender difference was found in reading scores, but there was little difference in mathematics scores between boys and girls.
Pellerone (2013)	Found boys to perform worse than girls in the tests conducted.
Mazzocco (2003)	Test-retest results indicated that boys had a higher risk of dyscalculia compared to girls.
Peters et al. (2020)	A relationship was found between dyslexia and dyscalculia, with dyslexic individuals struggling with reading and dyscalculic individuals struggling with arithmetic.
Hasselharn (2008)	A significant relationship was found between dyscalculia and dyslexia in tests involving psychological lobes and visual-spatial skills.
Menon (2015)	No significant difference was found between dyscalculic individuals and those with other learning difficulties in number tests.
Brankaer (2014)	While confirming that dyscalculic individuals struggle with mathematics and dyslexic individuals with reading, the study suggests that the relationship between numerical magnitudes processing in these groups is unclear.

5. RESULTS AND DISCUSSION

In this study, a systematic review and bibliometric analysis of studies related to dyscalculia, published in the Web of Science database from January 1, 2003, to August 30, 2024, were conducted. The keywords "dyscalculia" or "math learning disability" was used to search the

Web of Science (WoS) database, and the results were filtered according to specific inclusion criteria. As a result, 101 articles were included in the study and analyzed based on the research questions.

When examining the distribution of published articles on dyscalculia in the WoS (Web of Science) database by year, it is observed that the first article was published in 1999. No articles were published in this field in the years 2001, 2002, 2005, 2006, and 2007. Additionally, it was noted that the number of articles increased from 2007 onward, with the highest number of studies published in the years 2016 and 2018. This differs from another review that included 30 studies, which found that 2014 had the most research (Güler & Koca, 2024).

When examining the distribution of published articles on dyscalculia in the WoS database according to data analysis methods, it was observed that ANOVA (SPSS) was the most commonly preferred analysis method. ANOVA was used in 49 studies, author interpretation in 11 studies, MANOVA in 6 studies, and Matlab and ANOVA were used together in 5 studies. In addition to these methods, various other methods were also employed.

When examining the distribution of published articles on dyscalculia in the WoS database according to research methods/designs, experimental research was the most commonly preferred method. Additionally, one study each employed action research, correlational research, and case study methods.

When examining the distribution of published articles on dyscalculia in the WoS database based on data collection tools, it was found that no single tool was used exclusively, and multiple tools were often employed together to collect data.

When examining the distribution of published articles on dyscalculia in the WoS database by participant age, it was found that the most frequently studied individuals were those aged between 8 and 10. Additionally, there were very few studies involving individuals older than 16 years.

When examining the distribution of published articles on dyscalculia in the WoS database by the number of participants, it was observed that the most common sample size ranged between 60 and 90 individuals. Additionally, it was noted that studies included as few as one participant and as many as 6121 participants.

When examining the distribution of published articles on dyscalculia in the WoS database by the number of identified dyscalculic individuals, it was observed that most studies identified between 10 and 20 individuals at risk of dyscalculia. The minimum number identified in the study was one, while the maximum was 183.

When examining the distribution of published articles on dyscalculia in the WoS database based on diagnosis and intervention methods, it was found that standardized math achievement tests were the most commonly used, while mAMAS, MaLT, and HGRT combined analyses, Raven's Standard Progressive Matrices Test, and individual ability tests were the least used.

According to bibliographic data, the relationships between author collaborations and their references were examined. This analysis showed that the top three most collaborative authors were David C. Geary and Mary K. Hoard. Additionally, the articles with the largest citation networks were Mazzocco (2011), Landerl (2009), Geary (2008), Geary (2009), Geary (2012) and Wilson (2015).

6. RECOMMENDATIONS

This study only utilized the Web of Science database. Future studies could include a broader dataset by reviewing research from databases such as Google Scholar, CORE, the Public Library of Science (PLOS), the Directory of Open Access (DOAJ), PubMed, Scopus, or ERIC. This study also only included publications from the fields of mathematics and education. Different filtering criteria could be used in future studies to explore other areas of research.

7. ABOUT THE AUTHORS

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