



A literature review on dyscalculia: What dyscalculia is, its characteristics, and difficulties students face in mathematics class

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Abstract:

Dyscalculia is a specific learning condition that affects the comprehension and manipulation of numerical concepts, which can impact students' academic performance and well-being in mathematics education. The research methodology used was a systematic literature review that aimed to identify and synthesize the existing evidence regarding the differences in understanding of dyscalculia, its characteristics and the difficulties that students with dyscalculia may face in class. The search string used in electronic databases, such as Crossref and Google Scholar, to generate articles for the review were "dyscalculia" and "dyscalculia characteristics." After the study selection process and appraising its quality, 23 articles met the selection criteria and were reviewed to synthesize answers to the research questions. The findings suggest despite many differences in understanding what dyscalculia was and it was clear that dyscalculia is a specific learning condition that affected students' comprehension and manipulation of numerical concepts. Students with dyscalculia exhibit various characteristics, the most noticeable of which was low mathematics achievement scores. The difficulties faced by students with dyscalculia in the classroom were numerous. However, the primary obstacles they faced involved comprehending and applying mathematical concepts, as these difficulties could lead to others, such as executing mathematical problem-solving instructions. Educators might comprehend the diverse characteristics of dyscalculia to provide appropriate support and accommodations for students with difficulties.

Keywords: Characteristics, Difficulties, Dyscalculia, Mathematics Learning Disability

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Introduction

Mathematics, whether as it is or as it is applied to other fields, is fundamental to our existence. Mathematics occupies a unique position in education, as it is the only subject taught to students of all ages and grade levels (Ernest, 2018). As a result of



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mathematics-led advances in science, technology, and engineering, more people are living longer, healthier, better educated, more comfortable, and wealthier lives than ever before, particularly in the last two centuries (Ernest, 2018).

It is abundantly clear that one's life will be affected by the mathematics that people learn in school (Aprinastuti et al., 2020; Kißler et al., 2021; Kunwar & Sharma, 2020; Lazo-Amado et al., 2022; Liu et al., 2022; Ziadat, 2022). Students must understand and master basic mathematical concepts because mathematics is a multidisciplinary subject that includes arithmetic, algebra, geometry, and statistics. Unfortunately, 5-8% of school-aged individuals have a mathematical learning disability that affects their comprehension of its basic concepts (Fauzan et al., 2022; Lazo-Amado et al., 2022; Patricia & Zamzam, 2021) and could go through more than one difficulty throughout their academic career (Mariera et al., 2021).

Mathematics learning disability, or dyscalculia, is one of the three most commonly found learning disabilities, with dyslexia and dysgraphia being the other two (Ahuja et al., 2022; Kariyawasam et al., 2019). While it has a similar prevalence to dyslexia and dysgraphia, dyscalculia is less known and understudied than the other two (Bulthé et al., 2019; Grigore, 2020). As a result, many teachers have limited knowledge about dyscalculia (Kunwar & Sharma, 2020), and students with dyscalculia do not get the support they need while learning mathematics in school.

Understanding dyscalculia and its characteristics could provide teachers with a better knowledge of the challenges students with dyscalculia may encounter in the classroom and the future. These insights could also help teachers identify students who have a dyscalculia tendency, as many teachers still do not have sufficient knowledge regarding dyscalculia and students who have it (Kunwar & Sharma, 2020). Numerous literature review studies have been conducted to cover, describe, and examine various aspects of dyscalculia. Two studies have examined the cognitive abilities and cognitive domains of students with dyscalculia, showing that some general cognitive domains were affected in children with mathematics difficulties (Agostini et al., 2022); furthermore, their visuospatial working memory and symbolic number processing abilities emerged as the greatest predictors of mathematics abilities (Mishra & Khan, 2022). One study that looked into the appropriate interventions for students with dyscalculia argued that technology-enhanced learning could help students with dyscalculia improve their learning outcomes (Fatwana et al., 2023). In another study, the characteristics of dyscalculia were categorized into four domains (Yoong & Ahmad, 2021): number sense, working memory, accurate or fluent calculation, and mathematics reasoning. This study focuses on systematically reviewing past studies on dyscalculia, and from this study, the differences in understanding of what dyscalculia is in the educational domain, as well as in-depth description of the characteristics and challenges that students with dyscalculia may face in the classroom, will be presented which can be used as guide for teachers to understand what dyscalculia is, how can it be detected in class, and what difficulties students with dyscalculia might face in class.

Research Methods

A systematic literature review was used to conduct this study, which reviews existing research employing clear, accountable research techniques (Newman & Gough,

2020). This study followed the research procedures of Aisyah & Juandi (2022), which consist of six steps.

Develop Research Question

The first step in this procedure was to develop research questions based on the study's background. The following are the research questions developed for this study.

1. Are there differences in understanding regarding dyscalculia in the literature?
2. What are the characteristics of dyscalculia in students?
3. What are the difficulties that students with dyscalculia may face in the classroom?

Selection Criteria

The next step of the study procedures was establishing selection criteria. The selection criteria themselves are multiple sets of inclusion and exclusion criteria that were applied during the article search process to ensure that the article that would be chosen was suitable the research questions. The selection criteria in this study are shown in Table 1.

Table 1. Selection Criteria

Criteria	Indicator
Inclusion	<ol style="list-style-type: none">1. The articles are the results of primary research published in a journal or proceeding.2. The articles are published from 2019 to 2023.3. The articles are written in English
Exclusion	<ol style="list-style-type: none">1. Chapter book, thesis, brief report, and non-empirical study types2. The articles are published outside of the stated timestamp3. The articles are not written in English

Developing the Search Strategy

The following step in this procedure is to create a search strategy. The search strategy for this study uses several electronic database sites, such as Crossref, Google Scholar and ERIC, using the application Publish or Perish to generate articles that would later be reviewed. The search strings used to generate articles from databases for this study are as follows.

1. Dyscalculia
2. Dyscalculia characteristics

The Study Selection Process

Following the development of a search strategy, the articles and abstracts were initially reviewed to assess their relevance and adherence to pre-determined selection criteria. The complete article was subsequently reviewed, and any article that did not meet the selection criteria and was deemed irrelevant was excluded from further consideration.

Appraising the Quality of Studies

After the study selection process, articles are evaluated for quality through questions to determine their relevance to the present study. The quality assessment criteria comprise the following set of questions.

AQ1. Is the article the result of primary research?

AQ2. Does the article discuss dyscalculia in the educational domain?

AQ3. Does the article discuss the characteristic(s) of dyscalculia?

AQ4. Does the article have a research problem that is relevant to this study?

Synthesis Result

The research objectives carried out the synthesis procedure to present a comprehensive analysis of the distinctions in understanding the concept of dyscalculia, its characteristics, and the difficulties that dyscalculia students may face in the classroom. The analysis included a thorough review of the contents of each article, followed by the identification and categorization of dyscalculia's definition, characteristics, and difficulties faced by students with dyscalculia. These findings were then utilized to address the research questions that were formulated.

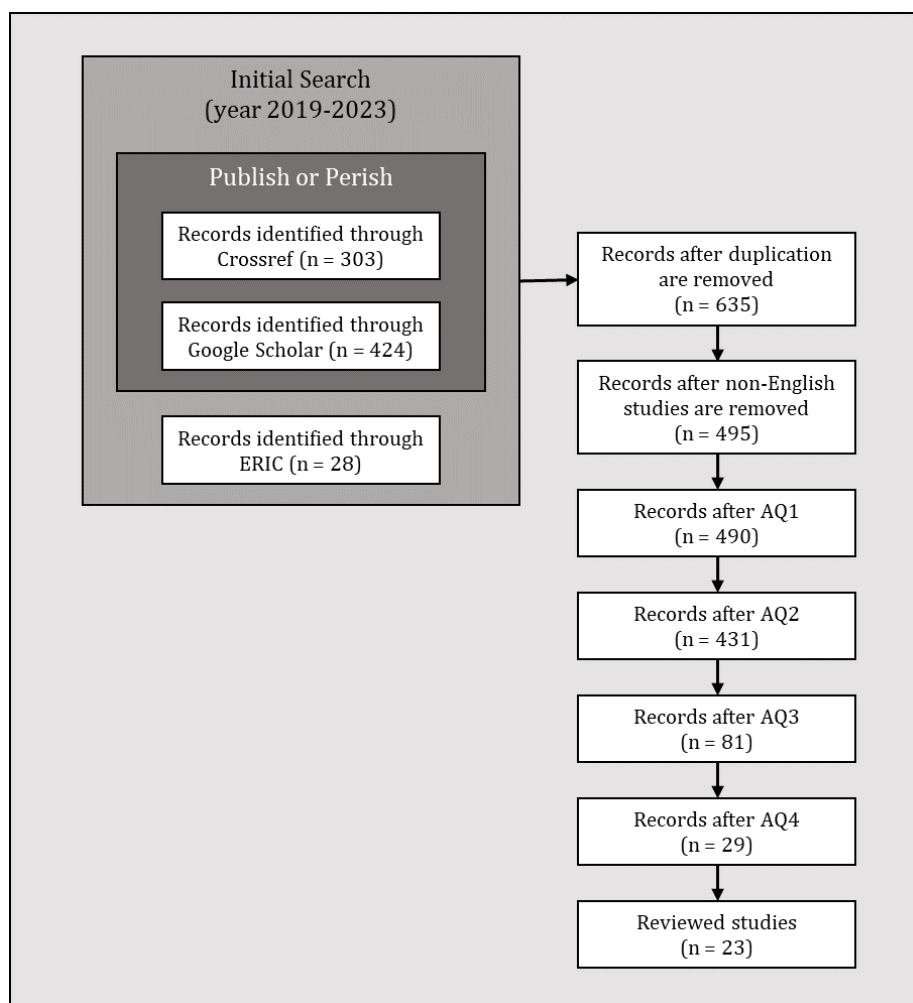


Figure 1. Research Flow

Results and Discussions

Based on the selection process, 23 articles that met the selection criteria were obtained. Out of the articles selected, more than 70% of the studies were conducted in elementary school or lower. Most of the research methods used in the studies are R&D and quantitative. With 15 studies, Asian countries dominate the location where the studies were conducted, while three are from Europe, two are from Africa and North America, and only one is from South America.

Table 2. Article Included in the Review

Study	Method	Level	Country
(Kariyawasam et al., 2019)	Research and Development	Elementary School	Sri Lanka
(Dehghani, 2019)	Research and Development	Elementary School	Iran
(Jannah & Bharata, 2020)	Qualitative	High School	Indonesia
(Cheng et al., 2020)	Quantitative	Elementary School	China
(Kunwar & Sharma, 2020)	Quantitative	Elementary School	Nepal
(Aprinastuti et al., 2020)	Research and Development	Preschool	Indonesia
(Noordin et al., 2020)	Research and Development	Elementary School	Malaysia
(Purwaningrum et al., 2021)	Research and Development	Elementary School	Indonesia
(N. Onyishi & M. Sefotho, 2021)	Quantitative	High School	South Africa
(Firmasari et al., 2021)	Qualitative	Elementary School	Indonesia
(Patricia & Zamzam, 2021)	Research and Development	Elementary School	Indonesia
(Mariera et al., 2021)	Qualitative	Middle School	Kenya
(Liu et al., 2022)	Quantitative	Elementary School	China
(Gut et al., 2021)	Quantitative	Elementary School	Poland
(Kißler et al., 2021)	Quantitative	Elementary School	Germany
(Lewis et al., 2022)	Qualitative	Adult	USA

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Study	Method	Level	Country
(Lewis, Thompson, et al., 2022)	Mixed Method	Middle School	USA
(Vigna et al., 2022)	Quantitative	Adult	Italy
(Ziadat, 2022)	Quantitative	Elementary School	Jordan
(Ahuja et al., 2022)	Mixed Method	Elementary School	India
(Putri Purwaningrum et al., 2022)	Qualitative	Elementary School	Indonesia
(Fauzan et al., 2022)	Qualitative	Elementary School	Indonesia
(Lazo-Amado et al., 2022)	Research and Development	Elementary School	Peru

Differences in Understanding Dyscalculia

While it has been mentioned before that dyscalculia is a mathematics learning disability, past studies have their understanding of it. Dyscalculia is a term used to describe someone who has difficulty calculating and counting numbers (Dehghani, 2019), and learning arithmetic (N. Onyishi & M. Sefotho, 2021). The term dyscalculia also had the meaning of a neurodevelopmental (Gut et al., 2021) learning disorder where one's mathematical ability is far below where it should be (Firmasari et al., 2021), which can lead to difficulties in any mathematics-related concepts (Firmasari et al., 2021; Gut et al., 2021; N. Onyishi & M. Sefotho, 2021). Dyscalculia was further described as a difficulty in learning and acquiring basic mathematical abilities (Dehghani, 2019; Jannah & Bharata, 2020; Kariyawasam et al., 2019; Kunwar & Sharma, 2020; Putri Purwaningrum et al., 2022) that could also affect reading, writing, as well as attention deficits (Lazo-Amado et al., 2022).

In two studies, dyscalculia was defined as cognitive differences in number processing that can make it hard to access and use standard mathematical mediation tools and hard to understand representations and symbols for someone who has it (Lewis, Sweeney, et al., 2022; Lewis, Thompson, et al., 2022). The term *differences* in this context are based on Vygotskian perspective of disability, in which Vygotsky argued that historically developed mediational signs and tools (such as language and symbols) were frequently incompatible with the biological development of children with disabilities (Lewis, Sweeney, et al., 2022; Lewis, Thompson, et al., 2022).

Some studies also mention Developmental Dyscalculia (DD) is different from dyscalculia. A person with DD has been defined as having a disorder in the development of mathematical abilities that cannot be accounted for by a lack of general intelligence or by a low-quality educational environment that has an effects on one's capacity to process numerical information and facts (Cheng et al., 2020; Kißler et al., 2021; Liu et al., 2022; Vigna et al., 2022).

There are nine types of dyscalculia, namely (Patricia & Zamzam, 2021): (1) quantitative dyscalculia, lack of counting and calculating skills; (2) qualitative

dyscalculia, difficulties in understanding mathematical instructions; (3) intermediate dyscalculia, inability to operate with mathematical symbols or numbers; (4) verbal dyscalculia, difficulties associated with describing mathematical concepts or relationships; (5) practognistic dyscalculia, problems in mathematically manipulating objects; (6) lexical dyscalculia, problem of reading mathematical symbols; (7) graphic dyscalculia, problems in writing mathematics symbols and numbers; (8) in-diagnostically dyscalculia, problems in understanding mathematical concepts and relationships; and (9) operational dyscalculia, problems in performing arithmetic operations and calculations. While many studies have identified several subtypes of dyscalculia, there are two major subtypes based on a broad range of variables (intelligence, reading fluency, working memory, attention, and various mathematical skills) (Kißler et al., 2021), that is a slightly impaired subtype and a strongly impaired subtype.

The present study reveals that the understanding of dyscalculia and its various subtypes are not uniform across the literature. Some definitions depict it as a learning disability, a disorder, a difficulty, or a cognitive difference. It is important to note that the term cognitive differences initially emerged from the perspective of learning disability in students (Lewis, Sweeney, et al., 2022; Lewis, Thompson, et al., 2022). However, in the context of dyscalculia, it carries a distinct yet comparable connotation. Whether dyscalculia is a learning disability, a disorder, a difficulty, or a cognitive difference, according to these studies, dyscalculia can be defined as a specific learning condition that impairs numerical concept comprehension and manipulation.

Dyscalculia Characteristics

Low mathematics achievement scores are frequently indicative of dyscalculia, especially in word problems (Firmasari et al., 2021; Ziadat, 2022), but it is essential to note that this is not the only characteristic of dyscalculia (Ahuja et al., 2022; Aprinastuti et al., 2020; Cheng et al., 2020; Dehghani, 2019; Fauzan et al., 2022; Firmasari et al., 2021; Gut et al., 2021; Jannah & Bharata, 2020; Kariyawasam et al., 2019; Kißler et al., 2021; Kunwar & Sharma, 2020; Lewis, Sweeney, et al., 2022; Lewis, Thompson, et al., 2022; Liu et al., 2022; Mariera et al., 2021; N. Onyishi & M. Sefotho, 2021; Noordin et al., 2020; Patricia & Zamzam, 2021; Purwaningrum et al., 2021; Putri Purwaningrum et al., 2022; Vigna et al., 2022; Ziadat, 2022). Students with dyscalculia usually have persistent difficulty with mathematics throughout the school year rather than just one mathematical concept (Lewis, Thompson, et al., 2022; Vigna et al., 2022), which may lead to low mathematics achievement scores, yet still have average intelligence and good performance in other subjects (Fauzan et al., 2022; N. Onyishi & M. Sefotho, 2021).

In addition to struggling with understanding and applying basic mathematical concepts (Ahuja et al., 2022; Dehghani, 2019; Firmasari et al., 2021; Jannah & Bharata, 2020; Kunwar & Sharma, 2020; Lewis, Thompson, et al., 2022; Mariera et al., 2021; Noordin et al., 2020; Patricia & Zamzam, 2021), such as numbers and their operations (Ahuja et al., 2022; Cheng et al., 2020; Dehghani, 2019; Gut et al., 2021; Kariyawasam et al., 2019; Kißler et al., 2021; Kunwar & Sharma, 2020; N. Onyishi & M. Sefotho, 2021; Noordin et al., 2020; Patricia & Zamzam, 2021; Putri Purwaningrum et al., 2022; Vigna et al., 2022; Ziadat, 2022), students with dyscalculia typically have an unconventional understanding mathematical concepts, like fractions (Lewis, Thompson, et al., 2022) and algebra, (Lewis, Sweeney, et al., 2022) and often characterized by poor spatial skills

(Aprinastuti et al., 2020; Firmasari et al., 2021; Liu et al., 2022; Mariera et al., 2021). They also struggle to understand and follow directions related to mathematical problems (Dehghani, 2019; Firmasari et al., 2021; Mariera et al., 2021; N. Onyishi & M. Sefotho, 2021).

Students' psychological characteristics while in the classroom can also provide insight into the characteristics of students with dyscalculia. The inability of students to keep information in their working memory may be one of the signs that they suffer from dyscalculia (Kißler et al., 2021; Liu et al., 2022; Patricia & Zamzam, 2021; Vigna et al., 2022). Another sign is that they count aloud or with their fingers (Gut et al., 2021; Kariyawasam et al., 2019; N. Onyishi & M. Sefotho, 2021; Noordin et al., 2020; Putri Purwaningrum et al., 2022). Additionally, it can be a source of anxiety and frustration for individuals, particularly when they cannot perform mathematical tasks that they perceive to be crucial for their academic or personal success (Fauzan et al., 2022). This may impact their sense of well-being and self-esteem.

The findings suggest dyscalculia is often associated with low mathematics achievement scores, specifically in word problems. However, it is crucial to note that this is not the sole defining feature of dyscalculia. Individuals diagnosed with dyscalculia tend to exhibit persistent difficulties with mathematical concepts throughout their academic career, as opposed to a particular area of difficulty. This can result in consistently poor performance in mathematics, despite possessing average cognitive abilities and excelling in other academic domains. Dyscalculia can impair a student's understanding and adherence to mathematical problem-solving instructions, potentially leading to frustration and anxiety.

Students with dyscalculia commonly encounter difficulties in comprehending fundamental mathematical concepts, including numbers and their operations. Moreover, they tend to exhibit an atypical comprehension of mathematical concepts such as fractions and algebra. Additionally, individuals with this condition exhibit poor spatial abilities, revealing challenges in retaining information within their working memory. Frequent indications of dyscalculia in the classroom include using audible or manual counting techniques and challenges in comprehending instructions about mathematical tasks.

This study's findings suit the 20 characteristics that were classified into four domains, as Yoong & Ahmad (2021) suggested. However, the study did not indicate a correlation between dyscalculia and a tendency towards depression and anxiety among students. In addition, the findings of the present study supported the findings of Agostini et al. (2022) as well as Mishra & Khan (2022), which concluded that the cognitive abilities of students with dyscalculia were significantly impacted and could be seen in the classroom.

Difficulties that Students with Dyscalculia Faced

Since dyscalculia is a condition that impairs a student's ability to comprehend and process mathematical information, students with dyscalculia will face numerous challenges in the classroom when learning mathematics. Students with dyscalculia commonly have problems with fundamental mathematics concepts throughout their school years (Gut et al., 2021; Lewis, Sweeney, et al., 2022; Lewis, Thompson, et al., 2022; Liu et al., 2022; Vigna et al., 2022), like numbers, operations with numbers (Ahuja et al., 2022; Cheng et al., 2020; Dehghani, 2019; Gut et al., 2021; Kariyawasam et al.,

2019; Kißler et al., 2021; Kunwar & Sharma, 2020; N. Onyishi & M. Sefotho, 2021; Noordin et al., 2020; Patricia & Zamzam, 2021; Putri Purwaningrum et al., 2022; Vigna et al., 2022; Ziadat, 2022), and mathematical relationships. They may have difficulty comprehending the meaning behind the mathematical symbols and expressions, leading them to have difficulty developing the advanced mathematical skills they need in class. In addition to this, they might have trouble converting information that is verbally communicated or written down into numerical or symbolic representations (Ahuja et al., 2022; Firmasari et al., 2021; Lewis, Sweeney, et al., 2022; Liu et al., 2022; Ziadat, 2022). Students with dyscalculia may also find it hard to understand and follow instructions for math problems (N. Onyishi & M. Sefotho, 2021; Noordin et al., 2020). They might have trouble following written or spoken instructions and need more help or clarification. Thus, they might miss important parts of a problem, which could lead to wrong answers.

As previously mentioned, dyscalculia is frequently characterized by poor spatial skill (Aprinastuti et al., 2020; Firmasari et al., 2021; Liu et al., 2022; Mariera et al., 2021), which can make it challenging to comprehend numerical relationships and quantities through visualization. This issue can manifest itself in a variety of ways, including difficulty with number lines, graphs, and other visual representations of mathematical concepts (Cheng et al., 2020; Mariera et al., 2021; Patricia & Zamzam, 2021; Putri Purwaningrum et al., 2022).

The challenges that students who have dyscalculia face do not consist solely of those that are associated with the process of learning and solving mathematical problems; but also coping with the psychological challenges that come along with the condition as it impairs students' neurodevelopment. Students with dyscalculia frequently have a weak working memory, making it difficult for them to remember and recall information related to numbers and mathematics (Ahuja et al., 2022; Deghani, 2019; Liu et al., 2022; Mariera et al., 2021; Patricia & Zamzam, 2021; Vigna et al., 2022; Ziadat, 2022). This can make it difficult to solve problems efficiently and quickly. Students with dyscalculia may struggle with time management (Kunwar & Sharma, 2020; Mariera et al., 2021) and word problem-solving (Firmasari et al., 2021; Ziadat, 2022). These struggles can lead to anxiety and stress related to mathematics (Fauzan et al., 2022), which can further impact academic development as they are unable to complete the cognitive task demanded by the school (Lazo-Amado et al., 2022; Purwaningrum et al., 2021). Anxiety and mathematics-related stress have a greater potential to occur if the individuals are trying to succeed in both their academic and personal lives (Lazo-Amado et al., 2022; Lewis, Sweeney, et al., 2022; Vigna et al., 2022). Students who have dyscalculia may have difficulty with a variety of academic tasks in addition to learning mathematics, including paying attention in class (Lazo-Amado et al., 2022; Liu et al., 2022; Mariera et al., 2021), reading (Aprinastuti et al., 2020; Firmasari et al., 2021; Kißler et al., 2021; Lazo-Amado et al., 2022), as well as writing (Jannah & Bharata, 2020; Lazo-Amado et al., 2022; Patricia & Zamzam, 2021).

The current study has revealed several difficulties that students with dyscalculia face within the classroom. Dyscalculia is a condition that impairs a student's ability to comprehend and process mathematical information. Therefore, students may encounter challenges in converting verbal or written information into numerical or symbolic representations, executing instructions, and efficiently resolving problems due to insufficient working memory. Apart from mathematics, students with dyscalculia may

encounter challenges with their focus, literacy, and written expression. Dyscalculia has been shown to have a negative impact on psychological well-being, causing anxiety and stress concerning mathematical tasks. It can harm both academic and personal development.

The results suggested that difficulties faced by students with dyscalculia in the classroom correlated with the characteristics that teachers might encounter in the classroom. Furthermore, these results were suitable with prior studies (Agostini et al., 2022; Mishra & Khan, 2022; Yoong & Ahmad, 2021), indicating that students' cognitive abilities impact the difficulties they encounter in the mathematical classroom setting. However, these studies did not address the possibility that students with dyscalculia might struggle with mental health issues.

Conclusions and Suggestions

This study aimed to identify and synthesize existing evidence regarding differences in understanding of dyscalculia and its characteristics, as well as the challenges that students with dyscalculia may face in class. There are differences in understanding what dyscalculia is, resulting in various definitions. Nonetheless, it can be argued that dyscalculia is a specific learning disorder that impairs numerical concept comprehension and manipulation. Students with dyscalculia face persistent difficulties in various mathematical domains, leading to consistently poor academic performance and potential feelings of frustration and anxiety. These difficulties relate to basic mathematical concepts, poor spatial abilities, working memory limitations, and difficulties following instructions and problem-solving. The impact of dyscalculia is not limited to the mathematical domain, as it has been found to affect students' concentration, literacy and written expression. The results emphasize the significance of understanding the diverse characteristics of dyscalculia and providing suitable interventions and accommodations to support affected students. Given the potential impact of dyscalculia on academic and personal life, it is crucial to continue research in this area as well as whether differences of opinion regarding what dyscalculia is can affect whether a student is diagnosed with dyscalculia or not, especially those in middle school or older.

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