

**Examining the Level of Dyscalculia Awareness among Primary and Secondary
School Mathematics Teachers in Urban Mainstream Schools in South Kazakhstan**

Azhar Satybaldy

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Ethical Approval



53 Kabanbay Batyr Ave.
010000 Astana,
Republic of Kazakhstan
22th October 2021

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This letter now confirms that your research project entitled *Examining the Level of Dyscalculia Awareness among Primary and Secondary School Mathematics Teachers in Urban Mainstream Schools in South Kazakhstan* has been approved by the Graduate School of Education Ethics Committee of Nazarbayev University.

Yours sincerely,

Rita Kasa, Assistant Professor

On behalf of Zumrad Kataeva
Chair of the GSE Ethics Committee
Assistant Professor
Graduate School of Education
Nazarbayev University

Block C3, Room 5006
Office: +7 (7172) 70 9371
Mobile: +7 777 1929961
email: zumrad.kataeva@nu.edu.kz

CITI Training Certificate



Completion Date 13-Jul-2019
Expiration Date 12-Jul-2022
Record ID 31901939

This is to certify that:

Azhar Satybaldy

Has completed the following CITI Program course:

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**EXAMINING THE LEVEL OF DYSCALCULIA AWARENESS AMONG
PRIMARY AND SECONDARY SCHOOL MATHEMATICS TEACHERS IN
URBAN MAINSTREAM SCHOOLS IN SOUTH KAZAKHSTAN**

Abstract

Dyscalculia is defined as a specific learning disability in mathematics with some challenges in arithmetic skills, math problem-solving skills, calculations, processing, and remembering mathematical facts (APA, 2018). Although this phenomenon is less studied than reading difficulties such as dyslexia, its prevalence rates are no less and range from 3% to 6% among the world's population (Kucian & Von Aster, 2015). Dyscalculia poses significant difficulties in school as students with dyscalculia have a greater degree of math anxiety and poorer achievement than other students (Kucian et al., 2018). Dyscalculia is a permanent disability; however, adequate support and early identification may reduce to the minimum the difficulties it causes to the child (Sousa et al., 2017). Accordingly, teachers' sufficient knowledge regarding dyscalculia is essential in identifying at-risk students and providing the necessary support to them in the classroom.

The present study examined the level of dyscalculia awareness among primary and secondary school mathematics teachers in urban mainstream schools in South Kazakhstan. This study utilized a quantitative survey research design. Overall, 751 teachers from 60 schools participated in an online anonymous survey. The present study examined teachers' knowledge about dyscalculia across three dimensions i.e., definition and nature of dyscalculia, its symptoms, and methods of intervention. The findings indicate that teachers have limited knowledge about the definition and nature of dyscalculia as well as its symptoms. However, teachers are better informed about intervention methods than the nature and symptoms of dyscalculia. It was revealed that, on average, teachers at both levels of education hold very similar views about this disability. Furthermore, it was

revealed that teachers' exposure to the phenomenon of dyscalculia is associated with better knowledge about dyscalculia.

Keywords: inclusive education, dyscalculia, teachers' awareness, teachers' knowledge, primary school, secondary school, Kazakhstan.

**ОҢТҮСТІК ҚАЗАҚСТАНДАҒЫ ҚАЛАЛЫҚ ОРТА МЕКТЕПТЕРДЕГІ
БАСТАУЫШ ЖӘНЕ ОРТА БУЫНДАРЫНЫҢ МАТЕМАТИКА ПӘНІ
МҰҒАЛІМДЕРІНІҢ ДИСКАЛЬКУЛИЯ ТУРАЛЫ ХАБАРДАРЛЫҚ
ДЕҢГЕЙІН ЗЕРТТЕУ**

Аңдатпа

Дискалькулия - арифметикалық дағдылар, математикалық есептерді шешу дағдылары, есептеулер, математикалық фактілерді өңдеу және есте сақтаудағы қиындықтары бар математикадағы оқу кемістігі ретінде анықталады (APA, 2018). Бұл құбылыс дислексия сияқты оқу қиындықтарына қарағанда аз зерттелгенімен, оның таралу деңгейі кем емес және әлем халқы арасында 3% -дан 6% -ға дейін ауытқиды (Kucian & Von Aster, 2015). Дискалькулия мектепте айтарлықтай қиындықтар туғызады, өйткені дискалькулиясы бар оқушылардың математикалық мазасыздық деңгейі жоғары және басқа оқушыларға қарағанда оқу үлгерімі төмен (Kucian et al., 2018). Дискалькулия тұрақты құбылыс; дегенмен, адекватты қолдау және ерте анықтау балаға әкелетін қиындықтарды барынша азайта алады (Sousa et al., 2017). Тиісінше, мұғалімдердің дискалькулия туралы жеткілікті білімі қауіп тобындағы оқушыларды анықтау және оларға сыныпта қажетті қолдау көрсету үшін өте маңызды.

Бұл зерттеу Оңтүстік Қазақстандағы қалалық орта мектептердің бастауыш және орта сыныптарында математика пәні мұғалімдерінің дискалькулия туралы хабардарлық деңгейін зерттеді. Бұл зерттеуде сандық зерттеу дизайны қолданылды. Анонимді онлайн сауалнамаға қаланың 60 орта мектебінен барлығы 751 мұғалім қатысты. Бұл зерттеу мұғалімдердің дискалькулия туралы білімін үш өлшем бойынша зерттеді, яғни дискалькулияның анықтамасы мен табиғаты, оның белгілері және қолдау әдістері. Нәтижелер мұғалімдердің дискалькулияның анықтамасы мен

табиғаты, сондай-ақ оның белгілері туралы білімі шектеулі екенін көрсетеді.

Дегенмен, мұғалімдер дискалькулияның табиғаты мен белгілерінен гөрі қолдау әдістері туралы жақсырақ хабардар екені айқындалды. Орташа алғанда екі буындағы мұғалімдердің дискалькулияға көзқарастары өте ұқсас екені анықталды. Сонымен қатар, мұғалімдердің дискалькулия құбылысымен бұрынғы байланысы дискалькулия туралы жақсы біліммен байланысты екені анықталды.

Түйін сөздер: *инклюзивті білім беру, дискалькулия, мұғалімдердің хабардарлығы, мұғалімдердің білімі, бастауыш мектеп, орта мектеп, Қазақстан.*

**ИССЛЕДОВАНИЕ УРОВНЯ ОСВЕДОМЛЕННОСТИ О ДИСКАЛЬКУЛИИ
СРЕДИ УЧИТЕЛЕЙ МАТЕМАТИКИ НАЧАЛЬНЫХ И СРЕДНИХ КЛАССОВ
В ГОРОДСКИХ ОБРАЗОВАТЕЛЬНЫХ ШКОЛАХ ЮЖНОГО КАЗАХСТАНА**

Аннотация

Дискалькулия определяется как особая неспособность к обучению в математике с некоторыми проблемами в арифметических навыках, навыках решения математических задач, вычислениях, обработке и запоминании математических фактов (APA, 2018). Хотя это явление менее изучено, чем трудности с чтением, такие как дислексия, показатели его распространенности не меньше и составляют от 3% до 6% населения мира (Kucian & Von Aster, 2015). Дискалькулия создает значительные трудности в школе, поскольку учащиеся с дискалькулией имеют большую степень беспокойства по математике и более низкую успеваемость, чем другие учащиеся (Kucian et al., 2018). Дискалькулия имеет постоянный характер; однако адекватная поддержка и раннее выявление могут свести к минимуму трудности, которые это вызывает у ребенка (Sousa et al., 2017). Соответственно, достаточные знания учителей о дискалькулии необходимы для выявления учащихся из группы риска и оказания им необходимой поддержки в классе.

В данном исследовании изучался уровень осведомленности о дискалькулии среди учителей математики начальных и средних классов городских общеобразовательных школ Южного Казахстана. В этом исследовании использовался количественный исследовательский дизайн. Всего в анонимном онлайн-опросе приняли участие 751 учитель из 60 городских общеобразовательных школ. В настоящем исследовании изучались знания учителей о дискалькулии по трем параметрам: определение и характер дискалькулии, ее симптомы и методы вмешательства. Результаты показывают, что учителя имеют ограниченные знания об

определении и природе дискалькулии, а также о ее симптомах. Однако учителя лучше информированы о методах вмешательства, чем о природе и симптомах дискалькулии. Выявлено, что в среднем учителя обоих уровней образования придерживаются очень близких взглядов о дискалькулии. Кроме того, выявлено, что предыдущий контакт учителей с феноменом дискалькулии в значительной степени связана с более высоким уровнем знаний о дискалькулии.

Ключевые слова: *инклюзивное образование, дискалькулия, информированность учителей, знания учителей, начальная школа, средняя школа, Казахстан.*

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Introduction

Background of the Study

Mathematics is one of the primary subjects at school which is foundational in acquiring knowledge and skills. Mathematics is not only an important school subject but is also used in everyday life which is heavily based on numeracy starting from time management, shopping, calculating money, and other social and economic activities. Furthermore, an inadequate level of mathematical skills may impact individuals' educational perspectives, employability, and salaries even if they are highly literate (Parsons et al., 2005; Rivera-Batiz, 1992, as cited in Soares et al., 2018). The term used to describe students who have challenges in arithmetic skills, calculations, reasoning, remembering math facts, and solving mathematical problems is called dyscalculia (American Psychiatric Association, 2018). The term itself stems from the Greek word "dys" which means "badly", and the Latin word "calculare" which means "to count" (Kunwar & Sharma, 2020). So, the term dyscalculia means bad at counting. Students with dyscalculia manifest in the classroom with short-term and long-term memory problems, symptoms such as confusing mathematical symbols and signs, and having difficulties with measurement, direction, time, and speed. They are not able to subitize and do not have an intuitive grasp of numbers (Williams, 2013). They may often use their fingers when counting while their peers left this strategy a long time ago.

Mathematical disability is common among mathematics learners (Sousa et al., 2017). It is estimated that 3 to 6% of people worldwide have dyscalculia (Haring, 2020; Kosci, 1974; Kucian & Von Aster, 2015; Shalev & Von Aster, 2008). Statistics aside, individuals with dyscalculia are likely to encounter serious hardships starting from their school years and persisting throughout their lives (Sousa et al., 2017). Dyscalculia has a significant influence on people's lives affecting their career choices, psychological and emotional

wellbeing, as well as social relationships (Wadlington et al., 2006). This can be seen in the case of a teacher with dyscalculia who was trying to avoid having lunch with his colleagues and always used a credit card so as not to be in a situation to count money (Wadlington et al., 2006).

It is important to note that not every student with difficulties in mathematics will necessarily have dyscalculia. Mazzocco (2005) suggests distinguishing between mathematical difficulties and disabilities, the former being more overarching than the latter. Mathematical difficulties may be related to insufficient instruction, social environment, home, and school atmosphere. Whereas, mathematical disability has a biological set of causes (Mazzocco, 2005). Mathematical difficulties are affected by environmental causes and may disappear after an intervention. On the other hand, mathematical disability is long-lasting, and symptoms may not disappear with proper assistance. In any instance, children with this disability would definitely benefit from initiated support (Kosc, 1974).

Dyscalculia is a less researched phenomenon compared to reading disabilities such as dyslexia. The fact that dyscalculia is less often encountered than dyslexia and other learning disabilities, does not mean that the disorder is rare. Perhaps it is camouflaged under disorders (Dias et al., 2013) such as ADHD, dyslexia, depression, anxiety, as well as other factors such as crowded classes, social and family problems, inadequate teaching methods, or curriculum (Shalev & Von Aster, 2008). Dyscalculia may co-occur with dyslexia in 50% of cases, and with ADHD in 40% of cases (Williams, 2013). These statistics reasonably explain the possible reason for the underdiagnosis of the learning disability.

Another reason for the underdiagnosing of dyscalculia is an identification gap which leads to a late diagnosis of the disability. Altarac and Saroha (2007, as cited in Graves,

2018) reported that in the USA many children remain undiagnosed with a learning disability (LD) until the ages of 10-14 and 15-17. The authors claim that the reason is not that LD starts at these ages, but that there exists a gap between when the child is suspected to have a learning disability and eventually diagnosed with having it. This gap can continue for 3.5 years. There is a tendency that children with LD are diagnosed more often as they become older (Child Trends, 2016, as cited in Graves, 2018). Thus, there is a need to close the gap between the first suspicion of the condition and the diagnosis of it.

One more reason for the underdiagnosing of dyscalculia could be the social notion that a person is either good or bad at mathematics (Holaway, 2020). Mathematics is one of those subjects where many students perform poorly, and dyscalculia is one of the many reasons for low academic achievement in mathematics (Kunwar & Sharma, 2020). A common feature of students with dyscalculia is that they can be successful in other subjects but challenged in mathematics. The danger is that these students don't get the help they need; their condition should be regarded as more serious than simply being bad at mathematics (Hornigold, 2015, as cited in Kunwar & Sharma, 2020).

Research has shown that teachers play a crucial role in identifying learning disabilities among students (Dias et al., 2013). For example, dyslexia as a learning disability most often begins to manifest itself when students get to school (Chideridou-Mandari et al., 2016). This factor makes a teachers' role significant in the identification of dyslexia and its further development (Chideridou-Mandari et al., 2016). It would be fair to presume that a teachers' role in identifying dyscalculia is equally important.

Inclusive Education and Dyscalculia in Kazakhstan

Since 1991, Kazakhstan has prioritized inclusive education as one of the important strategic directions in the development of its education (Makoelle, 2018). Kazakhstan has ratified international documents including the UN Convention on the Rights of the Child in

1994, the Convention on the Rights of Persons with Disabilities, legislated in 2015, and Convention against Discrimination in Education legislated in 2016 (Ramazanova, 2020). Signing these documents that affirm equal access to education for people with special educational needs, Kazakhstan demonstrates a determination to maintain and support inclusive education and the international movement of Education for All (EFA). Since then, the government has established several documents at the legislative level. The latest legislation on inclusive education was signed by president Qasym-Zhomart Tokayev on the need to update the current standards that are used in inclusive and special education (Sputnik, 2021). It is expected that the standards will be updated according to the Convention on the Rights of Persons with Disabilities. Kazakhstan has made considerable effort and progress in the development of inclusive education; however, it is only at the start of a long way toward implementation in the classrooms (Makoelle, 2018). Despite the ratified reforms and steps taken to improve inclusive education, there remain inconclusive issues of recognizing and addressing learning disabilities like dyscalculia in the classrooms. Currently, it is not recognized and there is no legislative basis for diagnosing, assessing, and assisting dyscalculia as a disability in Kazakhstan.

Problem Statement

A significant amount of research can be found in the literature on teachers' knowledge of other learning disabilities like dyslexia, etc. However, a relatively scarce amount of research can be found on teachers' awareness of dyscalculia (Williams, 2013).

Research that exists indicates that the lack of teachers' knowledge about dyscalculia has been revealed as one of the biggest barriers in assisting children with dyscalculia (Graves, 2018). Consequently, teachers' insufficient knowledge regarding dyscalculia can lead to a failure to see the symptoms of students in the classroom and provide the necessary assistance to them. Because the more teachers know about the nature of

dyscalculia and are trained on educational methods, the more effective support they can provide for their students (Butterworth et al., 2011, as cited in Sousa et al., 2017). This, in turn, will positively affect the learning of students who have dyscalculia and other difficulties in mathematics.

There is insufficient research on dyscalculia in Kazakhstan, contributing to a low level of teachers' knowledge about dyscalculia. Because dyscalculia is not officially diagnosed as a disability in Kazakhstan, there is no information on its prevalence across the country. According to the National Scientific and Practical Center for the Development of Special and Inclusive Education (NSPC DSIE) (2020), dyscalculia is referred to as a specific learning disability (SLD) in Kazakhstan and there is no exact definition of it. Children in Kazakhstan are not officially diagnosed, assessed, or assisted by professionals and educators likely because of insufficient knowledge about SLD and dyscalculia. Another problem is that inclusive education is conflated with special education in Kazakhstan (Makoelle, 2018). This is another likely reason that educators don't have resources to support their students with learning disabilities such as dyscalculia. In addition, as teachers report, they are neither trained on dyscalculia at the university level as students nor at the school level as educators (Zhanatbekova, 2018). This leads to a situation where teachers miss the symptoms of students who need help and leave them without any assistance in learning. Since the role of teachers in the identification of dyscalculia is central, their knowledge about it remains crucial.

Purpose of the Study

The purpose of the study is to examine the level of dyscalculia awareness among primary and secondary school mathematics teachers in urban mainstream schools in one of the large cities in South Kazakhstan with respect to understanding the definition and nature of the phenomenon, recognizing its symptoms, and methods of intervention.

The study seeks to answer the following research question:

- To what extent are primary and secondary mathematics school teachers in urban mainstream schools in South Kazakhstan aware of dyscalculia in respect to understanding the definition and nature of the phenomenon, recognizing its symptoms, and intervention methods?

It also tests the following hypotheses:

- H1: Primary and secondary school mathematics teachers' awareness of the definition and nature of dyscalculia is low.
- H2: Primary and secondary school mathematics teachers' awareness of the symptoms of dyscalculia is low.
- H3: Primary and secondary school mathematics teachers' awareness of the interventions to support students with dyscalculia is low.
- H4: The level of awareness about the definition, nature, symptoms of dyscalculia, and interventions among primary and secondary school mathematics teachers is at the same level.
- H5: Exposure to the phenomenon of dyscalculia is associated with a better level of knowledge about dyscalculia. The exposure is measured via two criteria:
 1. Theory: have respondents heard about the phenomenon of dyscalculia in any of the pre-service, in-service teacher training courses, from colleagues/friends, or as a self-study.
 2. Experiential: have they encountered students with math difficulties in class as suspected cases of dyscalculia.

Significance of the Study

There is relatively scarce research on teachers' knowledge about dyscalculia even though the number of students diagnosed with dyscalculia is increasing (Chideridou-

Mandari et al., 2016). The scarcity of literature and research makes it harder to identify the level of knowledge teachers have about dyscalculia and how they support their students in educational settings. Mathematical learning disability (MLD) poses significant difficulties in school as students with dyscalculia have a greater degree of math anxiety and poorer achievement than other students (Kucian et al., 2018). One of the reasons for students' reluctance or negative reactions to learning mathematics may be teachers' poor knowledge of MLD (Kunwar et al., 2021). Furthermore, dyscalculia may negatively affect the career choices of students with this learning disability. This is evident in the case of a student with dyscalculia who initially wanted to be a computer scientist, but after failing high school mathematics classes for two years in a row, his teachers set him on a course for a language degree as opposed to computer science (Wadlington et al., 2006). This advice opposite to the student's career aspirations can be explained by the lack of teachers' knowledge of dyscalculia. Teachers' lack of knowledge is likely to result in inadequate assistance, low expectations, and little effort in supporting those students. Teachers' little effort and low expectations for students are exemplified in the work by Zhanatbekova (2018), where teachers reported that they assigned simpler tasks to their students with mathematical difficulties in the classroom. Therefore, it is important for teachers to have adequate knowledge about dyscalculia, its manifestations in the classroom, and strategies of appropriate interventions and guidance in school for students with MLD. Otherwise, low levels of knowledge among teachers can lead to a failure to detect on time the symptoms of students with MLD who need help. However, existing national and international findings indicate that the majority of teachers do not have enough knowledge about dyscalculia (Chideridou-Mandari et al., 2016; Dias et.al, 2013; Graves, 2018; Karasakal, 2018; Zhanatbekova, 2018). Considering all of the above, the results of this study will be useful to inform the actions of the government, school administrations, and

teachers themselves in Kazakhstan. It is also expected that this study will contribute to the academic field examining teachers' knowledge of dyscalculia on primary and secondary education levels.

Definitions of Central Concepts

Different concepts are used in research related to difficulties in learning mathematics. These terms include “mathematical learning difficulties”, “mathematical learning disabilities”, “dysnomia”, “arithmetical difficulties”, “developmental dyscalculia”, etc. They all describe the notion of dyscalculia. As this thesis focuses on dyscalculia, these terms will be used in this study interchangeably.

The key terms of the study:

- *Dyscalculia* is a term used for difficulties learning mathematics. These difficulties include poor memorization of math facts, poor calculation skills, as well as poor math problem solving and math reasoning skills (APA, 2018).
- *Numeracy* - “ability to understand and work with numbers: the quality or state of being numerate” (Merriam-Webster, n.d.).
- *Knowledge* - “the fact or condition of knowing something with familiarity gained through experience or association” (Merriam-Webster, n.d.).
- *Awareness* - “knowledge and understanding that something is happening or exists” (Merriam-Webster, n.d.). In this study, teachers' awareness of dyscalculia and their knowledge regarding its definition, nature, symptoms, as well as intervention methods are examined. Since these terms are used interchangeably in the literature, they are also used interchangeably in this study.

- *Specific learning disability* is defined as a condition affecting children in at least one of these learning areas: reading, writing, and mathematics, and is not the result of reduced intelligence or poor quality of education (APA, 2018). It is important to note that even though the terms “learning disability” and “learning disorder” are not exact synonyms of one another (APA, 2018), they are used interchangeably in research and are used in this study as well.

Thesis Outline

This thesis introduces the phenomenon of dyscalculia and teachers' awareness of this disability in the world and in the context of Kazakhstan, which is presented and discussed in each chapter of this thesis. The first introductory chapter presents the problem statement, significance of the research as well as clearly states the main aims and hypotheses of the study.

Chapter two reviews the existing literature on the phenomenon of dyscalculia and provides information about its definition, nature, symptoms, diagnosis, as well as intervention methods. The second chapter also highlights different theories that exist around dyscalculia. Eventually, teachers' awareness of dyscalculia across the world and in Kazakhstan is also reviewed in this chapter.

The third chapter is concerned with the methodology used for this study. Chapter four analyses the results of the survey questionnaire regarding teachers' knowledge of dyscalculia, which is then discussed with reference to the literature in chapter five. Finally, chapter six concludes with the overall findings and suggestions for further research.

Literature Review

Specific Learning Disabilities and Dyscalculia

This chapter presents a review of the literature on the phenomenon of dyscalculia. To better understand this disability, sections of this chapter are organized firstly to define dyscalculia in relation to other learning disabilities. Secondly, to present information on how the term emerged, as well as to discuss the nature, and symptoms of dyscalculia. To address the possible causes of dyscalculia, views that exist around this phenomenon are also discussed. Sections in this chapter review the types of dyscalculia, diagnosis, interventions, and why we need to understand teachers' awareness of this disability. Research on learning disabilities conducted in Kazakhstan is also reviewed.

Specific Learning Disabilities

Dyscalculia is a type of specific learning disability (SLD). SLD is defined as a neurological disability that starts at school time and hinders the ability of children to learn, which manifests itself in foundational skills such as reading, writing, or mathematics (American Psychiatric Association, 2018). The prevalence rates of SLD vary between 5-14% of the school-age student population in the world (Geary, 2013, as cited in Kunwar et al., 2021). SLD is an overarching term that encompasses learning disabilities such as dyslexia (difficulties in reading), dysgraphia (difficulties in writing), and dyscalculia (difficulties in mathematics). These types of learning disabilities are often comorbid with each other, i.e., people who have dyscalculia will often also have dyslexia or dysgraphia (Willcutt et al., 2019). This comorbidity makes the process of identification of SLD more difficult. Thus, to better understand each of these learning disabilities they are briefly explained in the following paragraphs.

Dyslexia is a language-related neurobiological disability manifested by inaccurate word recognition, poor spelling, and decoding competencies (International Dyslexia

Association [IDA], 2002). Typically, people with dyslexia have reading difficulties, poor vocabulary, and poor understanding of what they have just read (IDA, 2002). Moreover, between 30-60% of children diagnosed with dyslexia also have comorbid math difficulties (Soares et al., 2018; Willcutt et al., 2019). One explanation for this common comorbidity is that it is more difficult for dyslexic students with reading difficulties (RD) to learn mathematics involving word problems and symbols (Willcutt et al., 2019). Approximately 5% (Kaufmann & Von Aster, 2012) of primary school students and 6% (Robert & Sarah, 2014, as cited in Kunwar et al., 2021) of people around the world have dyslexia.

Dysgraphia is a “specific learning disorder in written expression” (Chung et al., 2020, p.46). People with dysgraphia have difficulties with writing and spelling skills, are often slower in writing than others, skip some letters in the words when writing, and may produce grammatical errors in the sentences (Chung et al., 2020). The literature reports varying prevalence estimates of the disability as between 10-34% among primary school students (Rosenblum & Dror, 2016) and 7-15% amongst school-age children around the world (Sharma, 2020, as cited in Kunwar et al., 2021).

The term “dyscalculia” literally means bad at counting (Kunwar & Sharma, 2020). Sometimes it is referred to as “math dyslexia” or “number blindness”. However, it is a “heterogeneous learning impairment affecting numerical and/or arithmetic functioning at behavioral, psychological and neuronal levels” (Kucian & Von Aster, 2015, p.3). People with dyscalculia have some challenges in arithmetic, calculations, reasoning, remembering math facts, and solving mathematical problems (APA, 2018). Children with dyscalculia often lag behind their peers in academic performance, and perform tasks inaccurately and slower than typically developing children (Monei & Pedro, 2017). Yet these difficulties are not caused by low intelligence levels (Monei & Pedro, 2017). It is important to note that dyscalculia should not be confused with acalculia, which is acquired later in life and is a

consequence of brain injuries (Ardilla & Roselli, 2002). By contrast, dyscalculia is innate and has neurological origins.

Prevalence of Dyscalculia

It is difficult to evaluate the predominance of dyscalculia in the world mainly because its identification directly depends on the definition of the disability. As there is no universally accepted definition of dyscalculia, different definitions applied in different countries lead to different diagnostic criteria. Thus, its prevalence rates cannot be compared across countries. However, there are numerous studies with the same patterns of findings on the proportion of dyscalculic people in the population which makes a global estimate of between 3 to 6% reasonably reliable (Kosc, 1974; Kucian & Von Aster, 2015; Shalev & Von Aster, 2008). Specifically, it is estimated that 6 to 8% of students in the world have dyscalculia (Sharma, 2020, as cited in Kunwar et al., 2021), and around 5% are in primary schools (Kaufmann & Von Aster, 2012). This is underpinned by the results of the two independent studies in India, in which prevalence rates reached 5.98% and 5.54% in all primary school children (Ramaa & Gowramma, 2002). Kucian and Von Aster (2015), as well as Jovanović et al. (2013), have found that dyscalculia is more prevalent among boys than girls. However, there are studies that contradict this finding. Statistics from Austria (Landerl & Moll, 2010) and Pakistan (Ashraf & Najam, 2020), indicate that more girls have arithmetic difficulties than boys. There are even discrepancies in gender ratios among students with dyscalculia within the same study, depending on the methodology. In the study of Ramaa and Gowramma (2002), the prevalence of dyscalculia among male and female students was based on the criteria used for the diagnosis. More boys were identified with dyscalculia when the researchers used diagnostic tests. Yet, more girls were identified based on the teachers' observations of students' strategies when solving problems which were then reported to the researchers. The prevalence was equal

for both boys and girls if exclusionary criteria were applied. This means that if students met all the criteria that exclude all the external factors such as school absenteeism and include factors such as having an adequate motivation for learning, lagging behind for two years in arithmetic, and not having serious emotional and/or behavioral issues.

Comorbidity

One of the reasons affecting the prevalence rates of dyscalculia could be comorbid disorders under which dyscalculia could have been masked. The highest rates of comorbidity with mathematical learning disabilities belong to reading disabilities (RD) and attention deficit hyperactivity disorder (ADHD). For a person with dyscalculia, the possibility of also having dyslexia is 50%, and ADHD 40% (Williams, 2013). If a student with dyscalculia is also dyslexic, it will be even harder for them to solve word problems as previously discussed. Indeed, research reveals that students with dyscalculia who also have RD show worse results in solving word problems than those without RD (Andersson, 2008; Fuchs & Fuchs, 2002, as cited in Chideridou-Mandari et al., 2016). Given these statistics of comorbidity, the process of identifying one specific learning disability becomes more difficult, since one disorder may be masked by the second one.

Mathematical Anxiety

As math difficulties often coexist with the other disorders mentioned above, math anxiety can be an effect of these comorbid difficulties (Kucian & Von Aster, 2015). Children with dyscalculia typically have a greater degree of math anxiety. For instance, Kucian et al. (2018) reported that students with dyscalculia had higher math anxiety and poorer performance in comparison with other children. Interestingly, Mammarella et al. (2015) discovered that deficits in verbal working memory were specific to children with math anxiety, and deficits in visuospatial working memory were specific to children with dyscalculia (as cited in Kucian et al., 2018). However, currently, it is unknown whether

math anxiety is a cause of dyscalculia, but it surely poses some problems for students with dyscalculia and affects their learning process by exacerbating the existing condition (Butterworth, 2005b).

This section has given an overview of several common learning disabilities. The next sections of the literature review specifically focus on dyscalculia. They discuss its definition, nature, symptoms, types, and potential causes of the disability. Also, they discuss different views and theories that exist around dyscalculia in the research field.

Definition, Nature, and Symptoms of Dyscalculia

The term “dyscalculia” was first used in 1940, yet it was only acknowledged in 1974 when Ladislav Kosc defined it as:

...a structural disorder of mathematical abilities which has its origin in a genetic or congenital disorder of those parts of the brain that are the direct anatomico-physiological substrate of the maturation of the mathematical abilities adequate to age, without a simultaneous disorder of general mental functions (p.47).

Kosc's (1974) study has established that the notion has nothing in common with mental disabilities which affect people's intellect and thinking. He further stated that people differ from each other by their abilities and if developmental dyscalculia (DD) is present in children, does not mean that abilities are evenly afflicted by the disorder (Kosc, 1974). This means that children with dyscalculia may excel in one area but underachieve in another. Their intellect may be either low or at an average level regardless of having dyscalculia.

Kosc (1974) has classified dyscalculia into (1) verbal dyscalculia, (2) practognostic dyscalculia, (3) lexical dyscalculia, (4) graphical dyscalculia, (5) ideognostical dyscalculia, and (6) operational dyscalculia. Verbal dyscalculia is when a person is constrained to recognize the spoken numerical quantities, or vice versa, cannot speak out numerals that have been shown to them although they can read or write the same numbers. Practognostic dyscalculia is manifested by the problems with comparing real or illustrated things,

sequencing them, and understanding concepts such as bigger/smaller, more/less, and other comparisons. Lexical dyscalculia is present when a child is not able to read math symbols, operational signs, and multi-digit numbers, cannot distinguish pairs of numbers (6 and 9, 2 and 5, 3 and 8), and may read numbers reversed (17 as 71). Graphical dyscalculia is demonstrated when a child cannot write numbers or symbols whether it is orally dictated or if the child should replicate a written number. They may write them inverted or rotated. Interestingly, a child may be able to write the word for a dictated number, but not the numerical value. In the literature, the lexical type is also called “numerical dyslexia” and the graphical type is called “numerical dysgraphia” (Kosc, 1974). It is important to note that these reading and writing difficulties are specific to the mathematics domain. Ideognostical dyscalculia is displayed when problems arise in the conceptual understanding of mathematics. Children cannot solve simple mental calculations and do not understand the concept of conservation (e.g., “6”, “4+2”, and “2*3” are equivalent to each other). Finally, operational dyscalculia can be found in children who confuse and cannot use math symbols correctly, cannot select appropriate math symbols (or strategies) to solve problems, and continue to use their fingers to count when their peers have progressed to use other strategies. Despite this classification, the symptoms of different types of dyscalculia can be combined and found in one child.

Generally, children with dyscalculia have problems with the conceptual understanding of counting principles: *one-to-one correspondence*, in which one word corresponds to one number; *stable order*, in which the order of the numbers should not be changed when counting; *cardinality*, in which the last component of a set also indicates the quantity of the whole set; *abstraction*, in which any assortment of objects can form a set and be counted; *order irrelevance*, in which the order of the numbers/objects can be changed, and it does not affect the counting; and counting features which involve *standard*

direction and *adjacency* (an inaccurate belief that objects should be counted consecutively) (Geary, 2004, p.6). Moreover, children with dyscalculia often have problems with managing money, time (i.e., telling time from an analog clock, managing time in daily life) (Williams, 2013), and measurement (i.e., weight, temperature, and speed) (Sousa et al., 2017). They may struggle with applying the correct methods, formulas, and rules to solve math tasks; in severe cases, they cannot even solve simple calculations (Sousa et al., 2017). Besides, it is difficult for them to understand the actual representation of mathematical formulas (Soares et al., 2018). It is challenging for them to further move to theoretical interpretations of math concepts (Sousa et al., 2017). Additionally, they have short-term and long-term memory problems manifested by difficulties in memorizing multiplication tables, facts, and rules (Williams, 2013). Moreover, they have sequencing and directional confusion i.e., difficulties in distinguishing between Left and Right, as well as East and West (Williams, 2013). Furthermore, children with dyscalculia have difficulties in visual-spatial orientation and lateralization (Michaelson, 2007). They are not able to give explanations of and grasp information from maps and graphs (Sousa et al., 2017). Dyscalculia is not itself an effect of poor instruction, reduced intelligence, lack of motivation, emotional or social problems. Yet, undiagnosed it could exacerbate any existing difficulties with motivation and emotional issues.

Theories of Dyscalculia

Numerous theories exist around the notion of dyscalculia. They can be grouped into three main paradigms: neurobiological, cognitive, and educational. While the neurobiological perspective treats dyscalculia as a neurological disorder, the cognitive perspective treats it as a working memory deficit. What they both have in common is an “internalist” view of dyscalculia which views the causes as an innate deficit of neurological or cognitive mechanisms. In contrast to these first two theories, the

educational perspective remains externalist, which means that the behavioral features of dyscalculia are caused by environmental factors (Williams, 2013). These three perspectives are discussed in more detail below.

Neurobiological Perspective

The theories that fall under the neurological perspective are concentrated around systems such as the approximate number system (ANS) and object tracking system (OTS) whose efficiency determines mathematical competency. Neuropsychologists have mainly focused on investigating the two broad fields as the human brain and the genome. They define dyscalculia as an innate neurological disability that involves impairments in the structure and function of relevant areas of the brain and has a genetic predisposition. Hypotheses that support the idea of the biological causes of dyscalculia are termed domain-specific core deficit hypotheses. They imply that there are specific brain areas that are responsible for numerical cognition.

Researchers in the field of dyscalculia who adopted the neurobiological perspective searched for a core deficit in dyscalculia and argued that there should be a core characteristic for numerical awareness. These researchers have considered that the competency to recognize, manipulate, and compare magnitudes is a core characteristic of numerical skills (Chinn, 2015). These numerical skills are supposed to have neural correlates in particular regions of the brain. The deficiencies in those brain areas that constrain this ability were then thought to be a potential cause of dyscalculia. The hypothesis that supports this view is predominantly known as a deficit in the approximate number system (ANS) (Mazzocco et al., 2011). It implies that people with dyscalculia have difficulties in comparing and distinguishing between magnitudes in an approximate manner with the use of a mental number line. These approximate non-symbolic number representations or, in other words, number senses are considered to be innate in newborns

and also in many animal species (Fias, 2016). For the reason that animals and newborns cannot state the exact number of magnitudes, the term “approximate” is included. This hypothesis is also known as the number sense theory. ANS acuity is usually tested with a non-symbolic number comparison task where a child should decide whether one of the two presented strings of dots contains a greater number of dots (Traff et al., 2017). Research indicates that children with dyscalculia have less accuracy in ANS than other children (Mazzocco et al., 2011). Moreover, the results of the study by Mazzocco et al. (2011) demonstrated that ANS deficiency is a feature characteristic of children with dyscalculia.

Butterworth (2005a) has proposed a second core deficit called numerosity coding. It states that deficit in an innate number sense that allows recognizing the numerosities causes dyscalculia. To illustrate this, every day people encounter many numbers in different forms such as Arabic numerals (2), Roman numerals (II), number words (two), quantities (e.g., two dots, two books), time (2 o'clock), size, and height (Kucian & Von Aster, 2015). The common characteristic of these number expressions is that they display the number of elements (cardinality) in a set, which is the “numerosity” of a set according to Butterworth (2005a). The ability of subitizing and estimating quantities are the core elements of this hypothesis (Gillum, 2014). Subitizing is the skill of exactly naming the number of elements up to three or four, whereas estimating is approximately stating the number of elements above these numbers (i.e., above four). Another important element of this hypothesis is that it is not important for the things to be visible, they may be physical, audible, or abstract; the most important thing is to be able to recognize the numerosities. Furthermore, Butterworth (2005a) argues that all other difficulties of children with dyscalculia emerge from a deficit in numerosity, which implies a “lack of intuitive grasp of numbers” (p.12). For instance, addition and subtraction are usually taught to children through applying them and manipulating the sets. This means that development of

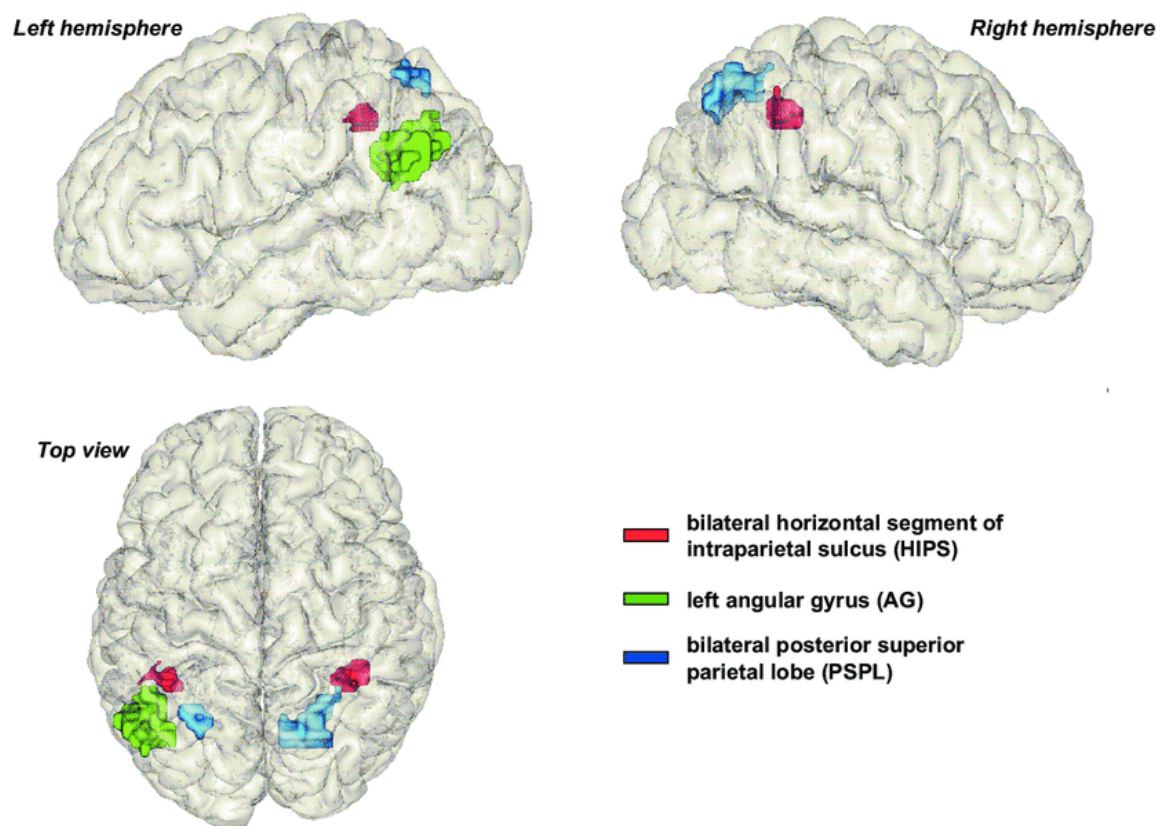
arithmetic skills is based on the understanding of numerosities. What Butterworth (2005a) argues is that if children struggle with subsequent arithmetic concepts, it is due to their lack of intuitive grasp of numbers.

The neural correlates of the aforementioned domain-specific core deficit hypotheses suggest that numerical awareness is affected by impairment in the brain area called the intraparietal sulcus (IPS) (Butterworth, 2005b). Neuroimaging studies have shown that different functional and structural abnormalities in the brain areas that are responsible for number processing are mainly located in the intraparietal sulcus (IPS) (Kucian & Von Aster, 2015), specifically, the horizontal intraparietal sulcus (HIPS) (Dehaene et al., 2003; Wilson & Dehaene, 2007). Research indicates the functional differences in the brains of children with dyscalculia as compared to those without dyscalculia. For instance, the study conducted by Price et al. (2007) revealed decreased IPS activation in DD children in numerical comparison tasks as compared to their peers with typical IPS functions. Other studies have found structural differences, reporting less volume of grey and white matter in IPS in children with dyscalculia compared to typically developing children (Rotzer et al., 2008; Rykhlevskaia et al., 2009, as cited in Kucian & Von Aster, 2015).

Other researchers have explored multiple brain areas that are involved in numerical processing. Dehaene et al. (2003) have proposed a triple-code model for number processing and explained to what extent particular brain areas are involved in numerical skills. This model hypothesized three mechanisms of representation: a “quantity system” which is responsible for the non-verbal representation of magnitudes, a “verbal system” which is responsible for the lexical representation of numbers, and a “visual system” in which numbers are presented in an array of Arabic numerals (Dehaene et al., 2003). The model’s neural correlates state that the “quantity system” is affected by the horizontal segment of the IPS region (HIPS), the “verbal system” is affected by the left angular gyrus

(AG) and perisylvian areas, and the “visual system” is affected by posterior superior parietal lobes (PSPL) (Dehaene et al., 2003; Soares et al., 2018). Dehaene et al. (2003) proposed that these three parietal regions together exist in the process of numerical cognition and are utilized depending on the nature of the task (Figure 1). The quantity system located in the HIPS forms the “phylogenetic precursor” of mathematical proficiency (Fias, 2016, p.3). For example, the study by Thioux et al. (2005) reported that the HIPS region is specific to the number domain and activates more in response to number words than other categories of words such as animal names. In the study by Thioux et al. (2005), participants were given number words and names of animals. The

Figure 1 *Three-dimensional Representation of the Parietal Regions of the Brain*



Source: From “Three Parietal Circuits for Number Processing”, by S. Dehaene, M. Piazza, P. Pinel, and L. Cohen, 2003, *Cognitive Neuropsychology*, 20(3), 487-506 (<http://doi.org/10.1080/02643290244000239>). [In the Public Domain].

tasks included the comparison of number words (i.e., whether “seven” is bigger/smaller than “five”) or animal names (i.e., whether a “bear” is fiercer than a “dog”), and a categorization task (i.e., whether a number is even/odd or an animal is a mammal/bird). The HIPS activated bilaterally more to numbers than to animal names independent of the tasks. This is indicative of the specificity of the HIPS region to the number domain and is convincing evidence for the core deficit hypotheses. Except for the HIPS region, the left AG and PSPL are not specific to the number domain. The left AG activates more when verbal representation is required (Dehaene et al., 2003). It is proposed that the left AG is “part of the language system” and is involved in language-related tasks such as multiplication, which requires a lexical representation of numbers (Dehaene et al., 2003, p.494). For instance, research found deficits in both numerical and verbal areas, in which children with dyscalculia presented with decreased brain activations in response to multiplication tasks (Berteletti et al., 2014). The PSPLs are involved and active while contrasting, estimating, and counting the quantities (Dehaene et al., 2003). However, PSPL is not only related to number processing but also is involved in other functions such as visuospatial processes, attention, and spatial working memory. For instance, a study has reported that PSPLs were activated when children subitized or moved their eyes (Simon et al., 2002, as cited in Dehaene et al., 2003). This means that numerical cognition is a complex process that involves additional brain areas apart from IPS that affect number processing. The implication of multiple brain areas signifies that dyscalculia has more complex causes than was initially proposed by ANS theory (Fias, 2016). It is important to understand how the brains of children with dyscalculia are different from others. However, it should also be considered that brain imaging studies are mostly criticized for their “restricted applicability to education and classroom interventions” (Kaufmann, 2008, p.167).

It is accepted among researchers that people have a second system associated with number processing known as an object tracking system (OTS) (Henik et al., 2011; Traff et al., 2011; Wilson & Dehaene, 2007). This system involves visuospatial skills which allow the child to track up to 3 to 4 objects while observing them (Wilson & Dehaene, 2007). OTS is tested in children by the subitizing task in which participants should exactly name the number of presented dots. Children with dyscalculia can subitize a maximum of 3 dots, whereas their peers do this up to 4 dots (Traff et al., 2017). It is accepted that infants sometimes use their visuospatial skills rather than their innate capacities to recognize numerosities (Wilson & Dehaene, 2007). However, research remains inconclusive that deficits in the OTS may cause dyscalculia (Wilson & Dehaene, 2007).

Rousselle and Noel (2007) have presented another view called the access deficit hypothesis. According to this hypothesis, dyscalculia is caused by the inability to link symbols to their underlying magnitudes. Access deficit is also characterized as a disconnection syndrome (Wilson & Dehaene, 2007). This means that the disconnection between “symbolic numbers and innate magnitude representations” may cause dyscalculia in children (Skagerlund & Traff, 2014b, p.2). According to this view, people with dyscalculia may have intact non-symbolic number processing (ANS), but impaired symbolic number processing which prevents them from connecting the symbols to their underlying quantities (Wilson & Dehaene, 2007). The neural evidence for this hypothesis states that the brain of people with dyscalculia fails to link its frontal lobes to the parietal areas while the child develops (Traff et al., 2017). One study found that white matter in the brains of children with dyscalculia grew neither in the frontal nor in the parietal regions as compared to their typically developing peers (Ranpura et al., 2013, as cited in Traff et al., 2017). These results, as the authors further argue, may provide evidence that dyscalculia is partially a disconnection syndrome (Rousselle & Noel, 2007).

Recent research shows that there are deficits not only in number processing but also in magnitude processing skills (Traff et al., 2017). The deficit in magnitude processing implies difficulties with other magnitudes apart from numbers such as time and space. This view is supported by the study of Skagerlund and Traff (2014a), who have found that children with dyscalculia had deficits not only in the ANS but also difficulties with the perception of time and processing the spatial information.

Within the neurobiological frame, genetic studies show that dyscalculia runs in families. For instance, Landerl and Moll (2010) conducted a “family transmission analysis” of arithmetic difficulties and found that the prevalence rate was higher among family members of children with mathematical difficulties. The first twin study of mathematics disability has provided essential evidence for the heredity of dyscalculia. In that study, 40 identical and 23 same-sex fraternal twins were tested, and it was revealed that 58% of monozygotic (identical) and 39% of dizygotic (same-sex) twins also had dyscalculia (Alarcón et al., 1997). In addition, Shalev et al. (2001) discovered that families and relatives of children with math learning disabilities are ten times more prone to be identified with dyscalculia than other people (as cited in Geary, 2004).

Research in the neurobiological area emphasizes the brain and genome as potential causal factors of dyscalculia. Nevertheless, researchers from the cognitive area highlight the involvement of other cognitive mechanisms apart from biological factors that may cause dyscalculia.

Cognitive Perspective

The cognitive view of the phenomenon of dyscalculia put forward the existence of additional deficits which could be affected by non-numerical factors such as deficits in executive functioning and different components of the working memory (Traff et al.,

2017). The hypothesis that supports this view can be found in the literature as a domain-general cognitive hypothesis (Henik et al., 2011; Traff et al., 2017).

Cognitive psychologists one of which is David Geary, suggest that dyscalculia is a cognitive disorder of working memory. Geary (2004) proposed three main subtypes of dyscalculia: procedural, semantic memory, and visuospatial. The procedural subtype implies difficulties in learning and applying basic mathematical procedures which are proposed to be caused by deficits in verbal working memory, conceptual knowledge, and attentional control. The semantic subtype implies difficulties in retrieving math facts which may be due to deficits in long-term memory. Finally, the visuospatial subtype implies difficulties in the understanding of spatially represented quantities, which involves problems in geometry, understanding graphs, tables, and using a mental number line (Geary, 2004). There is a debate among researchers on whether working memory constitutes a cause of dyscalculia. Some of these researchers have highlighted the absence of conclusive evidence for a cognitive basis for dyscalculia (Butterworth, 2005a). However, it is widely accepted that many children with dyscalculia have difficulties remembering and retrieving mathematical facts (Traff et al., 2017).

The cognitive theory also proposes defective executive functioning as a possible cause of dyscalculia in children. Executive functions are responsible for broad processes such as attention shifting, processing speed, updating the information, switching from one method to another, organization, and planning skills (Karagiannakis & Cooreman, 2017). This can be seen in a study conducted by Van der Sluis et al. (2003) in which children with arithmetic difficulties were slower in naming the numbers and quantities than the control group. Additionally, these children showed deficits in the tasks that tested their processing speed and cognitive shifting abilities. Similarly, a study by Traff et al. (2017) has found deficits in the executive function of shifting ability and visuospatial working memory in

children with dyscalculia. However, the processing speed for the children in this study was not affected; they named colors and numbers at a normal range of speed. Currently, literature is inconclusive about the causality of executive function deficits to dyscalculia. Yet, it is evident that children with dyscalculia present with difficulties in executive functioning such as attention shifting and processing speed (Traff et al., 2017). Notwithstanding, there exists another view from the educational researchers on the causes of dyscalculia, which is discussed further.

Educational Perspective

Some researchers from the field of mathematics education say that dyscalculia does not exist and instead has emotional and experiential causes which means that the causes come from external factors (Gifford, 2006). Their view originates from a disagreement with the whole ideology of the models of disability, specifically with the medical model (Lindsay, 2003, as cited in Gifford, 2006). They argue that paradigms such as those proposed in the neurobiological view that stand for the innate nature of the disability use unfavorable words such as “deficits”, which do not coincide with some teachers' beliefs about setting an inclusive environment in the classroom with positive anticipation about all their students (Gifford, 2005; 2006). Educational researchers criticize the cognitive theories of disability saying that it fits the “medical model” of disability (Lindsay, 2003, as cited in Gifford, 2006). These researchers explain that it is more concentrated on medical factors that are “within-child”, whereas environmental factors, socio-cultural diversity, students' emotions, and feelings are under-considered. In addition to this, they argue that concentrating on children's memory problems may actually produce children with dyscalculia. Dowker (2004) adds that such “labeling could turn a child's learning delay into a deficit” (as cited in Gifford, 2006, p.45). In response to the genetic predisposition of

dyscalculia, Gifford (2006) emphasizes the “home learning environment” as a possible bridge that conveys poor math personalities in families.

Researchers have found a link between a child's family characteristics and academic performance. The factors such as low socioeconomic status (SES), “home learning environment” regardless of SES, and parental perspective on math such as mothers' low self-confidence in math can cause dyscalculia in children, according to Gifford (2006). Studies that are based on the view of educational researchers report that mothers' poor numeracy skills and low self-esteem in math affect children's numerical experience and hence, academic achievement (Young-Loveridge, 1989, as cited in Gifford, 2006). Evidence suggests that children who belong to low SES families have poorer achievement scales, and children who were not exposed to the early experience of number learning at home regardless of SES have lower arithmetic progress than children who were exposed (Sammons et al., 2002).

Other factors that should be considered according to educational researchers are the attitudes and feelings of the students themselves. This is evident from the case of some students who ended the usage of compensating strategies for other disciplines after losing their math confidence (Bfuzka et al., 2000, as cited in Gifford, 2006). Gifford (2006) claims that “failure to learn or to demonstrate learning may be due to a child's attitudes towards the learning or assessment situation” (p.42). Additionally, Gifford and Rockliffe (2012) state that insufficient “educational experiences” and difficulties in mathematics can lead to math anxiety and hence hinder the learning of students. Gifford (2006) argues that there is a need for a more multi-dimensional model of MD, which would consider all the factors and circumvent the “medical model”. However, a significant part of the scientific community thinks that these external factors should be considered not as a cause but as

concomitant factors which should be eliminated before the final diagnosis (Kaufmann et al., 2012; Kucian & Von Aster, 2015).

Overall, the neurobiological perspective highlights the biological causes of dyscalculia, the cognitive perspective highlights the working memory deficit, and the educational perspective highlights the external factors. Although there is an ongoing debate around the causes of dyscalculia, recently researchers have combined these views for further investigation of the disability which are discussed in the next section.

Heterogeneity and Types of Dyscalculia

There has been much debate done around the causes of dyscalculia, specifically whether it is caused by biological factors or also involves domain-general cognitive factors which is explained in this section. Researchers are gradually agreeing on the presence of other domain-general factors such as working memory and executive functioning which may cause dyscalculia (Henik et al., 2011; Karagiannakis et al., 2014; Kucian & Von Aster, 2015; Traff et al., 2017). More recently, dyscalculia was recognized as a heterogeneous disability that may involve both neurological factors and cognitive mechanisms. Kucian and Von Aster (2015) defined dyscalculia as a “heterogeneous learning impairment affecting numerical and/or arithmetic functioning at behavioral, psychological and neuronal levels” (p.3). Currently, there seems to be a consensus on heterogeneity and this proposed definition of dyscalculia.

Some researchers argue that academia should distinguish between two types of dyscalculia: *primary* and *secondary dyscalculia* (Traff et al., 2017). *Primary dyscalculia* is considered to be caused by “neurobiological factors” which are specific to the number domain or in other words domain-specific factors. *Secondary dyscalculia*, on the other hand, is explained by cognitive factors or “non-numerical impairments” such as attentional control, working memory, executive functioning, and processing speed which in other

words are domain-general factors (Traff et al., 2017). Even if the causal factors are distinct, a person may display mixed symptoms of both neurological and cognitive domains. This is evident in the study conducted by Traff et al. (2017), in which they tested four students for having different deficits. They reported that children with dyscalculia may have a combination of cognitive and neurological deficits. Only one of the four investigated students had primary dyscalculia caused by defective ANS and magnitude processing deficit, which suggests that pure dyscalculia is a rare condition. The other two students had primary dyscalculia mixed with cognitive deficits, and one student had secondary dyscalculia entirely caused by domain-general cognitive factors. The authors further support the suggestion that the term *secondary dyscalculia* must be applied only when the difficulties are completely produced by the domain-general factors. Otherwise, in the presence of both cognitive and neurological factors, considering the core neurological deficits as the main cause must be seen as a priority issue (Traff et al., 2017). These findings support the hypothesis of the heterogeneous nature of dyscalculia.

Some researchers have categorized the manifested symptoms according to their underlying deficits. Karagiannakis et al. (2014) proposed four subtypes of dyscalculia. They have criticized the subtypes that Geary (2004) proposed from the cognitive view (i.e., procedural, semantic memory, and spatial), saying that this categorization is limited because multiple characteristics can be discovered in one child that belongs to distinct subtypes. Karagiannakis et al. (2014) have proposed a “multidimensional” model as a bridge from unidimensional dyscalculia to multifaceted mathematics learning difficulties (MLD). MLD is a broader term that is used for difficulties in all math domains rather than dyscalculia which is narrower and includes only the arithmetical domain. The proposed classification model comprises both domain-specific and domain-general factors that affect students' math learning (Karagiannakis et al., 2014, p.2, table 1). The proposed subtypes

include core number, memory, reasoning, and visual-spatial difficulties of students with dyscalculia.

1) Core number. This subtype includes deficits in the “ANS, OTS, numerosity coding, representation of symbols, and access deficit” (Karagiannakis et al., 2014, p.2). Encountered difficulties are in the arithmetical domain such as number processing, counting, subitizing skills, placing numbers on a number line, manipulating Arabic numerals, the ability to convert one form of a number to another as in the “triple-code model” (quantity, lexical and Arabic digits), and understanding the meaning of mathematical operation symbols (+-x:);

2) Memory. Memory, which consists of retrieval and processing, includes deficits in the “working memory (WM), semantic memory, and inhibitions of irrelevant information from entering WM” (Karagiannakis et al., 2014, p.2). Encountered difficulties are in all math domains. Manifested difficulties are poor extraction of math facts, understanding of mathematical terms, understanding and solving verbally presented tasks and rules, incorrect mental calculation, poor memorization and use of formulas, and inability to follow the steps required in arithmetic problems;

3) Reasoning. This subtype includes various executive functions such as “entailment, inhibition (not connected to WM), updating relevant information, shifting from one operation-strategy to another, updating and strategic planning, decision-making” (Karagiannakis et al., 2014, p.2). Encountered difficulties are in all math domains. Children show difficulties in understanding mathematical concepts, solving and understanding the multiple steps in solving complicated problems, and understanding the logic of fundamental math rules;

4) Visual-Spatial. This subtype includes deficits in “visuospatial working memory, and visuospatial reasoning/perception” (Karagiannakis et al., 2014, p.2). Encountered

difficulties are in written arithmetic, geometry, algebra, analytical geometry, and calculus. Children exhibit problems with understanding the visual representation of math concepts such as geometric figures or notation systems, inaccurate calculation in written form, visualizing and evaluating the three-dimensional geometric figures when mental rotation is required, understanding and interpreting tables, graphs, and maps.

In view of the primary/secondary dyscalculia, the presence of core number subtype would be primary, whereas other remaining subtypes would be considered as secondary dyscalculia. This model is suggested by Karagiannakis et al. (2014) as being applicable to mathematics education and classroom interventions. Moreover, it may stand as an instrument that helps mathematics teachers both at primary and secondary levels of education (Karagiannakis et al., 2014). The model can help mathematics teachers in the early identification of profiles of math difficulties of children which in turn will assist in providing proper support to them.

In conclusion, this section has provided an information on the heterogeneity and subtypes of dyscalculia. However, at present, no information is available on whether differentiating between biological factors and cognitive impairments positively affect the “diagnostic accuracy or interventional outcomes” (Kaufmann et al., 2013, p.4). In other words, knowing about the heterogeneity of the disability does not influence accurate diagnosis and successful interventions. The following section presents an information on the diagnosis of dyscalculia.

Diagnosis

To date, there is no universal and standardized instrument for the diagnosis of dyscalculia. This is due to the inconsistencies around the definition of this disability as discussed in previous sections. The literature provides tools used for the diagnosis of dyscalculia which can be either curriculum-based or neuropsychological (Kaufmann &

Von Aster, 2012). The following criteria are curriculum-based tools that are used to identify the learning disability dyscalculia:

1) Discrepancy criterion. Identification of dyscalculia is made if there exists an extensive gap between students' intellectual quotient (IQ) and overall performance in mathematics (Shalev & Von Aster, 2008; Williams, 2013). Currently, using IQ in the identification process is recognized as not an objective measure of the disability. It is evident from research that children with low and average IQ present with the same forms of math difficulties (Ehlert et al., 2012, as cited in Kucian & Von Aster, 2015). According to the American Psychiatric Association (APA) (2013) in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), the requirement of the diagnosis that pupils' academic achievement should be lower than their IQ was also removed. Otherwise, pupils with low IQ would be barely identified as having dyscalculia based on the discrepancy model since their mathematics achievement should have been remarkably low (Kucian & Von Aster, 2015).

2) Severity criterion. This model uses cut-off points in standardized educational tests to show the degree of the severity of the condition (Geary, 2004; Shalev & Von Aster, 2008; Williams, 2013). These cut-off points differ from study to study, assuming that DD students should fall under the lowest 10-25th percentile on standardized tests. As children's progress is not static and changes over time, Kaufmann et al. (2013) recommend that it should be retested during an academic year, especially for those children falling under the 10th percentile.

3) "Resistant to intervention (RTI)" criterion. When a child does not react to any of the initiated interventions, it is a plausible criterion for the identification of dyscalculia (Shalev & Von Aster, 2008; Williams, 2013). The RTI model is a three-level procedure that is aimed to identify students who are at-risk at an early stage (Soares et al., 2018). This

model, overall, depicts the large number of students educated in general classrooms, with a lesser number of students (at some risk) getting supplementary assistance, and a few numbers of students (at high risk) getting exhaustive educational support (Soares et al., 2018). According to this model, those students who do not respond to any of the initiated additional support will be recognized as possibly having dyscalculia.

4) “Two-year achievement delay” criterion. If a child lags in performance behind age-matched peers with a two-year academic gap, then it is considered as a reasonable diagnostic criterion (Shalev & Von Aster, 2008).

In addition to these curriculum-based methods, some researchers developed special diagnostic tools such as Dyscalculia Screener (Butterworth, 2003) and Number Sense Screener (Jordan et al., 2010) that will help to diagnose dyscalculia in children (see Appendix A for more information).

Apart from the educational diagnostic tools, neuroimaging studies put forward the value of eye-tracking data (Van Viersen et al., 2013) and functional magnetic resonance imaging (fMRI) methods (Dinkel et al., 2013) to diagnose dyscalculia in children. Specific patterns of brain and eye-movements that are obtained from these methods are used in the diagnosis of dyscalculia. Although these methods have a strong potential as a promising tool for the diagnosis of the disability, tools such as MR scanner and eye-tracker are not accessible for educators because of their availability only for the scientific community (Appendix A).

It is important to note that possible comorbidities and exogenous factors such as brain damage, poor instruction, and low intelligence should be eliminated before the final diagnosis. As Kucian and Von Aster (2015) caution “In view of the multiplicity of the functional components participating in these disturbances”, it is obvious that the assessment of disability should comprise the investigation of “a thorough personal,

familial, and scholastic developmental history” (p.5). Kaufmann et al. (2012) also highlighted the importance of considering cognitive factors, social and emotional well-being, and results from brain imaging studies where needed. The final decision should be made based on the testing, clinical examination, and history taking, followed by psychosocial assessment (Haberstroh & Körne, 2019).

To sum up, to diagnose dyscalculia, only factors such as hereditary or neurological should be considered. External factors should be excluded for being a possible cause for children's difficulties. It is important to know that external factors do not cause dyscalculia. However, their presence may pose significant problems for children's learning process. Early and successful diagnosis of dyscalculia will lead to effective and targeted forms of interventions which are discussed in the next section.

Interventions to Support Students with Dyscalculia

It is important to identify dyscalculia as early as possible to provide proper support and assist students in learning. A strong and rigorously designed teaching strategy contributes greatly to the educational achievements of any student including students with dyscalculia (Karagiannakis & Cooreman, 2015). A review of the literature revealed two types of interventions - educational and behavioral. Educational methods are aimed to increase students' understanding of math procedures, whereas behavioral ones are intended to reduce math anxiety and form positive attitudes towards mathematics.

Educational Interventions

The literature provides some educational methods on enhancing DD students' reading comprehension, math problem-solving skills, and word problem solving skills which include techniques such as breaking the whole into smaller parts, starting with concrete then moving to abstract, using highlighters to solve word problems, using

postcards that are helpful in memorization of facts, reviewing the learned material, and instructing in small groups (Trott, 2003; Wadlington & Wadlington, 2008).

Ise and Schulte-Körne (2013) have conducted a study that aimed to identify the effectiveness of strategies to support students with dyscalculia (as cited in Kucian & Von Aster, 2015). The study showed the intervention is most effective if it is individualized teaching, and/or is aligned with and tailored to the child's academic success rates. Furthermore, lessons which are arranged in a structural manner that starts with concrete then moves to abstract notions, involving "curricular" and "non-curricular" arithmetic themes, as well as repeating activities to retain knowledge identified to be effective strategies. Similarly, in the study by Re et al. (2014, as cited in Monei & Pedro, 2017) individualized instruction has enhanced students' mental and written calculation skills. Moreover, it is argued to be effective especially for severe and mild math difficulties.

Using technology and working in small-groups are identified as effective in supporting many students with dyscalculia (Monei & Pedro, 2017). For instance, the math achievement of children with dyscalculia has increased from using computer-based digital interventions (Benavides-Varela et al., 2020; Syah et al., 2015). Working in small-groups helped children with dyscalculia to become more competent and fluent in arithmetic tasks since it allowed instructors to apply interventions intensively and explicitly (Monei & Pedro, 2017).

"Strategy instruction" interventions stand as an effective student-centered approach that is aimed to help students to focus on the primary and important information in the task rather than on secondary information. It includes techniques such as highlighting the keywords, using visual materials and providing clear instructions that are used to guide students to understand math concepts (Monei & Pedro, 2017).

Karagiannakis and Cooreman (2015) have proposed interventions according to every four subtypes that were presented in the heterogeneous view of the disability as discussed before. They stress the importance of focusing on the strengths of students rather than on weaknesses; this will allow them to compensate for their impairments. This means that students will be able to use their strengths to learn and achieve in mathematics.

Core number. The first set of interventions concerns the difficulties in core number concepts. Karagiannakis and Cooreman (2015) suggest that for the core number subtype, interventions that are aimed to explain the link between the numbers and their mathematical notations using real-world examples are beneficial (i.e., fingers, stairs, cards, money, and hands). For example, teachers can use the stairs to explain the counting principles, and also use hands to explain the meaning of the symbol “=” in which students should balance the amount in two hands. Many repetitions are also useful. Some children are strong in “reasoning” and “visual-spatial” areas, where logic is important and no numerals are needed, respectively. Thus, expanding their abilities in these fields should be a priority and long-term goal. For instance, allowing the use of calculators will help them overcome their difficulties in this primary core number area.

Visual-Spatial. The second set of interventions are related to the visual-spatial difficulties of DD students (Karagiannakis & Cooreman, 2015). As large numbers, geometric figures, rotations, symmetry, graphs, and tables all are challenging for students with dyscalculia in this group, supporting them with visual aids is beneficial. For example, teachers can use colorful pens to highlight the figures or words in some topics of geometry. Clear instructions should be provided and connections should be made between real-life and math topics in which visual interpretation and visualization are needed. The best support is verbal for this type of students. Verbal clues may be given but not simultaneously with the visual information. It is important to keep their attention on either

the visual or verbal information. Evidence suggests that fostering the abilities close to language skills to be able to understand word problems, fostering listening comprehension skills, and improving visuospatial comprehension by providing physical and hands-on activities are proven to be effective in increasing DD students' mathematical achievement (Faramarzi & Sadri, 2014).

Memory. The third set of interventions concerns memory. Karagiannakis and Cooreman (2015) recommended to explain the logic and how the task should be solved rather than presenting a list of steps that should be done to solve the problem for DD students in this subtype. However, the students, especially their memory, should not be overwhelmed by long instructions. Providing them with tables, graphs, formulas, and “structured algorithms” will help students to remember and learn math facts. Many repetitions are also needed for students to reach automaticity to solve problems. Faramarzi and Sadri (2014) have reported that fostering active memory by repeating and recalling the learned material was discovered to be effective educational support. Moreover, stimulating memory has been shown to be positively correlated with academic math achievement in children with dyscalculia (Faramarzi & Sadri, 2014).

Reasoning. The fourth set of interventions concerns reasoning skills (Karagiannakis & Cooreman, 2015). The students that have a “reasoning” subtype often start to fail when a formula or a rule should be applied to the problem. They need an example to get back and look for the algorithm of how the problem should be solved. They tend to rely on memorized rules and formulas as they have a good memory. This strength can be helpful for them for some time, but not in all math domains. It is beneficial for them to say out loud the process of solving the problem to promote their thinking. It is also important to show the connections between math and real life. These students fail when abstract topics are introduced because in these topics executive functioning and reasoning skills are

required. It is comfortable for them to follow the provided steps to solve the problem. They should be taught to find the key information and signs needed to solve the problem according to Karagiannakis and Cooreman (2015). It is proven that stimulating the visual and auditory attentional control by visual and auditory aids, respectively, as well as training executive functions by teaching students to organize and arrange their time and goals are effective educational methods (Faramarzi & Sadri, 2014).

Behavioral Interventions

Researchers have given a little attention to behavioral interventions compared to aforementioned educational interventions. Behavioral interventions are focused on the psychological well-being of children with dyscalculia and are aimed at helping them to overcome math anxiety. The suggested interventions include ensuring a positive environment in the classroom, praising success, role modeling such as stories of famous people as Einstein, Churchill who overcame their learning difficulties, as well as fostering favorable attitudes towards math (Wadlington & Wadlington, 2008). Research indicates that motivating children by acknowledging and praising them, as well as using techniques that help them to overcome their math anxieties are proven to be effective in supporting those students (Ise & Schulte-Körne, 2013, as cited in Kucian & Von Aster, 2015).

In conclusion, despite the view that dyscalculia is a persistent disability, adequate support, and early identification could reduce its consequences for a child (Sousa et al., 2017). If not assisted on time, dyscalculia may hamper children's educational perspectives and bring problems with employability in adulthood (Soares et al., 2018). Although dyscalculia is not the result of inappropriate instruction and teaching methods, having adequate knowledge and applying it, will positively influence the process and lead to a more successful intervention. The next section specifically explains how teachers themselves understand dyscalculia and handle it in their pedagogy.

Teachers' Awareness of Dyscalculia

Teachers are at the forefront of working with students who have learning disabilities. Their role is central in early identification and providing interventions for their students. This makes their awareness of learning disabilities such as dyscalculia very important. This section provides a review of the literature which has focused on teachers' awareness of the definition and nature of dyscalculia, recognizing its symptoms, and intervention methods. Also, it discusses how primary and secondary school mathematics teachers compare in their awareness of dyscalculia. The relationship between teachers' exposure to the phenomenon of dyscalculia and their level of knowledge is also discussed.

Teachers' Awareness of the Definition and Nature of Dyscalculia

Research reveals different general level of knowledge among teachers in different countries. Teachers in some countries seem to have a better knowledge of the definition and nature of dyscalculia (Chideridou-Mandari et al., 2016; Kunwar & Sharma, 2020; Sousa et al., 2017, Table 1). However, research identified widespread confusions about some aspects of teachers' knowledge. Although most teachers in Nepal reported to be aware of dyscalculia, they have limited knowledge in other aspects of dyscalculia such as the causes of this disability (Kunwar & Sharma, 2020). Similarly, most teachers in Greece knew the innate nature of dyscalculia, its prevalence and that dyscalculia is not the result of a poor instruction (Chideridou-Mandari et al., 2016). Yet they tended to blame school absenteeism and reduced intelligence for dyscalculia rather than their own teaching strategies. These research findings show that even those teachers who have some familiarity with dyscalculia may have a different understanding of what they know about this disability.

Other studies reveal even more confusion and lack of awareness about dyscalculia among teachers. Many studies indicate that teachers have not heard about dyscalculia at all

Table 1 *Review of the Literature: Teachers' Knowledge of the Definition and Nature of Dyscalculia*

#	Studies (Adequate level)	Definition and Nature of Dyscalculia
1	Chideridou-Mandari et al. (2016)	Majority of teachers (between 69-86%) had moderate level of knowledge about the definition and nature of dyscalculia. 86% of teachers knew the prevalence and innate nature of dyscalculia. 83% of them knew that dyscalculia is not the result of a poor instruction. 31% of teachers thought that students' school absenteeism was a cause for dyscalculia. Only 40.4% of teachers correctly answered to all questions about nature of dyscalculia. Most teachers had limited knowledge of the symptoms of dyscalculia.
2	Kunwar and Sharma (2020)	67.33% of teachers reported to know the definition and nature of dyscalculia. Yet, very few (17%) had good knowledge of all dimensions of dyscalculia, including the definition and nature, symptoms, and interventions.
3	Sousa et al. (2017)	75.4% of teachers have heard about dyscalculia. Having heard about dyscalculia predicted a higher level of knowledge about the definition and nature of it, but did not improve teachers' knowledge on the symptoms of dyscalculia.
	Studies (Low level)	Definition and Nature of Dyscalculia
1	Dias et al. (2013)	45.2% of teachers reported that they do not know what dyscalculia is.
2	Fu and Chin (2017)	57.5% of teachers reported that they do not know what dyscalculia is. 66.3% - perceived that dyscalculia is highly uncommon across children. 62.5% - associated it as a synonym for math anxiety. 55% - think that students with dyscalculia also have dyslexia.
3	Graves (2018)	51.1% of teachers have not heard the term dyscalculia. 62.3% reported to not know what dyscalculia is.
4	Karasakal (2018)	51% of teachers reported that they do not know what dyscalculia is. Majority of teachers were not aware of the term dyscalculia, they used the term "learning disability".
5	Kunwar et al. (2021)	Majority of teachers have not heard the term dyscalculia before (4 out of 6 teachers). Moreover, some teachers associated it with math anxiety, disliking the subject, and mental disabilities.
6	Sezer and Akin (2011)	All of 10 teachers were not aware of the term dyscalculia, they used the term "learning disability". Several teachers think that math anxiety and attention deficit are main characteristics of students with dyscalculia.

(Graves, 2018; Karasakal, 2018; Kunwar et al., 2021; Sezer & Akin, 2011) or do not know what it is (Dias et al., 2013; Fu & Chin, 2017, Table 1). For instance, in Turkey teachers were not aware of the term dyscalculia; they described the students as having a “learning disability” instead (Karasakal, 2018; Sezer & Akin, 2011). Karasakal (2018) reported that half of the participants did not accept that dyscalculia is a real disability that may bring distress for students as well as alter their behavior. Consequently, many teachers did not know how to support such students and tried to get help from other specialists. In another study in Malaysia, more than half of the teachers did not know the definition and prevalence of dyscalculia (Fu & Chin, 2017).

It is known from literature that dyscalculia can be accompanied by other learning and behavioral disabilities. The most common are dyslexia and ADHD as well as other factors such as math anxiety (Kucian et al., 2018; Williams, 2013). The risk is that educators may not notice the dyscalculia underlying these contributing factors. Fu and Chin (2017) reported that teachers thought dyscalculia was a synonym for math anxiety. Moreover, over half of the teachers thought that students with dyscalculia always have dyslexia. Comparably, Dias et al. (2013) found that teachers think that students who have a deficit of attention (65%) or not interested in mathematics (68%) may have dyscalculia. At the same time, the majority of teachers (84.1%) knew that not every student with dyscalculia might also have dyslexia. The same was reported by Kunwar et al. (2021) that some teachers associate dyscalculia with math anxiety and disliking the subject. Moreover, some teachers associated it with intellectual disability.

A significant body of research demonstrates poor knowledge of the causes of dyscalculia among teachers (Table 2). For instance, majority of teachers in Nepal did not know the causes of dyscalculia, indicating only external factors such as poor instruction and low performance (Kunwar & Sharma, 2020; Kunwar et al., 2021). Studies in other

Table 2 *Review of the Literature: Teachers' Knowledge of the Causes of Dyscalculia*

Studies	Causes
1 Kunwar and Sharma, 2020	Reported causes: students' low performance, home and school environment, language problems, math anxiety
2 Kunwar et al., 2021	Reported causes: poor instruction, home atmosphere, students' low self-efficacy in math
3 Dias et al., 2013	Brain damage (49.2%) Emotional problems (44.4%)
4 Fu and Chin, 2017	Lack of attention (60%) Brain damage (51.2%)
5 Karasakal, 2018	Heredity (28%) Lack of attention (20%)

countries identified confusions about teachers' knowledge of the causes of dyscalculia. On the one hand teachers in Turkey knew that heredity is a main cause for dyscalculia, but at the same time they thought that a lack of attention can cause this disability (Karasakal, 2018). Similarly, teachers in Brazil and Malaysia reported brain damage along with other factors such as students' lack of attention (Fu & Chin, 2017) and emotional problems to be primary factors which cause dyscalculia in students (Dias et al., 2013).

These findings demonstrate that teachers have low levels of knowledge of the definition and nature of dyscalculia. Research shows that the more knowledge and understanding teachers have about the phenomenon of dyscalculia, the better they can support children with dyscalculia in learning mathematics (Butterworth et al., 2011, as cited in Sousa et. al, 2017). However, only knowledge about the nature of the disability is insufficient to recognize students with dyscalculia (Chideridou-Mandari et al., 2016). To recognize and provide proper and effective educational support, it is important to be aware of manifestations of dyscalculia in the classroom. The following subsection provides a review of the literature on teachers' knowledge regarding the symptoms of the disability.

Teachers' Awareness of the Symptoms of Dyscalculia

Even if teachers in the studies described before did not fully understand the nature of the phenomenon of dyscalculia, they were able to report some symptoms that students with dyscalculia manifest and struggle with (Table 3). Further, the discussion is made according to the type of difficulty such as core number, visual-spatial, behavioral, reasoning and memory difficulties.

Several studies report that teachers have adequate knowledge of the symptoms of DD students related to core number concepts such as working with numbers or sequencing elements (Dias et al., 2013; Fu & Chin, 2017; Graves, 2018); visual-spatial such as confusing the directions (Fu & Chin, 2017); behavioral such as struggling to explain their answers (Chideridou-Mandari et al., 2016); memorization problems and reasoning difficulties such as poor problem solving skills and understanding of math symbols (Chideridou-Mandari et al., 2016; Fu & Chin, 2017; Sezer & Akin, 2011).

However, research identifies discrepancies among teachers' knowledge of these aspects of the symptoms of dyscalculia. This means that even if teachers knew some symptoms, yet they did not know other characteristics of students with dyscalculia. For instance, even if the majority of teachers in Greece knew that students with dyscalculia have difficulties that require reasoning skills such as weight and length issues, only a minority knew that they also have difficulties with telling time and exchanging money (Chideridou-Mandari et al., 2016). Moreover, the majority of teachers believed that solving word problems is just because of students' comprehension difficulties of the task. Furthermore, the most falsely believed symptom was that students can solve arithmetic algorithms if they are given enough time. However, limited time is not the only reason for their difficulties (Chideridou-Mandari et al., 2016). Similarly, teachers in Brazil have limited knowledge about DD students' difficulties requiring reasoning skills such as

Table 3 *Review of the Literature: Teachers' Knowledge of the Symptoms of Dyscalculia (by types)*

Types	Adequate level	Low level
Core number	<ul style="list-style-type: none"> • 82.5% - difficulties with sequencing elements (Fu & Chin, 2017). • 69.8% - difficulties with sequencing elements (Dias et al., 2013). • Teachers knew the symptoms associated with dyscalculia such as difficulties in number sense, reading, understanding, and working with numbers (Graves, 2018). 	<ul style="list-style-type: none"> • 45-46% - poor organization of numbers, and difficulties in counting and calculations (Kunwar et al., 2021).
Reasoning	<ul style="list-style-type: none"> • 99% - difficulties with linking arithmetic terms to their symbols (Chideridou-Mandari et al., 2016). • 95% - difficulties in choosing correct operation to solve problems (Chideridou-Mandari et al., 2016). • 82% - difficulties with weight and length issues (Chideridou-Mandari et al., 2016). • 67.5% - difficulties with the perception of time (Fu & Chin, 2017). • 7 of 10 teachers - lack of problem-solving skills (Sezer & Akin, 2011). 	<ul style="list-style-type: none"> • 58% - difficulties with telling the time (Chideridou-Mandari et al., 2016). • 60% - difficulties with exchanging money (Chideridou-Mandari et al., 2016). • 2 of 10 teachers - difficulties with exchanging money (Sezer & Akin, 2011) • 36.5% - difficulties with solving word problems (Dias et al., 2013). • 55.6% - difficulties with comparing quantities by using terms "bigger/smaller" (Dias et al., 2013). • 60.3% - difficulties in measurement (time, distance, weight) (Dias et al., 2013). • 58.8% - difficulties in measurement (Fu & Chin, 2017).
Visual-Spatial	<ul style="list-style-type: none"> • 67.5% - difficulties in confusing left/right directions when speaking out (Fu & Chin, 2017). 	<ul style="list-style-type: none"> • 55% - difficulties in representing word problems visually (Chideridou-Mandari et al., 2016). • 63% - difficulties in interpreting diagrams (Chideridou-Mandari et al., 2016).
Memory	<ul style="list-style-type: none"> • 91% - difficulties with retrieval of basic math facts (Chideridou-Mandari et al., 2016). • 73% - difficulties in memorizing multiplication tables (Chideridou-Mandari et al., 2016). • 9 of 10 teachers - difficulties in memorizing multiplication tables (Sezer & Akin, 2011). • 67.5% - difficulties with keeping in mind phone numbers (Fu & Chin, 2017). 	<ul style="list-style-type: none"> • 52.8% - poor memorizing of math facts and symbols (Kunwar et al., 2021).
Behavioral	<ul style="list-style-type: none"> • 93% - difficulties with explaining their answers (Chideridou-Mandari et al., 2016). • 84% - respond to word problems impulsively (Chideridou-Mandari et al., 2016). 	<ul style="list-style-type: none"> • 61.9% - DD students appear to be frustrated and anxious in math lessons (Dias et al., 2013).

solving word problems, issues of measurement, and comparing things with terms such as “bigger/smaller” and “more/less” (Dias et al., 2013). Moreover, these teachers had limited knowledge of behavioral difficulties of DD students such as being frustrated and anxious in math lessons (Dias et al., 2013). A study conducted in Nepal revealed that teachers lack knowledge about DD students' core number difficulties such as poor organization of numbers, as well as difficulties in counting and calculations (Kunwar et al., 2021). Despite memory difficulties being the most commonly known symptom among teachers in other studies, most teachers in Nepal did not know that DD students struggle with memorization of math facts and symbols (Kunwar et al., 2021). In addition, teachers in Greece lacked knowledge about visual-spatial difficulties of students with dyscalculia such as difficulties in interpreting diagrams and representing word problems visually (Chideridou-Mandari et al., 2016).

The evidence presented thus far shows moderate to low levels of teachers' knowledge regarding the symptoms of dyscalculia. Having a solid knowledge of students' characteristics positively impacts the way teachers instruct them (Ernest, 1989, as cited in Chideridou-Mandari et al., 2016). This means that the more they know about symptoms, the more effective they become in their instructions. Teachers' awareness about interventions to support students with dyscalculia is discussed further in the next section.

Teachers' Awareness of Interventions for Students with Dyscalculia

Evidence shows that teachers are relatively better aware of the intervention strategies than the nature and symptoms of dyscalculia. This section discusses teachers' knowledge of intervention methods through the prism of educational and behavioral methods that teachers in different countries believe to be effective in supporting students potentially having dyscalculia.

The review of the literature identified most frequently used teaching strategies among teachers to support their struggling students (Table 4). For instance, many teachers in the USA and Turkey believed visual aids (Graves, 2018) and hands-on manipulatives (Graves, 2018; Sezer & Akin, 2011) would best support DD students. As one teacher explain “for instance, to help students understand graphing, I lay out a coordinate plane on the floor and have students graph themselves. When they [the students] begin working with linear equations, I give them strings to make the lines.” (Graves, 2018, p.46). Similarly, teachers in Turkey emphasized activity-based teaching as an effective educational intervention (Sezer & Akin, 2011). Moreover, the use of online resources and multimedia was believed to be effective in teaching students with dyscalculia by teachers in the USA and Nepal (Graves, 2018; Kunwar et al., 2021). Furthermore, teachers in these countries reported that teaching in small groups, one-on-one and student-centered instruction would best support DD students in learning mathematics (Graves, 2018; Kunwar et al., 2021). Teachers in many studies mostly provided extra individual support for their struggling students (Graves, 2018; Sezer & Akin, 2011; Kunwar & Sharma, 2020; Kunwar et al., 2021). However, they also believed that students would benefit from one-to-one support from a specialist (Graves, 2018; Karasakal, 2018).

Apart from these findings, Kunwar et al. (2021) revealed behavioral interventions that are mainly used for reducing math anxiety in children. Teachers were aware of the behavioral interventions even if they did not know the causes and symptoms of dyscalculia. Strategies they used involved developing in students a positive attitude towards mathematics, setting a positive atmosphere in the classroom, encouraging the active involvement of students in and out of the classroom, role modeling of famous people, motivating students to learn, encouraging students not to give up, and taking numerous attempts to succeed.

Table 4 *Review of the Literature: Teachers' Knowledge of the Interventions to Support Students with Dyscalculia*

#	Studies	Educational Interventions
1	Sezer and Akin (2011)	Teachers mostly used hands-on projects, activity-based teaching as well as emphasized the use of peer consulting and many repetitions, as well as extra individual support/lesson.
2	Graves (2018)	The educational strategies teachers reported included the use of (1) "multiplication tables"; (2) "manipulatives and visual aids"; (3) "online resources"; (4) "assistive technology" including calculators; (5) mini-groups, and one-on-one instruction; (6) "support and extra practice"; as well as (7) "standard IEP accommodations" such as giving extra time, different tasks, "preferential seating", and allowing students to work in a remote place (Graves, 2018, p. 45). About more than half of the teachers believed that students would benefit from one-to-one support from a specialist and used a co-teaching strategy when a student with dyscalculia was present in the classroom. One teacher mentioned a visual representation of mathematical ideas. As they explain "for instance, to help students understand graphing, I lay out a coordinate plane on the floor and have students graph themselves. When they [the students] begin working with linear equations, I give them strings to make the lines.", and another teacher explained use of "hands-on manipulatives to make abstract concepts concrete; IXL for individualized instruction and practice; use of calculators; extended teaching time through a flex class period; additional support through a 45-minute intervention class." (Graves, 2018, p.46).
3	Kunwar and Sharma (2020)	An effective and exhaustive instruction was adopted by teachers as educational interventions.
4	Kunwar et al. (2021)	Teachers reported using multimedia, student-centered teaching as well as providing help and extra support to students with dyscalculia.
5	Karasakal (2018)	Teachers reported to not know how to treat students with dyscalculia. However, they tried to understand their students, motivated them to learn mathematics, worked with concrete problems, and sought help from psychologists and parents, advising them to refer the student to a specialist.
	Studies	Behavioral Interventions
1	Kunwar et al. (2021)	Strategies that teachers used involved developing in students a positive attitude towards mathematics, setting a positive atmosphere in the classroom, encouraging the active involvement of students in and out of the classroom, role modeling of famous people, motivating students to learn, encouraging students not to give up, and taking numerous attempts to succeed.

In summary, research revealed adequate knowledge of the intervention methods among teachers. Although teachers had low levels of awareness about dyscalculia, they instinctively tried to assist their students who have difficulties in mathematics.

Mathematics is a complex subject, different at primary and secondary school. Teachers that educate students at these levels may have different views of students' math development. Thus, as one of the main purposes of this study, the next section looks at how primary and secondary school teachers vary in their awareness of dyscalculia.

How Primary and Secondary School Teachers Differ in Their Awareness of Dyscalculia

Teachers teaching at different grade levels may have different views about students' difficulties in mathematics learning. One of the main aims of this study is to compare the primary and secondary teachers' awareness of dyscalculia. It is important to note that the primary level in Kazakhstan includes grades 1 to 4 and the secondary level involves grades 5 to 11. Moreover, mathematics teachers in secondary school in Kazakhstan teach not all the subjects as primary school teachers do, but rather only mathematics. Thus, studies that have focused purely on the primary (Fu & Chin, 2017; Kunwar & Sharma, 2020; Kunwar et al., 2021) and secondary levels (Chideridou-Mandari et al., 2016; Graves, 2018) are discussed further in this section.

Research identified that teachers' knowledge of the definition and nature of dyscalculia, its symptoms, and intervention methods does not differ by grade levels they teach. Little was known about the definition and nature of dyscalculia equally by teachers at both levels of education (Chideridou-Mandari et al., 2016; Fu & Chin, 2017; Graves, 2018; Kunwar et al., 2021), although adequate knowledge has also been found in some studies (Chideridou-Mandari et al., 2016; Kunwar & Sharma, 2020). Interestingly, several studies have reported that primary teachers have associated dyscalculia with math anxiety, and disliking the subject (Fu & Chin, 2017; Kunwar et al., 2021). Teachers at both levels

equally declared the external factors as the cause of dyscalculia (Chideridou-Mandari et al., 2016; Fu & Chin, 2017; Kunwar et al., 2021). At the same time, they knew that dyscalculia is not the result of a poor instruction (Chideridou-Mandari et al., 2016; Fu & Chin, 2017).

Moreover, both primary and secondary teachers were able to report some symptoms of dyscalculia despite having limited knowledge about its definition and nature. Teachers at both levels knew the symptoms associated with core number concepts and memory issues (Chideridou-Mandari et al., 2016; Fu & Chin, 2017; Graves, 2018). However, teachers' knowledge of the symptoms associated with reasoning skills were divergent for both primary and secondary levels. Although teachers at both levels equally knew certain symptoms requiring reasoning skills (Chideridou-Mandari et al., 2016; Fu & Chin, 2017), at the same time, they equally did not know that DD students also have difficulties with measurement (Fu & Chin, 2017), time, and exchanging money (Chideridou-Mandari et al., 2016).

Teachers' awareness of the interventions was equally good at both levels of education compared to their knowledge of the symptoms and nature of dyscalculia (Graves, 2018; Kunwar & Sharma, 2020; Kunwar et al., 2021). Teachers at both levels reported the use of different educational strategies that are aimed at improving learners' math achievement. Nevertheless, primary teachers in Nepal also mentioned behavioral interventions that are aimed to reduce math anxiety and motivate children to learn mathematics (Kunwar et al., 2021).

As evidence shows no explicit difference is found between primary and secondary teachers' knowledge of dyscalculia. The next section discusses how teachers' previous exposure to the phenomenon of dyscalculia is related to their level of knowledge about this disability.

Exposure to the Phenomenon of Dyscalculia and Teachers' Level of Knowledge About Dyscalculia

Teachers' previous exposure to the phenomenon of dyscalculia can be either theoretical such as learning about it in any of the pre-service, in-service teacher training courses, from colleagues/friends, as a self-study, or experiential such as having encountered students with math difficulties as suspected cases of dyscalculia. Many studies over the past years have emphasized the importance of teachers' theoretical exposure to the phenomenon of dyscalculia (Chideridou-Mandari et al., 2016; Kunwar & Sharma, 2020; Kunwar et al., 2021). Evidence shows that majority of teachers in different countries faced the topic of dyscalculia neither at pre-service nor at in-service training (Kunwar et al., 2021; Fu & Chin, 2017; Zhanatbekova, 2018); and neither at their professional training at graduate nor at postgraduate levels (Dias et al., 2013; Karasakal, 2018). Studies conducted in India (Pio Albina, 2019) and Brazil (Dias et al., 2013) have provided an evidence that the theoretical exposure to the topic of dyscalculia seems to be more important than the type of school. The author states that public school teachers in India were receiving training on learning disabilities organized by the government, thus they had more knowledge about dyscalculia (Pio Albina, 2019). Comparably, private school teachers in Brazil believed that they knew more on what dyscalculia is rather than their colleagues from public schools (Dias et al., 2013). This discrepancy is explained by the authors that private schools organize more training courses for their educators than public schools where it is hard to motivate teachers and students due to different "socio-economic conditions" (Dias et al., 2013, p.6). It can be said that it is not the type of school that is more important for teachers' awareness of dyscalculia, but rather teachers' exposure to this disability. Indeed, teachers were not well aware of dyscalculia in a significant part of the

studies reviewed. Evidently, training the teachers, to a greater extent, affects their awareness of this disability.

However, experiential exposure to the phenomenon of dyscalculia as having met a student suspected of dyscalculia did not predict better awareness of dyscalculia in Portugal (Sousa et al., 2017). This could be due to the small number of teachers who have had such students in that study. At the same time, facing the topic of dyscalculia predicted a higher level of knowledge on two dimensions such as definition and nature of dyscalculia and intervention strategies (Sousa et al., 2017).

To sum up, considering the above-mentioned evidence, it is fair to assume that exposure to the phenomenon of dyscalculia better affects the knowledge of teachers about this disability. The next section provides information on the current situation in Kazakhstan about learning disabilities. The identified gap that this study aims to close is also discussed further in the next section.

Research in Kazakhstan

The current situation in Kazakhstan is that there is no practice of identifying specific learning disabilities, with no data on their prevalence across the country. There is also very scarce literature on SLD in Kazakhstan. The author of this study was able to identify only one empirical study on dyscalculia (Zhanatbekova, 2018) and one on dyslexia (Galimzhanova, 2021).

In 2018, Zhanatbekova conducted qualitative research that aimed to find out the level of awareness about dyscalculia among primary school teachers (1-4 grades) and school leadership in three primary schools of Nur-Sultan, Kazakhstan. The study revealed that overall, school leaders (i.e., vice-principals) and teachers are not aware of dyscalculia. Zhanatbekova (2018) reported that teachers have never heard of the term dyscalculia and could not provide an adequate definition of it. Respondents were not familiar with

dyscalculia even if they had many years of experience. Regarding the causes of dyscalculia, the majority of teachers thought hereditary factors, whereas others declared neurological as well as external factors to be the cause. Mostly they thought that students with dyscalculia generally outgrow their problems. However, they admitted that they do not know what happens with students after transferring to secondary school. School principals confirmed that there were cases when students with symptoms of dyscalculia were present at the secondary level too, which means that the disability does not disappear with age. As far as the interventions are concerned, mainly teachers tried to run individual support after lessons and set easier goals in the classroom (Zhanatbekova, 2018).

Furthermore, Zhanatbekova (2018) argues that there is a likelihood that students with dyscalculia might be also labeled as “lazy” or “stupid” at school because teachers held views that these children are “weak” or “unsuccessful” (p. 46). Moreover, Zhanatbekova’s study (2018) have shown that one of the main reasons for teachers’ low awareness about dyscalculia, could be the fact that none of them received training on the topic of dyscalculia neither before starting nor during their careers. This and other research in Kazakhstan (Galimzhanova, 2021) identified that teachers need a formal training to understand and recognize specific learning disabilities such as dyscalculia and dyslexia.

For instance, a study in Kazakhstan which focused on teachers’ knowledge of dyslexia and their training experiences revealed that there is a need to add the topic of dyslexia to university preparation courses and organize professional training for pre-service and in-service teachers (Galimzhanova, 2021). Overall, this study revealed low awareness of dyslexia among educators. Over half of the teachers did not know the permanent nature and prevalence of dyslexia as well as its hereditary and neurological causes. Most teachers in the study were not trained about dyslexia at the university, and did not attend any additional professional development (PD) courses on dyslexia. However,

the study revealed that teachers' knowledge was not significantly related to their preparation courses. Only a small number of those who had training on dyslexia had a good level of knowledge about dyslexia, which suggests that the quality of those training sessions should be refined. Overall, evidence suggest that there is a low level of knowledge on specific learning disabilities on the whole in Kazakhstan. Teachers must receive quality training on specific learning disabilities in order to understand their nature and recognize them in the classroom.

To conclude this chapter, the review of the literature published within the last ten years identified a low level of knowledge about dyscalculia among primary and secondary school teachers worldwide (Dias et al., 2013; Fu & Chin, 2017; Graves, 2018; Karasakal, 2018; Kunwar et al., 2021; Sezer & Akin, 2011; Zhanatbekova, 2018). The main purpose of the current study is to identify teachers' awareness of dyscalculia and compare how they differ in their knowledge at different grade levels as well as to find how teachers' exposure to the phenomenon of dyscalculia is related to their level of knowledge about dyscalculia. So far, no research has been conducted to compare teachers' knowledge by grade level. Thus, this study attempts to close this gap. The primary level is important in the early recognition and support of the disability. However, it is important to consider the secondary level of education where mathematics is more complex and comprises a deep understanding of the concepts and applications of mathematical facts. The evidence from international studies presented in this literature review, helped to shape the hypotheses of this study as follows:

- H1: Primary and secondary school mathematics teachers' awareness of the definition and nature of dyscalculia is low.
- H2: Primary and secondary school mathematics teachers' awareness of the symptoms of dyscalculia is low.

- H3: Primary and secondary school mathematics teachers' awareness of the interventions to support students with dyscalculia is low.
- H4: The level of awareness about the definition, nature, symptoms of dyscalculia, and interventions among primary and secondary school mathematics teachers is at the same level.
- H5: Exposure to the phenomenon of dyscalculia is associated with a better level of knowledge about dyscalculia. The exposure is measured via two criteria:
 1. Theory: have respondents heard about the phenomenon of dyscalculia in any of the pre-service, in-service teacher training courses, from colleagues/friends, or as a self-study.
 2. Experiential: have they encountered students with math difficulties in class as suspected cases of dyscalculia.

Finally, only two of the examined research studies were conducted in post-soviet countries which indicates a lack of studies conducted in this context. Therefore, the proposed research will greatly contribute to the existing literature on the topic internationally and in the context of Kazakhstan. The next section provides full information on the methodology and ethical aspects of the current study.

Methodology

Research Design

Most of the studies over the past ten years that have investigated teachers' knowledge of dyscalculia have utilized a survey research design and used a questionnaire for the data collection (Chideridou-Mandari et al., 2016; Dias et al., 2013, Fu & Chin, 2017; Graves, 2018; Haring, 2020; Karasakal, 2018; Kunwar & Sharma, 2020; Kunwar et al., 2021, Pio Albina, 2019; Sousa et al., 2017). The current study also applied the quantitative research approach that allows obtaining data from a group of people, then generalizing it to the entire population (Creswell, 2012). The approach applied was similar to that in the study by Sousa et al. (2017), which was an exploratory quantitative study focused on the selected region's population and described it quantitatively. The design helped the researcher of this study to find out trends in data (Creswell, 2012) and explore the level of dyscalculia awareness among primary and secondary mathematics teachers.

Within the quantitative approach, this study employed a cross-sectional survey design as it allows collecting data like teachers' awareness of the dyscalculia phenomenon at one point at a time (Creswell, 2012). This study utilized an existing survey instrument developed by the same authors Sousa et al. (2017), which was changed and adapted to the Kazakhstani context, piloted, and administered online. The current study preferred the web-based survey method as a type of data collection since it saves time and provides an economical and efficient means of gathering a large amount of data from participants (Creswell, 2012).

This study builds on research by Sousa et al. (2017) which sought to determine predictors of teachers' knowledge of dyscalculia. In the current study, the focus is on teachers' knowledge of dyscalculia and how they differ across the grade levels. The main purpose of the current study was to examine the level of dyscalculia awareness among

primary and secondary school mathematics teachers in urban mainstream schools in one of the large cities in South Kazakhstan in respect to understanding the definition and nature of the phenomenon, recognizing its symptoms, and intervention methods; and to compare how teachers at different levels of education differ in their answers. This study was guided by the following research question:

- To what extent primary and secondary mathematics school teachers in urban mainstream schools in South Kazakhstan are aware of dyscalculia in respect to understanding the definition and nature of the phenomenon, recognizing its symptoms, and intervention methods?

The study tested the subsequent hypotheses:

- H1: Primary and secondary school mathematics teachers' awareness of the definition and nature of dyscalculia is low.
- H2: Primary and secondary school mathematics teachers' awareness of the symptoms of dyscalculia is low.
- H3: Primary and secondary school mathematics teachers' awareness of the interventions to support students with dyscalculia is low.
- H4: The level of awareness about the definition, nature, symptoms of dyscalculia, and interventions among primary and secondary school mathematics teachers is at the same level.
- H5: Exposure to the phenomenon of dyscalculia is associated with a better level of knowledge about dyscalculia. The exposure is measured as learning about the concept and having students with math difficulties in class as suspected cases of dyscalculia.

The next section provides information about the survey instrument that was used in this study.

Survey Questionnaire

To date, several questionnaires have been developed by researchers to evaluate teachers' knowledge about dyscalculia. The present study utilized an existing survey instrument that demonstrated high reliability and validity indexes (Sousa et al., 2017). Before being piloted, the survey questionnaire was revised and changed. Some items in the questionnaire were either omitted or reformulated, and new items were also added according to the given context and information emerging from the relevant literature. After making changes, the questionnaire was translated into Kazakh and Russian languages. Then, the survey was piloted among six mathematics teachers to adapt it to the Kazakhstani context and to make sure that the translation of the instrument is accurate. After that, based on the recommendations the survey instrument was brought into the final version to be administered online.

The final version of the survey questionnaire (Appendix B) consists of two sections. The first section included 14 questions on teacher demographics, followed by the second section of 44 questions which examines the teachers' knowledge of dyscalculia that was adapted from Sousa et al. (2017). The second section of the questionnaire consists of three parts, focusing on (1) the definition and nature of dyscalculia; (2) the symptoms of dyscalculia; and questions about (3) intervention methods. The survey questionnaire had response options of "Agree", "Don't know" and "Disagree". At the end of the survey, two questions were asked whether participants have any additional comments and whether they would like to receive any training about dyscalculia.

The researcher also assessed the reliability of the survey questionnaire by calculating Cronbach's alpha (α). The reliability index was excellent for the scale questions on the "Symptoms" ($\alpha = .95$) and "Interventions" ($\alpha = .94$). The reliability index was low for the

scale question "Definition and nature of dyscalculia" ($\alpha = .55$), but still acceptable (George & Mallery, 2003, as cited in Gliem & Gliem, 2003).

Revising the Original Survey Questionnaire

The researcher revised the original survey questionnaire before piloting it with teachers. Firstly, four questions that showed a low-reliability index in the study by Sousa et al. (2017) were excluded from this study. The authors of the original survey tool assessed the reliability of the instrument by calculating Cronbach's alpha (α), the person separation reliability (PSR), and the item separation reliability (ISR) indexes (Sousa et al., 2017). At first attempt the first two parts showed low reliability, but after eliminating the four items in the questionnaire reliability indexes of all three parts were high ("definition and nature": $\alpha = .66$, PSR = .57, ISR = .96; "symptoms": $\alpha = .88$; PSR = .78; ISR = .79; and "interventions": $\alpha = .90$; PSR = .75; ISR = .89.) (Sousa et al., 2017, p.212). Thus, these four questions were not included in this study.

Secondly, the following item: "Dyscalculia is more common in girls than boys" was excluded from this study because of contradicting findings found in the literature (Ashraf & Najam, 2020; Jovanović et al., 2013; Kucian & Von Aster, 2015; Landerl & Moll, 2010).

Thirdly, the following item "Drawing the human figure in an organized and structured way" was also omitted due to its inapplicability to secondary education level. The curriculum at the secondary school in Kazakhstan does not include tasks that assess or require students to draw a human figure. This is more common at the primary school level than at the secondary school.

Three new items measuring teachers' knowledge of the symptoms of dyscalculia such as difficulties in comparing quantities (Kosc, 1974), memorizing multiplication tables

(Williams, 2013), and difficulties with concentrating on math lessons (Soares et al., 2018; Kucian et al., 2018) were also added based on the review of the literature (Appendix C).

Finally, the third part of the questionnaire focusing on the methods of interventions was entirely changed. The authors of the original survey instrument suggested adding new items to this part of the questionnaire to have a deeper understanding of teachers' knowledge of the intervention methods (Sousa et al., 2017). Nine new items measuring teachers' knowledge of the interventions were added based on the review of the literature. These items include the following methods: structured lessons beginning with more concrete and moving to abstract concepts, motivating children by acknowledging and praising them (Ise & Schulte-Körne, 2013, as cited in Kucian & Von Aster, 2015), improving reading and listening comprehension skills (Faramarzi & Sadri, 2014; Trott, 2003), using postcards (Trott, 2003), working in small groups (Ise & Schulte-Körne, 2013, as cited in Kucian & Von Aster, 2015; Monei & Pedro, 2017), stimulating memory, providing physical and hands-on activities, training executive functions by teaching students to be organized, as well as stimulating attentional control by providing visual and auditory aids (Faramarzi & Sadri, 2014) (see Appendix C for detailed information about the changes in the items of the questionnaire).

Pilot Study

Since the intended audience of the study was teachers the survey was piloted among six mathematics teachers to adapt it to the Kazakhstani context and to make sure that the translation of the instrument from English to Russian and Kazakh is accurate. It was important because the views of the target audience on the questionnaire itself will finally exert influence on how they will be responding to the items (Muijs, 2004). The survey was critiqued using a structured interview process, which has been described by Thomas (2011) as an efficient method for piloting surveys. Firstly, four mathematics teachers (2 Kazakh

speaking teachers, and 2 Russian speaking teachers) reviewed the questionnaire for its validity. The teachers during the pilot study were asked to review the survey and comment on the clarity of the questionnaire items, instructions, readability, and layout. Time taken to complete the survey questionnaire was also recorded. The survey was revised based on the feedback and suggestions of the four reviewing teachers. The author of this study omitted the following item in the first part of the questionnaire: "If a student performs well in an activity and then fails to complete it, he does not have dyscalculia" because it was not clear to the teachers. Other changes were minor and concerned with the accurate translation of the items. In the end, the questionnaire was piloted with the remaining two mathematics teachers (Kazakh and Russian speaking). Both of them stated that all questions were clear and understandable in both languages (see Appendix C for detailed information about the changes in the items of the questionnaire).

Sample

The population in this study was all primary and secondary mathematics teachers who work in urban mainstream schools in the selected city in Southern Kazakhstan. The site – a city in Southern Kazakhstan - is chosen for the current study due to its large economic relevance in Kazakhstan. Galimzhanova (2021) and Zhanatbekova (2018) have conducted research on teachers' awareness of dyslexia and dyscalculia, respectively, in Northern Kazakhstan. The rationale behind choosing a city in Southern Kazakhstan as a research site is to extend the research on learning disabilities in this region.

The participants were selected by the cluster sampling method as it allows selecting a specific number of schools and then surveying all primary and secondary school mathematics teachers in those schools (Cohen et al., 2007). Special and selective schools were not included in the study. According to the directory of educational organizations of the selected city included in this study in Southern Kazakhstan, there are 111 mainstream

schools across eight districts. To ensure that only mainstream school teachers participate in the current study, only the respondents who selected the “mainstream school” option for the type of school where they work continued the survey. Teachers who selected the other options answering the question were not included in the study. According to information received by telephone from the Mathematics Coordinator in the municipality of the selected city, the number of primary school teachers was about 2000 and the number of mathematics teachers at the secondary level was about 575. It is suggested that with a population of 2500 people at a confidence level of 95%, the sample size should be 484 (Cohen et al., 2007, box 4.1).

To reach the sample, firstly, the researcher got a written agreement from the municipal Education Authority to access the sites. Once the consent was gained, the researcher applied the cluster sampling method. Only schools that include primary and secondary school levels of education and contain more than 500 students were included in the study. Also, the privilege was made in favor of those schools that had more mathematics teachers. With these considerations in mind, the clusters were formed to fairly represent and cover the whole region. To do this, the researcher formed a list of all the mainstream schools for each district, then every third school was selected from the list. The schools which did not fit the inclusion criteria were excluded from the cluster. The researcher contacted the administration of the selected schools by phone and asked to distribute the link to the survey to all primary and secondary mathematics teachers in their schools. If a school refused to participate or there was no response, another school was added to the sample. Overall, 751 respondents from 60 schools participated in the survey.

Data Collection Procedures and Research Ethics

This research was approved by the Graduate School of Education (GSE) Ethics Review Committee at Nazarbayev University (NU). This study employed a web-based

questionnaire which provides gathering a large amount of data from participants (Creswell, 2012). The survey was completely anonymous. No names, email addresses, or IP addresses were collected by the survey instrument, only personal characteristics such as age, gender, teaching experience, and level of education were asked. As the information that is obtained during this study is anonymous this means that not even the researcher knows the participants' identity and their responses to the questions will not disclose the respondents' identities. The survey was hosted by Qualtrics Survey Platform which does not retain any identifiable data as the option to anonymize data was activated in Qualtrics. Qualtrics is a secure platform, which means that it supports TLS and encrypts data in transit (between user and server). Thus, no information provided by the respondents can be tracked and connected back to their personalities which could reveal them. The collected data will be kept in a safe place to ensure confidentiality. The data will be stored electronically in the researcher's personal computer, locked by a password and only the researcher will have access to the files. After the thesis is completed and all analysis required is conducted, the dataset will be destroyed by the researcher.

Given the time spent on questionnaires, they have always been an invasion into the lives of respondents (Cohen et al., 2007). Thus, all participants were informed about the subject and purpose of the study and were provided with information about the potential risks and benefits of participation at the beginning of the survey questionnaire. The participants were assured that no personal identifying data is collected and the results will be presented in the aggregate form only, not allowing to identify separate answers. The participants were explicitly asked about their agreement to participate in the survey. Accepting and continuing further with the survey questions was considered as they have signed the informed consent form and accepted all the information provided by the researcher. If they decided not to participate in the study and pressed the "I Disagree"

button, the survey was closed with words of thanks for their participation. If they decided to participate and press the "I Agree" button, the participants were asked to indicate the type of their schools as mainstream, selective, or special. Teachers who work at special and/or selective schools did not continue with the questionnaire being thanked for their participation. In this way, the selective and special schools were excluded from the sample. The survey took approximately 15 minutes to complete. At the end of the survey, the respondent was thanked for their time and participation.

Data Analysis

The current study was conducted to examine the level of dyscalculia awareness among primary and secondary school mathematics teachers regarding the definition and nature, symptoms of dyscalculia, and intervention methods. All collected information was downloaded from the Qualtrics Survey Platform, then analyzed using a computer program called Statistical Program for Social Sciences (SPSS). Data were analyzed to test the following hypotheses:

- H1: Primary and secondary school mathematics teachers' awareness of the definition and nature of dyscalculia is low.
- H2: Primary and secondary school mathematics teachers' awareness of the symptoms of dyscalculia is low.
- H3: Primary and secondary school mathematics teachers' awareness of the interventions to support students with dyscalculia is low.
- H4: The level of awareness about the definition, nature, symptoms of dyscalculia, and interventions among primary and secondary school mathematics teachers is at the same level.
- H5: Exposure to the phenomenon of dyscalculia is associated with a better level of knowledge about dyscalculia. The exposure is measured as learning about the

concept and having students with math difficulties in class as suspected cases of dyscalculia.

The first step was to run descriptive statistics and frequency distributions to present information about the characteristics of the sample. This type of analysis is called univariate analysis as it implies looking at the variables separately (Muijs, 2004) such as teachers' education level, teaching experience, and grade levels they teach.

The next step was to run a bivariate analysis. Specifically, cross-tabulations and chi-square tests were performed to measure teachers' knowledge about dyscalculia by looking at how many teachers answered specific questions as well as to compare primary and secondary school mathematics teachers' answers about this disability. This analysis allowed the researcher to describe the situation among mathematics teachers concerning their awareness of dyscalculia. Next, teachers' knowledge was measured on a continuous scale by counting the correct answers on the survey questionnaire. A new variable was created combining correct responses for all scale items. A maximum score for the scale question "Definition and Nature of Dyscalculia" was 9, for "Symptoms" was 21, and for "Interventions" was 13. The smallest score for each scale question was 1.

Mann-Whitney test was then performed to compare the primary and secondary teachers' mean scores as well as to look at how exposure to the phenomenon of dyscalculia affects teachers' level of knowledge of this disability. Mann-Whitney test which is a non-parametric test was chosen over the parametric one because the sample size of the present study was non-normally distributed. A Shapiro-Wilk test showed a significant departure from normality for both primary and secondary school teachers in each scale question. Particularly, the Shapiro-Wilk test did not show evidence of normality for the scale question "Definition and Nature of Dyscalculia" for primary $W(232)=.915$, $p=.000$ and secondary school teachers $W(99)=.941$, $p=.000$; for the scale question on the "Symptoms"

for primary $W(232)=.885$, $p=.000$ and secondary teachers $W(99)=.939$, $p=.000$; and for the scale question on the “Interventions” for primary $W(232)=.812$, $p=.000$ and secondary teachers $W(99)=.892$, $p=.000$ (Appendix D). Thus, to be conservative about the findings of the current research, a non-parametric Mann-Whitney test was preferred for this study. The findings are reported in the next chapter.

Findings

Demographic Characteristics

This chapter presents the findings of the current study examining the level of teachers' knowledge of dyscalculia, its definition, the nature of this disability, its symptoms, and knowledge of intervention methods. Also, the findings on the comparison of primary and secondary school teachers' knowledge, and the relationship between the teachers' exposure to dyscalculia and their level of knowledge about this disability are also presented in this chapter. This chapter has five subsections - demographic characteristics of respondents in the study, teachers' knowledge of the definition and nature of dyscalculia, teachers' knowledge of the symptoms of dyscalculia, teachers' knowledge of the interventions, and the relationship between the exposure to dyscalculia and teachers' level of knowledge about dyscalculia.

Overall, 751 teachers from 60 schools participated in an anonymous survey. Almost 83% (n=620) of respondents completed all sections of the survey; 443 (71.5%) were primary school and 177 (28.5%) secondary school mathematics teachers. The remaining part (17.4%, n=133), who did not consent to this study, completed only demographic questions, taught at both primary and secondary levels of education or did not specify which grade they teach were excluded from the data analysis. The total number of cases that were used for analysis was 620.

Almost all participants of the sample were females (96.8%, n=600), and a smaller proportion were males (3.2%, n=20). The mean age for teachers was 40.5 years (SD=12).

The most common highest educational degree for teachers was the bachelor's degree (60.8%, n=377), and 16% (n=99) of teachers indicated that they had received a higher education diploma before 1991 (Table 5). Almost half of the respondents had teaching experience of less than 10 years (45.4%, n=281). About one-quarter had an experience of

more than 25 years (27.7%, n=172), and between 11-25 years (26.9%, n=167) (see Appendix E for more characteristics).

Table 5 *Demographic Characteristics of Respondents*

	Background variables	N	Total
Gender	Male	20 (3.2%)	620 (100%)
	Female	600 (96.8%)	
The Highest Educational Degree	High school	10 (1.6%)	618 (99.7%)
	College	55 (8.9%)	
	Bachelor	377 (60.8%)	
	Master	58 (9.4%)	
	Doctoral	2 (0.3%)	
	Higher education diploma received prior to 1991	99 (16%)	
	Other	17 (2.7%)	
Teaching Experience	Less than 1 year	47 (7.6%)	620 (100%)
	2 - 5 years	132 (21.3%)	
	6 - 10 years	102 (16.5%)	
	11 - 25 years	167 (26.9%)	
	More than 25 years	172 (27.7%)	

It is interesting that more than half (61.5%, n=381) of the respondents had not encountered the topic of dyscalculia before this survey (Table 6). Those, who reported that they had encountered this term (38.4%, n=238), mostly indicated pre-service teacher training (TT) program at the bachelor's degree level (13.2%, n=82), in-service professional development training course (14%, n=87), or their colleagues and friends (13.1%, n=81) as a source of information. Similarly, a little more than half of the surveyed teachers indicated that they did not encounter dyslexia (51.3%, n=318) before. Since dyslexia is one of the most common disorders coexisting with dyscalculia, it was important to ask about dyslexia as well. Those who had heard about dyslexia (47.7%, n=296), predominantly specified the same sources of information which were the pre-service TT program at bachelor's degree

(14.5%, n=90), in-service professional development training course (17.7%, n=110), as well as colleagues and friends (14.8%, n=92).

Table 6 *Teachers' Exposure to the Phenomenon of Dyscalculia and Dyslexia*

Background variables		N	Total
Encountered the Topic of Dyscalculia Before	No	381 (61.5%)	619 (99.8%)
	Yes	238 (38.4%)	
	Pre-service TT program at Bachelor's Degree	82 (13.2%)	
	TT program at Master's Degree	22 (3.5%)	
	TT program at Doctoral Degree	2 (0.3%)	
	In-service training course	87 (14%)	
	I found and studied materials myself	44 (7.1%)	
	I heard about it in some presentation	38 (6.1%)	
	I heard about it from my colleagues/friends	81 (13.1%)	
	Other	7 (1.1%)	
Encountered the Topic of Dyslexia Before	No	318 (51.3%)	614 (99%)
	Yes	296 (47.7%)	
	Pre-service TT program at Bachelor's Degree	90 (14.5%)	
	TT program at Master's Degree	31 (5%)	
	TT program at Doctoral Degree	5 (0.8%)	
	In-service training course	110 (17.7%)	
	I found and studied materials myself	69 (11.1%)	
	I heard about it in some presentation	52 (8.4%)	
	I heard about it from my colleagues/friends	92 (14.8%)	
Other	14 (2.3%)		
Encountered Suspected Cases of Dyscalculia	Yes	201 (32.4%)	616 (99.4%)
	No	415 (66.9%)	

It stands out that the majority of teachers did not encounter suspected cases of dyscalculia throughout their career (66.9%, n=415). At the same time, the majority of teachers showed interest to participate in additional courses about dyscalculia (65.5%,

n=406). Most teachers (n=11) who left additional comments at the end of the survey expressed a need for TT courses about dyscalculia.

Teachers' Awareness of the Definition and Nature of Dyscalculia

Teachers' knowledge of dyscalculia was examined by the adoption and adjustment of the existing survey questionnaire developed by Sousa et al. (2017) to the Kazakhstani context. The instrument has 44 questions with response options of "Agree", "Don't know" (DN), and "Disagree". It is divided into three parts which are designed to measure teachers' knowledge of the definition and nature of dyscalculia (10 items), symptoms (21 items), and interventions (13 items). The questions were scored as correct or incorrect based on the facts about dyscalculia. Generally, the option "Agree" was correct for all items, except 1st, 3rd, 7th, 8th, and 9th items of the first part of the instrument that have the option "Disagree" as the correct answer. In addition, a chi-square test was performed in order to compare teachers' answers at different grade levels. On average, teachers did not differ in their awareness holding similar views about dyscalculia in most of the items. Nevertheless, some important findings emerged and there were several items that showed a statistically significant difference between primary and secondary teachers' knowledge of dyscalculia. Only statistically significant results on the chi-square test are presented and discussed in more detail in this chapter. Detailed tables with full information about teachers' knowledge of each question can be found in the appendices F, G, and H.

The first hypothesis that teachers lack knowledge of the definition and nature of dyscalculia was confirmed. None of the questions were correctly answered by more than half of the surveyed teachers. The scores for correct answers ranged from 4.9% to 49.3%. The average score of the correct answers in this section was 25.6% (2.3 out of 9 items) for both primary and secondary teachers which is very low.

Table 7 *Teachers' Knowledge of the Causes of Dyscalculia*

No Item		Primary	Secondary	Total
10 In your opinion, what is the cause of dyscalculia? (more than one alternative can be marked):	reduced intelligence	120	50	170 (27.4%)
	lack of attention	194	76	270 (43.5%)
	poor quality of education	87	52	139 (22.4%)
	brain damage	110	53	163 (26.3%)
	heredity	147	59	206 (33.2%)
	emotional problems	88	44	132 (21.3%)
	social problems	70	45	115 (18.5%)
	other problems	85	25	110 (17.7%)

When indicating the possible causes of dyscalculia, most teachers marked the lack of attention (43.5%, $n=270$), and heredity (33.2%, $n=206$) as a cause of dyscalculia (Table 7). Almost one-third of the respondents thought that reduced intelligence (27.4%, $n=170$), and brain damage (26.3%, $n=163$) can cause this learning disability. Finally, poor quality of education (22.4%, $n=139$), social (18.5%, $n=115$), and emotional problems (21.3%, $n=132$) teachers mentioned the least.

A chi-square test was performed to compare the answers of primary and secondary teachers. There was a statistically significant difference between their knowledge of dyscalculia on 6th question $\chi^2(2, N=524) = 10.34, p = .006, \phi = .14$ (Table 8). On average, secondary teachers did not know that “some developmental disorders such as ADHD may co-occur with dyscalculia” more than primary teachers. The effect size indicates the modest strength of this relationship.

Moreover, a statistically significant result was found on 9th question $\chi^2(2, N=515) = 9.8, p = .007, \phi = .14$. Primary teachers (32.4%, $n=116$) were more likely to incorrectly agree with the statement “unlike dyslexia, dyscalculia is a relatively rare disorder, affecting only 1% of students”. The expected counts for this option were higher than observed values for primary and fewer for secondary teachers. Whereas a higher proportion of

Table 8 *Statistically Significant Items on the "Definition and Nature of Dyscalculia"*

No	Item		Primary	Secondary	Total		
6	Some developmental disorders, such as Attention Deficit Hyperactivity Disorder (ADHD), may co-occur with dyscalculia.	Agree	Count	151	49	200	
			Expected Count	138.5	61.5	200.0	
			% within Primary and Secondary	41.6%	30.4%	38.2%	
		DN	Disagree	Count	191	92	283
				Expected Count	196.0	87.0	283.0
				% within Primary and Secondary	52.6%	57.1%	54.0%
			Agree	Count	21	20	41
				Expected Count	28.4	12.6	41.0
				% within Primary and Secondary	5.8%	12.4%	7.8%
		Total	Count	363	161	524	
				$X^2(2, N=524) = 10.34, p = .006, phi = .14$			
		9	Unlike dyslexia, dyscalculia is a relatively rare disorder, affecting only 1% of students.	Disagree	Count	19	8
Expected Count	18.8				8.2	27.0	
% within Primary and Secondary	5.3%				5.1%	5.2%	
DN	Disagree			Count	223	119	342
				Expected Count	237.7	104.3	342.0
				% within Primary and Secondary	62.3%	75.8%	66.4%
	Agree			Count	116	30	146
				Expected Count	101.5	44.5	146.0
				% within Primary and Secondary	32.4%	19.1%	28.3%
Total	Count			358	157	515	
				$X^2(2, N=515) = 9.8, p = .007, phi = .14$			

secondary teachers were not sure and ticked the "don't know" option (75.8%, n=119).

Accordingly, the expected counts were higher than the observed for secondary and fewer for primary teachers on this option. Only a minority of both secondary and primary

teachers knew that this statement was not true. The effect size indicates the modest strength of this relationship.

Teachers' Awareness of the Symptoms of Dyscalculia

The second hypothesis that teachers' lack knowledge about the symptoms of dyscalculia was confirmed. However, they were more knowledgeable about the symptoms than the nature of dyscalculia. The scores for correct answers ranged from 34.6% to 65.9%, which is slightly higher than that of the survey's previous section. The average score of the correct answers in this section was 44.3 % (9.3 out of 21 items) for all teachers which confirms their low level of knowledge. Primary and secondary school teachers had similar average scores for the correct answers which were 47.6% for primary and 49% for secondary teachers.

Table 9 Statistically Significant Items on the "Symptoms" of Dyscalculia (items 1,3,5)

No	Item		Primary	Secondary	Total
1	Understanding and using mathematical symbols (+, -, x, :).	Agree			
		Count	210	71	281
		Expected Count	201.7	79.3	281.0
		% within Primary and Secondary	51.6%	44.4%	49.6%
		DN			
		Count	133	50	183
		Expected Count	131.4	51.6	183.0
		% within Primary and Secondary	32.7%	31.3%	32.3%
		Disagree			
Count	64	39	103		
Expected Count	73.9	29.1	103.0		
% within Primary and Secondary	15.7%	24.4%	18.2%		
Total	Count	407	160	567	
$X^2(2, N=567) = 6.01, p = .049, phi = .10$					
3	Reading numbers (e.g., "12" instead of "21").	Agree			
		Count	158	43	201
		Expected Count	140.9	60.1	201.0
% within Primary and Secondary	42.9%	27.4%	38.3%		

No	Item		Primary	Secondary	Total
		DN			
		Count	125	55	180
		Expected Count	126.2	53.8	180.0
		% within Primary and Secondary	34.0%	35.0%	34.3%
		Disagree			
		Count	85	59	144
		Expected Count	100.9	43.1	144.0
		% within Primary and Secondary	23.1%	37.6%	27.4%
	Total	Count	368	157	525
	$X^2(2, N=525) = 15.4, p < .001, phi = .17$				
5	Difficulty in counting (repeating or omitting numbers).	Agree			
		Count	183	61	244
		Expected Count	170.4	73.6	244.0
		% within Primary and Secondary	51.7%	39.9%	48.1%
		DN			
		Count	108	54	162
		Expected Count	113.1	48.9	162.0
		% within Primary and Secondary	30.5%	35.3%	32.0%
		Disagree			
		Count	63	38	101
		Expected Count	70.5	30.5	101.0
		% within Primary and Secondary	17.8%	24.8%	19.9%
	Total	Count	354	153	507
	$X^2(2, N=507) = 6.5, p = .04, phi = .11$				

A chi-square test revealed a statistically significant difference in several items on knowledge of the symptoms between primary and secondary teachers (Table 9, Table 9a). The primary teachers, generally were more likely to correctly agree, while secondary teachers were more likely to incorrectly disagree with the given statements. The expected counts for primary teachers were fewer than the observed, whereas the expected counts for secondary teachers were higher than the observed values. This means that secondary teachers were less aware of the symptoms than their colleagues teaching primary level. For example, it is known that students with dyscalculia struggle with selecting appropriate

mathematical symbols (Kosc, 1974). However, secondary teachers had tendency to incorrectly disagree (24.4%, n=29) that students with developmental dyscalculia (DD) have difficulties in “understanding and using mathematical symbols” (i.e., +, -, x, :) than the primary teachers did (15.7%, n=64), $X^2(2, N=567) = 6.01, p = .049, \phi = .10$.

Though it is a correct statement (Kosc, 1974), secondary teachers also were likely to incorrectly disagree (37.6%, n=59) that DD students have difficulties with “reading numbers” i.e., reading 12 as 21, while primary teachers were more likely to agree with it (42.9%, n=158), $X^2(2, N=525) = 15.4, p < .001, \phi = .17$.

Moreover, secondary teachers more frequently did not believe (24.8%, n=38) that DD students have “difficulties in counting” such as repeating or omitting numbers while counting, $X^2(2, N=507) = 6.5, p = .04, \phi = .11$. However, it is a true characteristic of students with dyscalculia (Sousa et al., 2017). By contrast, primary teachers (51.7%, n=183) more frequently knew this fact.

A higher proportion of secondary teachers (18.8%, n=28) did not believe that students struggle with “understanding the concept of time”, $X^2(2, N=503) = 8.96, p = .01, \phi = .13$, though they do have such difficulties (Williams, 2013). Meanwhile, primary teachers (55.6%, n=197) relatively better knew this item.

Secondary teachers were more likely not to believe (23.1%, n=34) that DD students struggle with “performing activities that require sequencing elements i.e., saying the correct sequence of the months of the year, days of the week and seasons”, whereas primary teachers (45.2%, n=157) were more likely to agree with this statement, $X^2(2, N=494) = 7.4, p = .03, \phi = .12$. As it was mentioned before, sequencing confusion is one of the core characteristics of students with dyscalculia (Williams, 2013).

Table 9 a Statistically Significant Items on the "Symptoms" of Dyscalculia (items 6,8,12,14)

Nº	Item		Primary	Secondary	Total			
6	Understanding the concept of time (e.g., telling the time).	Agree	Count	197	62	259		
			Expected Count	182.3	76.7	259.0		
			% within Primary and Secondary	55.6%	41.6%	51.5%		
		DN	Count	114	59	173		
			Expected Count	121.8	51.2	173.0		
			% within Primary and Secondary	32.2%	39.6%	34.4%		
		Disagree	Count	43	28	71		
			Expected Count	50.0	21.0	71.0		
			% within Primary and Secondary	12.1%	18.8%	14.1%		
		Total			Count	354	149	503
		$X^2(2, N=503) = 8.96, p = .01, phi = .13$						
		8	Performing activities that require sequencing elements (e.g., saying the correct sequence of the months of the year, days of the week and seasons).	Agree	Count	157	52	209
Expected Count	146.8				62.2	209.0		
% within Primary and Secondary	45.2%				35.4%	42.3%		
DN	Count			141	61	202		
	Expected Count			141.9	60.1	202.0		
	% within Primary and Secondary			40.6%	41.5%	40.9%		
Disagree	Count			49	34	83		
	Expected Count			58.3	24.7	83.0		
	% within Primary and Secondary			14.1%	23.1%	16.8%		
Total				Count	347	147	494	
$X^2(2, N=494) = 7.4, p = .03, phi = .12$								
12	Difficulties with writing numbers and symbols (e.g., inverted or rotated).			Agree	Count	167	54	221
		Expected Count	154.8		66.2	221.0		
		% within Primary and Secondary	49.3%		37.2%	45.7%		

No	Item		Primary	Secondary	Total		
		DN	Count	129	60	189	
			Expected Count	132.4	56.6	189.0	
			% within Primary and Secondary	38.1%	41.4%	39.0%	
		Disagree	Count	43	31	74	
			Expected Count	51.8	22.2	74.0	
			% within Primary and Secondary	12.7%	21.4%	15.3%	
	Total		Count	339	145	484	
	$\chi^2 (2, N=484) = 8.5, p = .01, phi = .13$						
14	Understanding the concept of conservation (e.g., “6”, “4+2” and “5+1” are equivalent to each other).	Agree	Count	154	48	202	
			Expected Count	142.7	59.3	202.0	
			% within Primary and Secondary	45.4%	34.0%	42.1%	
		DN	Count	128	56	184	
			Expected Count	130.0	54.1	184.0	
			% within Primary and Secondary	37.8%	39.7%	38.3%	
		Disagree	Count	57	37	94	
			Expected Count	66.4	27.6	94.0	
			% within Primary and Secondary	16.8%	26.2%	19.6%	
		Total		Count	339	141	480
		$\chi^2 (2, N=480) = 7.69, p = .02, phi = .13$					

A higher proportion of secondary teachers were inclined to incorrectly disagree that DD students have “difficulties with writing numbers and symbols (e.g., inverted or rotated)” compared to primary teachers (49.3%, n=167) who tended to agree with this fact, $\chi^2 (2, N=484) = 8.5, p = .01, phi = .13$. Children with dyscalculia indeed have problems with correctly writing numbers and symbols (Kosc, 1974).

Finally, secondary teachers were disposed not to believe the fact that DD students may have problems in “understanding the concept of conservation” (Kosc, 1974) i.e., “6”, “4+2” and “5+1” are equivalent to each other, though primary teachers were apt to agree

(45.4%, $n=154$), $X^2(2, N=480) = 7.69, p = .02, \phi = .13$. Overall, the effect sizes for all these items show a modest relationship between primary and secondary teachers' knowledge.

Teachers' Awareness of the Interventions

The third hypothesis that teachers lack knowledge about the interventions to support students with dyscalculia was rejected. Teachers' knowledge about intervention methods was revealed to be at a moderate level. The level of their knowledge was determined as follows: up to 60% - a low level, from 61 to 80% - moderate level, above 81% - a high level. In comparison to the two previous parts of the survey, teachers had moderate average scores of the correct answers in this section which was 63.8% (8.3 out of 13 items). The scores for correct answers ranged from 54.1% to 70%. This means that at least half of the surveyed teachers answered correctly all questions regarding interventions to support students with dyscalculia. Primary and secondary teachers had a very similar level of knowledge about intervention methods. The average scores of the correct answers were 63.8% for primary and 63.1% for secondary teachers.

A chi-square test was performed to examine the relationship between primary and secondary teachers' knowledge of interventions. This analysis found no statistically significant difference between these two groups on all items measuring knowledge of intervention to help DD students.

Mann-Whitney test was performed and confirmed the fourth hypothesis that there is no statistically significant difference between primary and secondary teachers' knowledge of dyscalculia. To sum up, this test showed that teachers at primary and secondary levels did not have statistically significant differences in their mean scores holding very similar levels of knowledge on each dimension of the survey: (1) definition and nature of dyscalculia $U(N_{\text{primary}}=339, N_{\text{secondary}}=151) = 25263.00, z = -.23, p = .82$; (2) symptoms of

dyscalculia $U(N_{\text{primary}}=292, N_{\text{secondary}}=126) = 17157.00, z = -1.097, p = .27$; and (3)

interventions $U(N_{\text{primary}}=296, N_{\text{secondary}}=130) = 18464.00, z = -.67, p = .501$.

Relationship Between Teachers' Exposure to the Phenomenon of Dyscalculia and their Level of Knowledge of this Disability

One of the aims of the present study was to test the hypothesis that exposure to the phenomenon of dyscalculia is associated with a better level of teachers' knowledge about dyscalculia. The exposure was measured as learning about the concept of dyscalculia and having students suspected of dyscalculia throughout teachers' careers. Mann-Whitney test was used to test the abovementioned hypothesis. Overall, it can be said that this fifth hypothesis was confirmed.

The Mann-Whitney test indicated statistically significant differences in two dimensions of the survey (definition and nature of dyscalculia, symptoms of dyscalculia,) for teachers who encountered students suspected of dyscalculia in their careers. In particular, teachers who had students suspected of dyscalculia had better knowledge of the definition and nature of dyscalculia, $U(N=158) = 17763.50, z = -5.75, p < .001$; and symptoms of dyscalculia, $U(N=145) = 16118.50, z = -3.031, p = .002$. However, there was no statistically significant difference in their knowledge of the intervention methods to support DD students, $U(N=142) = 19136.50, z = -.75, p = .451$.

Comparably, the Mann-Whitney test revealed statistically significant differences in each dimension for teachers who learned about dyscalculia using different sources of information such as pre-service or in-service training, having heard about it from colleagues, or studying it by themselves. Teachers who learned about this disability were more aware of the definition and nature of dyscalculia, $U(N=176) = 21374.00, z = -4.18, p < .001$; symptoms of dyscalculia, $U(N=144) = 16282.00, z = -2.95, p = .003$; and interventions, $U(N=156) = 17915.00, z = -2.605, p = .009$.

Besides, the interesting finding is that the Mann-Whitney test revealed statistically significant differences in each dimension for teachers who learned about dyslexia from different sources of information. Teachers who learned about dyslexia were also more knowledgeable about the definition and nature of dyscalculia, $U(N=221) = 20619.00$, $z = -5.82$, $p < .001$; symptoms of dyscalculia, $U(N=198) = 18192.50$, $z = -2.92$, $p = .004$; and interventions, $U(N=196) = 19652.00$, $z = -2.24$, $p = .025$.

In addition, a chi-square test was performed to examine whether there is a significant relationship between teachers who learned about the concept of dyscalculia and those who had students suspected of this disability. There is a statistically significant relationship between learning about the concept and having students suspected of dyscalculia, $\chi^2(1, N = 615) = 18.43$, $p < .001$, $\phi = .17$. Teachers who had students suspected of dyscalculia were more likely to learn about this disability. The effect size indicates the modest strength of this relationship.

In conclusion, teachers showed a low level of awareness about dyscalculia. Specifically, they lacked knowledge on the “definition and nature” as well as “symptoms” of dyscalculia. Yet, they were relatively better informed about educational strategies. They had low average scores on the first two sections which were 25.6% and 44.3%, respectively. However, they had moderate average scores on the “interventions” section which were 63.8%. This indicates that teachers are somehow aware of the intervention methods to support students with MLD. Furthermore, the findings of the present research indicate that exposure to the phenomenon of dyscalculia is associated with a better level of knowledge about dyscalculia. The exposure is measured as learning about the concept and having students with math difficulties in class as suspected cases of dyscalculia. However, teachers who encountered students suspected of dyscalculia did not have better knowledge about interventions. Moreover, teachers' experience of learning about dyscalculia is

associated with having students with this disability. The next section discusses these findings in accordance with and reference to the literature.

Discussion

Low Primary and Secondary School Mathematics Teachers' Awareness of the Definition and Nature of Dyscalculia

The results of this study revealed a low level of teachers' knowledge of the definition and nature of dyscalculia which is consistent with findings in most other studies (Dias et al., 2013; Fu & Chin, 2017; Graves, 2018; Karasakal, 2018; Kunwar et al., 2021; Sezer & Akin, 2011).

Striking was a finding in this study that teachers believe dyscalculia is a relatively rare disorder compared to dyslexia, affecting only 1% of students. Only 5.3% of teachers in the current study knew this was not true. International studies, however, show varying results. One-third of teachers in Malaysia and 86% of teachers in Greece knew that dyscalculia is common and affects more than 1% of students (Chideridou-Mandari et al., 2016; Fu & Chin, 2017). Despite the discrepancy in the percentage of teachers' knowledge of the prevalence of dyscalculia in international studies, the result obtained in Kazakhstan is still at a very low level.

Another prominent finding of the current study was that teachers believed that symptoms may disappear if students are properly supported. Only 4.9% of the teachers knew that this was not true. This finding corroborates the findings of a study in Kazakhstan by Zhanatbekova (2018), in which teachers also were not well aware of the permanent nature of this particular disability. Zhanatbekova's (2018) study also revealed that teachers held the view that symptoms usually disappear by 4th grade. Nevertheless, vice-principals in the same study admitted that there are still some students with mathematics difficulties in secondary school, and symptoms do not disappear with age.

However, almost half of the teachers in the current study (49.3%) knew that dyscalculia significantly interferes with academic achievement or activities of daily living

that require calculation ability. Despite this item being correctly answered most frequently, it is still a low percentage of their level of knowledge. This means that the other half of the teachers do not know this fact. Similar results were reflected in Turkey, where half of the teachers disagreed that dyscalculia is real, may bring distress to students, and alter their behavior (Karasakal, 2018). A possible explanation for teachers' low awareness of the definition and nature of dyscalculia in this study may be the fact that the majority of teachers (61.5%) have not encountered the phenomenon of dyscalculia before. Teachers in this study have studied dyscalculia neither at the university level nor received professional training courses on this topic. These findings send a strong signal to the government and have important implications for developing quality professional training courses for teachers.

Regarding the causes of dyscalculia, the majority of teachers in the current study indicated students' lack of attention and heredity as the main causes of dyscalculia. On one hand, teachers correctly believed that heredity may cause dyscalculia, on the other hand, they did not know that lack of attention does not cause this disability. In accordance with the present results, previous studies in different countries have demonstrated that many teachers also think that the main causes for dyscalculia are students' lack of attention (Fu & Chin, 2017; Karasakal, 2018) and heredity (Karasakal, 2018; Zhanatbekova, 2018). The given findings especially mirror those obtained in Turkey, where most of the teachers indicated both lack of attention and heredity as the main factors causing dyscalculia (Karasakal, 2018). A possible explanation for teachers' view in this study that attention deficits can cause dyscalculia in students, might be the fact that one of the most common coexisting disorders with dyscalculia is ADHD (Williams, 2013).

Overall, these discussed findings show that the vast majority of primary and secondary mathematics teachers in the large city in Southern Kazakhstan have poor

knowledge of the causes, the prevalence of dyscalculia, and think symptoms may disappear if students are properly supported which is consistent with most earlier studies done in the field (Fu & Chin, 2017; Karasakal, 2018; Zhanatbekova, 2018).

Low Primary and Secondary School Mathematics Teachers' Awareness of the Symptoms of Dyscalculia

In the current study, teachers have shown a low level of knowledge of the symptoms of dyscalculia. Though teachers were more aware of the symptoms than the definition and nature of dyscalculia, the average score for the correct answers is still at a low level (44.3%). Further, this section discusses teachers' knowledge about the symptoms of dyscalculia as related to the core number, memory, reasoning, behavioral, and visual-spatial difficulties of students with dyscalculia.

The current study found that most of the teachers lacked knowledge of the items related to core number concepts. In particular, they did not know that difficulties in counting, distinguishing pairs of numbers, reading numbers, sequencing elements, and understanding the concept of conservation are the core characteristics of students with dyscalculia. This is consistent with the study in Nepal in which teachers were not well aware of the symptoms such as poor organization of numbers and counting difficulties (Kunwar et al., 2021). On the contrary, most studies indicate that teachers are aware of the core number difficulties of DD students. For instance, most teachers in Brazil and Malaysia knew that DD students have difficulties in sequencing elements (Dias et al., 2013; Fu & Chin, 2017). Additionally, teachers in a study conducted in the USA knew the symptoms associated with dyscalculia such as difficulties in number sense, reading, understanding, and working with numbers (Graves, 2018). For example, one of the teachers stated that dyscalculia is "The struggle/inability to read, understand, and calculate with numbers" and another stated that "Dyscalculia is a disability that makes it difficult to

understand number concepts” (Graves, 2018, p.107). As compared to these mentioned earlier studies, it can be said that teachers of the current study have limited knowledge about DD students' core number difficulties.

The current study found that most of the teachers also lacked knowledge of the items related to reasoning skills. The majority of the teachers did not know that DD students struggle with understanding the concept of measurement (weight, length), time, and dealing with money. These findings corroborate the findings of earlier studies. Many studies report that teachers have insufficient knowledge about DD students' difficulties in issues of measurement such as distance, weight, and time (Dias et al., 2013; Fu & Chin, 2017). Interestingly, findings of the study in Greece indicate that even if the majority of teachers knew that students with dyscalculia have difficulties with weight and length issues, only a minority knew that they also have difficulties with telling time and exchanging money (Chideridou-Mandari et al., 2016). Similarly, in Turkey almost all teachers reported that DD students lack problem-solving skills that require the application of math rules; yet very few reported that these students also have difficulties in exchanging money (Sezer & Akin, 2011). Perhaps low awareness of these symptoms among teachers of the current study may be related to the content of the curriculum - how much time the education system devotes to the topics related to reasoning skills or if teachers connect their lessons with everyday life activities such as telling the time or exchanging money.

Interestingly, the most known and unknown symptoms by teachers were related to the difficulties that require reasoning skills. The most common misunderstanding by teachers (only 34.6% were correct) in this study was that students with dyscalculia do not struggle with comparing quantities using terms such as “more/less”, and “bigger/smaller”. This finding corroborates the results of the study by Dias et al. (2013), in which more than half of teachers (63.5%) also did not know that students with dyscalculia have difficulties

in comparing quantities by using these mentioned terms. However, in contrast to these findings, a study conducted in Greece has found that most teachers knew that DD students struggle with understanding the meaning of arithmetic terms (i.e., bigger than) (Chideridou-Mandari et al., 2016).

The most frequently correctly answered question by teachers (65.9%) in this study was that DD students struggle with solving word problems which also require reasoning skills. This proportion is still small compared to a study in Greece, in which almost all teachers (95%) knew about DD students' difficulties in choosing appropriate arithmetic operations to solve word problems (Chideridou-Mandari et al., 2016). By contrast, the majority of the teachers in Brazil did not know this fact (only 36.5% were correct) (Dias et al., 2013). This discrepancy also may be explained by the number of hours devoted to this topic in the curriculum in different countries. Moreover, these results show that even if most teachers in this study knew that DD students have difficulties with word problems, only a minority knew that they also struggle with comparing quantities using terms such as "bigger/smaller" and "more/less".

This study has found that the majority of teachers are not well aware of the visual-spatial difficulties of DD students. These include difficulties with writing numbers and symbols, interpreting tables and graphs as well as difficulty in spatial orientation and lateralization. Similarly, teachers in Greece had limited knowledge that representing word problems visually and interpreting diagrams is difficult for students with dyscalculia (Chideridou-Mandari et al., 2016). In contrast, the levels observed in this study are far below those observed by Fu and Chin (2017) in Malaysia, who found that teachers knew about DD students' visual-spatial difficulties such as confusing the left and right directions (Fu & Chin, 2017).

One of the most frequently correctly reported symptoms of dyscalculia by teachers (60%) of the current research was related to memory difficulties. This is to say that teachers understood that students with dyscalculia often have problems with remembering math concepts, rules, and multiplication tables. These results match those observed in many earlier studies, in which teachers knew that students with dyscalculia often have problems with remembering math facts (Chideridou-Mandari et al., 2016; Fu & Chin, 2017; Graves, 2018; Sezer & Akin, 2011). This is the most commonly known symptom of students with dyscalculia according to the literature.

Additionally, over half of the teachers in the present study were informed that dyscalculia can alter the behavior of DD children. Students with dyscalculia may be anxious, and nervous and may not concentrate well on learning mathematics. However, these results are still small compared to the findings of other earlier studies. Dias et al. (2013) reported that the majority of teachers knew the behavioral symptoms as being anxious and distracted during mathematics lessons. Furthermore, almost all teachers in Greece knew that DD students struggle with explaining their answers and may respond impulsively, especially to word problems (Chideridou-Mandari et al., 2016).

Findings in the current study on Kazakhstan demonstrate that most teachers lacked knowledge about DD students' symptoms related to the core number, reasoning, and visual-spatial difficulties associated with this disability. However, teachers most frequently knew that students with dyscalculia have difficulties with memorizing math facts and solving word problems. The most common misunderstanding by teachers was that DD students can easily compare quantities using terms such as “bigger/smaller”, and “more/less”.

Moderate Primary and Secondary School Mathematics Teachers' Awareness of the Interventions to Support Students with Dyscalculia

The participants of the present study were more aware of the intervention methods compared to identifying the symptoms of dyscalculia. A possible explanation for this discrepancy may be the fact that all of the methods provided in the questionnaire can be used as effective strategies to support not only DD students but also all those who have difficulties in mathematics. Also, this could be because of teachers' belief that all students with difficulties in math will have dyscalculia. Indeed, the majority of teachers in this study did not know that not every student with difficulties in mathematics will have this disability. In addition, teaching struggling students encourages their teachers to try different teaching methods, and in practice, these teachers can determine which methods are effective. The findings are discussed further in accordance with the previous research.

The majority of teachers (69-70%) in this study mostly believed that teaching students individually and stimulating their memory would best support DD students. The latter technique could be explained by the fact that one of the most frequently believed symptoms of dyscalculia among teachers of this study was students' difficulties with memory. Similar to the findings of this study, research in the USA (Graves, 2018) and Kazakhstan (Zhanatbekova, 2018) indicates that individualized instruction was reported by teachers as a method of intervention that would best support students with dyscalculia. However, teachers in the USA believed that providing extra time to MLD students will cause other students to be ignored in the class (Graves, 2018). Most teachers in the study in the US believed that students would benefit from one-to-one support from a specialist and used a co-teaching strategy when a student with symptoms of dyscalculia was present in the classroom (Graves, 2018). Comparably, primary teachers in the study in Kazakhstan tried to run individual classes after school (Zhanatbekova, 2018). Definitely, tutoring is a common practice of teachers in Kazakhstan for all those who lag behind their peers in academic performance.

Teachers of this study least believed (only 54.1% were correct) that technology and computer-based interventions are effective in increasing DD students' math achievement. By contrast, teachers in earlier studies reported the use of technology, online resources (Graves, 2018), and multimedia (Kunwar et al., 2021) as effective tools to support students with math difficulties.

The findings of this study are consistent with previous research which has reported behavioral interventions apart from the educational tools that teachers used to support students with difficulties in mathematics. These are aimed at reducing math anxiety in children. More than half of the teachers (66.5%) in the present study believed that motivating children by acknowledging and praising them helps students with dyscalculia in their learning. Kunwar et al. (2021) reported that teachers in Nepal used methods to develop students' positive attitude towards mathematics, set a positive atmosphere in the classroom, encourage the active involvement of students in and out of the classroom activities, motivate students to learn, encourage students not to give up, and take numerous attempts to succeed. Similarly, even if teachers in the study conducted in Turkey did not know how to support students with dyscalculia, they tried to understand their students and motivate them to learn mathematics (Karasakal, 2018).

Overall, teachers of the present research in Kazakhstan had relatively better knowledge about the interventions compared to the definition, nature, and symptoms of dyscalculia. Teachers of this study knew that DD students gain much from individualized instruction; however, these teachers least believed that technology and computer-based interventions are effective strategies to support students with dyscalculia. Although teachers had a moderate level of knowledge about methods of intervention, it is suggested that this is not due to their knowledge of these strategies to support DD students, but because they mostly thought that all students who have difficulties in math will have

dyscalculia and intuitively arrived at these methods that are appropriate for all students who struggle in mathematics.

Similar Primary and Secondary Teachers' Knowledge about Dyscalculia

The findings of this study revealed that there was no statistically significant difference in teachers' average scores of the correct answers at both the primary and secondary levels of education. Primary and secondary school teachers in Kazakhstan, on average, had very similar levels of knowledge about the definition of dyscalculia, its nature, symptoms, and interventions. Nevertheless, the study revealed some important differences between the primary and secondary school teachers' knowledge in certain areas as well. A possible explanation for this might be that teachers teaching at different levels may have different views of how a student develops in math learning. Another possible explanation for this is the content of the curriculum at different grade levels that allows teachers to determine in which certain areas children may struggle.

For instance, secondary school teachers were less informed that some developmental disorders such as ADHD may co-exist with dyscalculia compared to primary teachers. This may be due to the fact that behavioral disorders such as ADHD are more visible at the primary level when children are younger, and identified at an age under 12 (APA, 2013).

The prevalence of dyscalculia was a puzzle for teachers at both levels. Most teachers at both levels did not know the correct answer to this question. In accordance with the present result, a previous study in Malaysia has demonstrated that most of the primary teachers (66%) perceived dyscalculia as a rare condition and believed children outgrow their disabilities (Fu & Chin, 2017). This study in Kazakhstan shows that this is not the issue only for primary school teachers, but also for secondary school teachers.

Regarding the symptoms of dyscalculia, the secondary teachers were less aware of the symptoms than their colleagues teaching at the primary level. The majority of these

symptoms include core number difficulties such as difficulties in understanding and using mathematical symbols, reading numbers, difficulty in counting, performing activities that require sequencing elements, as well as difficulties in understanding the concept of conservation. This could be attributed to the fact that these primary skills are taught at the primary school level. However, previous research in Nepal has contradicting results; most of the primary teachers did not know that dyscalculia is associated with counting skills (Kunwar et al., 2021).

Moreover, primary teachers in this study were more informed that DD students have difficulties in understanding the concept of time, and difficulties with writing numbers and symbols compared to secondary teachers. The skills of telling time and writing numbers and symbols in a correct way are also practiced more in primary school. This could explain primary teachers' higher awareness of these symptoms. This is consistent with the findings of earlier research in Greece, in which most secondary teachers did not know that DD students have difficulties with telling the time (Chideridou-Mandari et al., 2016).

As far as the intervention methods are concerned, all teachers held very similar views on how the students with dyscalculia should be supported. To sum up, teachers of primary and secondary school levels held very similar views and levels of knowledge about the definition and nature of dyscalculia, recognizing its symptoms, and intervention methods. However, primary teachers were more informed about certain symptoms of dyscalculia than secondary teachers. Additionally, primary teachers were more informed about the comorbidity of dyscalculia with other developmental disorders such as ADHD than their colleagues teaching at the secondary school level.

Exposure to the Phenomenon of Dyscalculia is Associated with a Better Level of Knowledge about Dyscalculia

One of the tasks in this study was to test the hypothesis of whether teachers' exposure to the phenomenon of dyscalculia is associated with a better awareness of dyscalculia. The exposure was measured by teachers' experiential contact as having a student suspected of dyscalculia in the class and theoretical contact as learning about the phenomenon of dyscalculia in any of the pre-service or in-service training courses, having heard about dyscalculia from colleagues or friends, or studying it by themselves.

The study revealed that teachers who learned about the phenomenon of dyscalculia were more aware of this disability. This is consistent with that of Sousa et al. (2016) who found that teachers who have heard about dyscalculia before were better informed about the definition and nature of dyscalculia as well as intervention methods. Teachers of the current study learned about dyscalculia from different sources including training courses. This study supports evidence from previous observations (Dias et al., 2013; Pio Albina, 2019) that the theoretical exposure to the topic of dyscalculia seems to be more important than the type of school. Public school teachers in India (Pio Albina, 2019) and private school teachers in Brazil (Dias et al., 2013) were receiving training on learning disabilities, thus they had better awareness of dyscalculia. This clearly demonstrates the importance of training courses organized rather than the type of schools. However, it should be kept in mind that teachers in this study learned about dyscalculia not only from training courses but also from other sources of information. Nevertheless, the majority of teachers in the current study most often indicated that they learned about it at pre-service and in-service training courses. A previous study in Kazakhstan demonstrates that the vast majority of teachers encountered the topic of dyscalculia neither during pre-service nor in-service training (Zhanatbekova, 2018). Similarly, more than half of the teachers of the current study have not heard about dyscalculia before. Thus, these findings have important

implications for developing quality in-service or pre-service training programs for teachers at all levels of education to raise their awareness about this disability.

In addition, the present study revealed that having encountered a student suspected of dyscalculia was associated with a better level of teachers' knowledge about the definition and nature of dyscalculia, recognizing its symptoms, but not the intervention methods. Teachers who had students suspected of dyscalculia were more likely to learn about this disability from different sources. This finding is contrary to that of Sousa et al. (2017) who found that having a student suspected of dyscalculia was not associated with a higher level of knowledge about dyscalculia. Sousa et al. (2017) argue that this result could be due to the small number of teachers who had this contact in the study. The findings of the current study mean that teachers' experiential exposure did not affect their level of intervention knowledge. They were informed about intervention methods regardless of having students suspected of dyscalculia, which may mean that teachers intuitively came to the methods that are suitable for all students having difficulties in math. In addition, it is not certain that students of those teachers who indicated that they had previous contact with DD students would have had this disability. Nevertheless, only one-third of teachers in this study encountered suspected cases of dyscalculia throughout their careers.

As dyslexia and dyscalculia are overlapping learning disabilities, the study also tested whether attending training courses on dyslexia was associated with a better level of teachers' knowledge of dyscalculia. The current study revealed an interesting finding - teachers who learned about dyslexia were also more knowledgeable about dyscalculia. Since dyscalculia and dyslexia belong to the same large category of specific learning disabilities, one would expect teachers who are aware of dyslexia to be potentially aware of dyscalculia. Another possible explanation for this could be that teachers are more exposed to dyslexia than dyscalculia, and could have guessed and found some similarities

between these two learning disabilities. The number of teachers in this study who encountered dyslexia before is much higher than those who encountered dyscalculia. These results reflect those of Dias et al. (2013) who also found that teachers were exposed more to the topic of dyslexia than dyscalculia in Brazil. While half of the teachers in the study in Brazil encountered the topic of dyslexia at their graduate level, the majority of them encountered dyscalculia neither at graduate nor at postgraduate levels (Dias et al., 2013).

To sum up, one of the issues emerging from the findings of this study specifically relates to the need to train teachers on dyscalculia. Findings indicate that more than half of the teachers have not heard about the phenomenon of dyscalculia before. What could be done at this stage to raise awareness at the governmental level, is to initiate adequate pre-service and in-service training for teachers. Teachers, in turn, would gain knowledge about the disability and assist DD students in the classroom. Because without adequate knowledge about dyscalculia, the effectiveness of interventions is doubtful. It should be also noted that the majority of the surveyed teachers in this study expressed a desire to participate in additional professional development courses on dyscalculia. The important thing here is to provide quality training since previous studies on learning disabilities have shown that even though teachers who received training on dyslexia were not well aware of this disability (Galimzhanova, 2021). Therefore, there is a certain need to provide adequate pre-service and in-service teacher training programs for teachers across Kazakhstan.

Conclusion

Teachers' Level of Knowledge about Dyscalculia: Answers to the Research Questions and Hypotheses

The purpose of this study was to examine the level of dyscalculia awareness among primary and secondary school mathematics teachers in urban mainstream schools in a large city in Southern Kazakhstan. This study tested five hypotheses: (1) teachers' level of knowledge of the definition and nature of dyscalculia is low, (2) teachers' level of knowledge of the symptoms is low, (3) teachers' level of knowledge of the interventions is low; (4) primary and secondary school teachers' knowledge is at the same level, and (5) teachers' exposure to the phenomenon of dyscalculia is associated with a better understanding of this disability. To answer the research questions and test the hypotheses, the study utilized a quantitative survey research method. Overall, 620 valid responses were obtained from teachers who have completed the online survey questionnaire.

The results of this questionnaire indicate that teachers demonstrated very limited knowledge of the definition and nature of dyscalculia, having an average score of correct answers of 25.6% in this dimension. One of the prominent findings of this study was that teachers lack knowledge about the prevalence and permanent nature of dyscalculia. Although teachers were better informed about the symptoms of dyscalculia than the definition and nature of this disability, the average score of the correct answers was still low at 44.3%. Teachers most frequently believed that DD students do not struggle with comparing quantities with terms such as "bigger/smaller", and "more/less", which is not the case. Interestingly, teachers were better informed about the intervention methods compared to the nature and symptoms of dyscalculia. The average score of correct answers was 63.8%, indicating a moderate level of awareness compared to their awareness of the definition and nature of dyscalculia, as well as symptoms of it. However, most teachers in

this study were unsure or thought that all students struggling in math would have dyscalculia. This may explain their moderate level of awareness of the interventions which may have led them to accept these methods as appropriate to support all students with math difficulties. Overall, teachers lacked knowledge about the nature of dyscalculia and its symptoms. This may imply that even if teachers may suspect cases of dyscalculia in the classroom to some extent, they do not know and understand the nature of this disability. In this case, the effectiveness of their teaching methods aimed at supporting these students would be in doubt. In order to provide effective and successful interventions, it is important to be knowledgeable of all dimensions of this disability.

The analysis of whether teachers at primary and secondary school levels have the same level of knowledge about dyscalculia showed the following. In most instances, teachers at both levels had a very similar level of knowledge. However, several statistically significant results emerged in certain characteristics. Teachers at the secondary level were less aware of certain characteristics of the definition and nature of dyscalculia, as well as its symptoms. For example, primary teachers were better informed that DD students have difficulties in counting and understanding the concept of time. This could be explained by the fact that these skills are taught and practiced more at the primary level. Nonetheless, there was no difference in their awareness of the intervention methods. Overall, it can be said that the fourth hypothesis that primary and secondary teachers' knowledge is at the same level was also confirmed.

Another important finding was that theoretical and experiential exposure to the phenomenon of dyscalculia was revealed to be associated with a better understanding of this disability regarding its definition, nature, symptoms, and interventions which confirmed the last hypothesis of this study. However, having encountered a student suspected of dyscalculia was not associated with a better awareness of the interventions.

This study showed that theoretical exposure as learning about dyslexia was also associated with a better understanding of dyscalculia. Despite these findings, the majority of teachers in this study reported that they did not face the topic of dyscalculia in any of the pre-service and in-service training. It would be fair to suggest that more teacher training courses should be organized in schools. We cannot demand teachers to be knowledgeable about dyscalculia if we have not properly trained them on the topic of dyscalculia and have not provided the needed resources. If teachers do not know about dyscalculia, the effectiveness of their teaching methods is doubtful. Based on the findings of this study the following recommendations emerge:

- Including the topic of dyscalculia in teacher training programs at university levels
- Organizing quality in-service professional development courses for teachers about dyscalculia

Limitations and Future Research

The present study has several limitations. Firstly, the items in the scale question about interventions were formulated in positive statements which would have led teachers to agree with them naturally. Since these strategies are appropriate for all students struggling in math including DD students, teachers may have recognized good methods that would also work for students with dyscalculia. Future research may change the formulation of these questions and include negative statements as well to mitigate bias.

Secondly, the reliability index for the scale questions “symptoms” ($\alpha = .95$) and “interventions” ($\alpha = .94$) were excellent. However, the reliability of the scale question “Definition and nature of dyscalculia” was low ($\alpha = .55$). This could be because of the changes that were done to the original survey questionnaire developed by Sousa et al. (2017). To improve the reliability of the scale, further piloting of new survey items in the context of Kazakhstan is recommended.

Thirdly, this study examined only teachers' knowledge about dyscalculia; it is recommended for future research to investigate teachers' attitudes towards students with dyscalculia, as well as their self-efficacy in supporting these students in learning. For instance, Graves (2018) investigated and revealed that teachers' self-efficacy is an important factor in supporting students with dyscalculia. It would be interesting to investigate this in Kazakhstan. It is also important to extend research on learning disabilities in other regions of the country to better understand and have a clearer picture of teachers' level of knowledge about this disability.

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Appendices

Appendix A

Description of Diagnostic Tools

#	Diagnostic methods	Information
1	Dyscalculia Screener	Butterworth (2003) has prepared an instrument called the Dyscalculia Screener. It is based on the hypothesis of a deficit in numerosity and includes four tests: simple reaction time, dot enumeration, number comparison, and arithmetic achievement test (multiplication and addition). "Simple reaction time" assesses the response time of a student to the questions, in which more time is indicative of dyscalculia in the student. "Dot enumeration" tests the subitizing and/or estimation skills of a student. "Number comparison" simply tests the ability to identify a larger number given on the screen. Finally, "Arithmetic achievement" tests the proficiencies of students in multiplication and addition of numbers with slower response time indicating those who use finger counting.
2	Number Sense Screener (NSS)	Number Sense Screener (NSS) is another diagnostic tool based on the number sense theory (Jordan et al., 2010). It is concerned with knowledge of counting and its principles (e.g., set enumeration, counting sequence (as a minimum to 10), and principles of one-to-one correspondence, stable order, and cardinality); number recognition (e.g., the ability to verbalize written digits); number knowledge (e.g., "what number comes right after 7?", or "which number is bigger, 5 or 4?"); and "nonverbal addition/subtraction calculations" (Jordan et al., 2010, p.186). The NSS screener is designated for use in kindergarten and first grade. According to the authors, NSS has a firm capacity to make a highly correct identification of students at risk and needing extra educational assistance (Jordan et al., 2010).
3	Functional magnetic resonance imaging (fMRI) method	Apart from the educational diagnostic tools, neuroimaging studies reported diagnosing dyscalculia based on the functional magnetic resonance imaging (fMRI) methods (Dinkel et al., 2013). In the study by Dinkel et al. (2013) imaging was accomplished on an MR scanner which helped to detect atypical reactions of the children's brains. The findings of the study indicate that the brains of children with dyscalculia are substantially different from those of children without dyscalculia in specific patterns of activations. Although this method has a strong potential as a promising tool for the diagnosis of the disability, tools such as MR scanners are not accessible for educators because of their availability only for the scientific community.
4	Eye-tracking data	Van Viersen et al. (2013) put forward the value of eye-tracking in diagnosing dyscalculia. They recorded the eye movements of a 9-year-old DD girl on an eye-tracker during the numerical tasks. Her working memory, number sense, and arithmetic abilities were compared to typically developing children. Results demonstrated that she was less accurate and used atypical strategies than the control group of children, and this was recorded as "unidentifiable eye fixation patterns" (Van Viersen et al., 2013, p.9). These patterns may be suggestive of dyscalculia in children. The authors concluded that eye-tracking data can be a helpful and hopeful instrument in the process of identification of the disability.

Appendix B**Nazarbayev University****M.Sc. in Educational Leadership: Inclusive Education****INFORMED CONSENT FORM****Mathematics Teachers' Awareness of Dyscalculia in Southern Kazakhstan**

You are invited to participate in a study entitled “Mathematics teachers’ awareness of dyscalculia in Southern Kazakhstan”. The purpose of the study is to examine the level of dyscalculia awareness among primary and lower secondary school mathematics teachers. The field of dyscalculia is not much investigated in Kazakhstan. The scarcity of existing literature and research on the topic of dyscalculia makes it harder for the process of development of the education system. Your participation in the study is of utmost importance and a great contribution to the science and enhancement of the current teacher education system and inclusive education system as a whole in Kazakhstan.

The survey is completely anonymous. Research results will be presented in only aggregate manner. The survey will take approximately 10-15 minutes to complete.

The benefits of the study are to contribute to the education system of Kazakhstan. Education authorities, researchers and teachers will be able to make use of the findings of the study for future policies, studies and classroom interventions. This study does not present any noticeable risks to respondents.

If you agree to take part in this survey, please, be informed that participation in the survey is voluntary, and you have the right not to continue and withdraw from the survey at any time you wish.

Contact Information. If you have any questions or concerns or complaints about this research, its procedures, risks and benefits, contact the researcher (Azhar Satybaldy, azhar.satybaldy@nu.edu.kz, +77022728516) or Thesis Supervisor, (Rita Kasa,

rita.kasa@nu.edu.kz). If you have any other questions you may contact NUGSE Research Committee at gse_researchcommittee@nu.edu.kz

Statement of Consent.

By clicking "I agree" below you are indicating that you are at least 18 years old, have read and understood this consent form and agree to participate in this research study.

I Agree

I Disagree => exit the survey

DATA COLLECTION INSTRUMENT (Survey)

Survey Questions

Section 1 (Demographics)

1. Depending on the nature of the school's education, mark the type of the school you are teaching at:
 - Mainstream
 - Selective
 - Special
2. Depending on the type of ownership of the school, mark the type of the school you are teaching at:
 - Private school
 - Governmental school
 - I am not sure
3. Type of the school you are teaching at:
 - School
 - Lyceum
 - Gymnasium
 - School-lyceum
 - School-gymnasium
 - I am not sure
4. Please, indicate your gender:
 - Male
 - Female
5. Please, indicate your age:
 - 18
 -
 - 99
6. Teaching experience:
 - Less than 1 year
 - 2-5 years
 - 6-10 years
 - 11-25 years
 - More than 25 years
7. Your highest educational degree:

- High-school
 - College
 - Bachelor
 - Masters
 - Doctoral
 - Higher education diploma received prior to 1991
 - Other: _____
8. Grade levels you are teaching:
- 1-4th grades
 - 5-9th grades
 - 10-11th grades
 - Other: _____
9. For how many years have you been teaching at this school?
- Less than 1 year
 - 2-5 years
 - 6-10 years
 - 11-25 years
 - More than 25 years
10. Have you learned about “**dyscalculia**” (difficulties with math) in any of the pre-service, in-service teacher training courses, from colleagues or as a self-study?
- Yes
 - No
11. If the answer is yes – Could you please specify if it was:
- Pre-service teacher training program at Bachelor’s degree
 - Teacher training program at Master’s degree
 - Teacher training program at Doctorate degree
 - In-service training course
 - I found and studied materials myself
 - I heard about it in some presentation
 - I heard about it from my colleagues/friends
 - Other: _____
12. Have you learned about “**dyslexia**” (difficulties with reading) in any of the pre-service, in-service teacher training courses, from colleagues or as a self-study?
- Yes
 - No
13. If the answer is yes – Could you please specify if it was:
- Pre-service teacher training program at Bachelor’s degree
 - Teacher training program at Master’s degree
 - Teacher training program at Doctorate degree
 - In-service training course
 - I found and studied materials myself
 - I heard about it in some presentation
 - I heard about it from my colleagues/friends
 - Other: _____
14. Did you already encounter situations during your professional career that made you suspect dyscalculia?
- Yes
 - No

Section 2

PART I (Definition and Nature of Dyscalculia)

Taking into account what you think about dyscalculia, mark your opinion: Agree (A); Don't know (DN); Disagree (D)

		A	DN	D
1.	All students with mathematics difficulties have dyscalculia.			
2.	Dyscalculia is a neurological disorder with a genetic origin.			
3.	Inappropriate teaching methods may be the cause of dyscalculia.			
4.	Dyscalculia significantly interferes with academic achievement or activities of daily living that require calculation ability.			
5	Students with dyscalculia usually have normal intellectual capabilities.			
6.	Some developmental disorders, such as Attention Deficit Hyperactivity Disorder (ADHD), may co-occur with dyscalculia.			
7.	All students with dyscalculia have dyslexia.			
8.	If a student with dyscalculia is properly supported, symptoms can disappear.			
9.	Unlike dyslexia, dyscalculia is a relatively rare disorder, affecting only 1% of students.			
10	<p>In your opinion, what is the cause of dyscalculia? (more than one alternative can be marked):</p> <ul style="list-style-type: none"> ○ reduced intelligence ○ lack of attention ○ poor quality of education ○ brain damage ○ heredity ○ emotional problems ○ social problems ○ other problems 			

PART II (Symptoms)

Taking into account some of the difficulties that students with dyscalculia may have, mark your opinion: Agree (A); Don't know (DN); Disagree (D)

		A	DN	D
1.	Understanding and using mathematical symbols (+, -, x, :).			
2.	Distinguishing pairs of numbers (e.g., 2 and 5, 3 and 8, 6 and 9, 17 and 71).			
3.	Reading numbers (e.g., "12" instead of "21").			
4.	Difficulties with solving word problems (e.g., selecting appropriate strategies/operations).			
5.	Difficulty in counting (repeating or omitting numbers).			
6.	Understanding the concept of time (e.g., telling the time).			
7.	Dealing with money (e.g., knowing the value of currencies, money exchanges).			
8.	Performing activities that require sequencing elements (e.g., saying the correct sequence of the months of the year, days of the week and seasons).			
9.	Understanding abstract concepts for children with dyscalculia is more difficult than understanding concrete concepts			
10.	Students with dyscalculia have difficulties in comparing quantities with terms such as "more/less", and "bigger/smaller".			
11.	Establishing one-to-one correspondence (e.g., between a number and a set of corresponding objects).			
12.	Difficulties with writing numbers and symbols (e.g., inverted or rotated).			
13.	Recognizing amounts without counting.			
14.	Understanding the concept of conservation (e.g., "6", "4+2" and "5+1" are equivalent to each other).			
15.	Memorizing multiplication tables, formulas and rules.			

16.	Understanding multiplication tables, formulas and rules.			
17.	Writing numbers in a slow, imperfect and illegible way.			
18.	Understanding the concept of measure (e.g., weight, length, temperature, speed).			
19.	Difficulty in spatial orientation (difficulties in the organization, writing and drawing difficulties, learning geometric elements) and lateralization (concept of leftness and rightness).			
20.	Difficulty in interpreting and grasping information from maps, tables and graphs.			
21.	Children with dyscalculia may be anxious, nervous and may not concentrate well on learning mathematics.			

PART III (Interventions)

Taking into account what you know about dyscalculia, mark the strategies you consider important and effective in supporting students who have difficulties in learning mathematics: Agree (A); Don't know (DN); Disagree (D)

		A	DN	D
1.	Individualized teaching that is adapted to a child's performance level is an effective strategy.			
2.	Stimulating memory helps to improve academic mathematics achievement among children with dyscalculia.			
3.	Providing physical and hands-on activities help children with dyscalculia to learn mathematics.			
4.	Technology and computer-based interventions are effective in increasing students' math performance.			
5.	Motivating children by acknowledging and praising them helps students with dyscalculia in their learning.			
6.	Improving reading and listening comprehension skills is effective in enhancing students' math learning (to understand word problems).			

7.	Consolidation exercises (lots of repetitions, rehearsals) are effective methods to support students with dyscalculia.			
8.	Using postcards is helpful in the memorization of facts.			
9.	Working in small groups have positive effects on students with dyscalculia.			
10.	Structured lessons beginning with more concrete and moving to abstract concepts is an effective educational method for students with dyscalculia.			
11.	Training executive functions by teaching students to be organized (making plans, schedules) is an effective method to support students with dyscalculia.			
12.	Providing extra time in carrying out activities, and allowing them to work at their own pace.			
13	Stimulating attentional control by providing visual and auditory aids is an effective educational method for students with dyscalculia.			

1. Would you like to participate in additional professional development courses on dyscalculia aimed at recognizing symptoms of, and working with students who have dyscalculia?
 - Yes
 - No
2. Do you have any additional comments?

Thank you for your participation in this survey!

Appendix C

Items that were Changed or Added to the Survey Questionnaire

Part 1. Definition and Nature of Dyscalculia		
#	Item	Reference
2	Dyscalculia is a neurological disorder with a genetic origin.	The item is reformulated from the original based on the recommendations of the pilot study. The original item was: "Some studies report that dyscalculia is a neurological disorder with a genetic origin".
3	Inappropriate teaching methods may be the cause of dyscalculia.	The item is reformulated from the original based on the recommendations of the pilot study. The original item was: "Inappropriate teaching methods, intellectual deprivation or sensory difficulties; cultural aspects or medical conditions; motivation or other factors that may affect learning may be the cause of dyscalculia". Also, this question showed a low-reliability index in the study by Sousa et al. (2017), so it was decided to reformulate the original question.
10	In your opinion, what is the cause of dyscalculia? (more than one alternative can be marked): <ul style="list-style-type: none"> ○ reduced intelligence ○ lack of attention ○ poor quality of education ○ brain damage ○ heredity ○ emotional problems ○ social problems ○ other problems 	In the studies conducted by Karasakal (2018) and Dias et al. (2013), teachers' knowledge of the causes of dyscalculia was measured by the given format of the question. It was decided to adopt this format.
Part 2. Symptoms		
#	Item	Reference
4	Difficulties with solving word problems (e.g., selecting appropriate strategies/operations).	The item is reformulated from the original based on the recommendations of the pilot study. The original item was: "Selecting appropriate strategies to solve problems".
9	Understanding abstract concepts for children with dyscalculia is more difficult than understanding concrete concepts	The item is reformulated from the original based on the recommendations of the pilot study. The original item was: "Difficulty in moving from a concrete level to an abstract level".
10	Students with dyscalculia have difficulties in comparing quantities	A new item was added based on the review of the literature (Kosc, 1974).

	with terms such as “more/less”, and “bigger/smaller”.	
15	Memorizing multiplication tables, formulas and rules.	A new item was added based on the review of the literature (Williams, 2013).
18	Understanding the concept of measure (e.g., weight, length, temperature, speed)	The word “length” was added based on the review of the literature (Chideridou-Mandari et al., 2016).
19	Difficulty in spatial orientation (difficulties in the organization, writing and drawing difficulties, learning geometric elements) and lateralization (concept of leftness and rightness)	The description of the item was added based on the recommendations of the pilot study and review of the literature (Muthee, n.d).
20	Difficulty in interpreting and grasping information from maps, tables and graphs.	The phrase “grasping information from maps, tables, and graphs” was added based on the review of the literature (Sousa et al., 2017).
21	Children with dyscalculia may be anxious, nervous and may not concentrate well on learning mathematics.	A new item was added based on the review of the literature (Soares et al., 2018; Kucian et al., 2018).

Part 3. Interventions

#	Item	Reference
1	Individualized teaching that is adapted to a child's performance level is an effective strategy.	The item was reformulated from the original based on the review of the literature (Ise and Schulte-Körne, 2013, as cited in Kucian & Von Aster, 2015). The original item was: “Individualized teaching”.
2	Stimulating memory helps to improve academic mathematics achievement among children with dyscalculia.	This new item was added based on the review of the literature (Faramarzi & Sadri, 2014).
3	Providing physical and hands-on activities help children with dyscalculia to learn mathematics.	This new item was added based on the review of the literature (Faramarzi & Sadri, 2014).
4	Technology and computer-based interventions are effective in increasing students' math performance	The item was reformulated from the original based on the review of the literature. The original was: “Information and communication technologies (ICT)”. Using technology: Monei and Pedro (2017) Computer-based interventions: Benavides et al. (2020), Syah et al. (2015).

5	Motivating children by acknowledging and praising them helps students with dyscalculia in their learning.	This new item was added based on the review of the literature (Ise & Schulte-Körne, 2013, as cited in Kucian & Von Aster, 2015).
6	Improving reading and listening comprehension skills is effective in enhancing students' math learning (to understand word problems)	This new item was added based on the review of the literature. Reading comprehension: Trott (2003) Listening comprehension: Faramarzi and Sadri (2014).
7	Consolidation exercises (lots of repetitions, rehearsals) are effective methods to support students with dyscalculia	The item was reformulated from the original based on the review of the literature (Trott, 2003; Ise & Schulte-Körne, 2013, as cited in Kucian & Von Aster, 2015). The original item was: "Consolidation exercises".
8	Using postcards is helpful in the memorization of facts	This new item was added based on the review of the literature (Trott, 2003).
9	Working in small groups has positive effects on students with dyscalculia	This new item was added based on the review of the literature (Ise & Schulte-Körne, 2013, as cited in Kucian & Von Aster, 2015; Monei & Pedro, 2017).
10	Structured lessons beginning with more concrete and moving to abstract concepts is an effective educational method for students with dyscalculia	This new item was added based on the review of the literature (Ise & Schulte-Körne, 2013, as cited in Kucian & Von Aster, 2015).
11	Training executive functions by teaching students to be organized (making plans, schedules) is an effective method to support students with dyscalculia	This new item was added based on the review of the literature (Faramarzi & Sadri, 2014).
12	Providing extra time in carrying out activities, and allowing them to work at their own pace	The item was reformulated from the original based on the review of the literature (Trott, 2003). The original item was: "extra time in carrying out activities".
13	Stimulating attentional control by providing visual and auditory aids is an effective educational method for students with dyscalculia	This new item was added based on the review of the literature (Faramarzi & Sadri, 2014).

Appendix D**The Results of the Shapiro-Wilk Test of Normality**

Shapiro-Wilk test of normality				
	Primary and Secondary	Statistic	df	Sig.
Definition and nature of dyscalculia	primary	.915	232	.000
	secondary	.941	99	.000
Symptoms	primary	.885	232	.000
	secondary	.939	99	.000
Interventions	primary	.812	232	.000
	secondary	.892	99	.000

Appendix E**Demographic Characteristics of Respondents**

	Background variables	N	Total
Gender	Male	20 (3.2%)	620 (100%)
	Female	600 (96.8%)	
Age	Mean	40.5	615 (99.2%)
	Std. deviation	12	
	Minimum	19 (3)	
	Maximum	71 (1)	
	Mode	28 (24)	
The Highest Educational Degree	High school	10 (1.6%)	618 (99.7%)
	College	55 (8.9%)	
	Bachelor	377 (60.8%)	
	Master	58 (9.4%)	
	Doctoral	2 (0.3%)	
	Higher education diploma received prior to 1991	99 (16%)	
	Other	17 (2.7%)	
Teaching Experience	Less than 1 year	47 (7.6%)	620 (100%)
	2 - 5 years	132 (21.3%)	
	6 - 10 years	102 (16.5%)	
	11 - 25 years	167 (26.9%)	
	More than 25 years	172 (27.7%)	
Grade Level	Primary School (1 - 4 grades)	443 (71.5%)	620 (100%)
	Secondary School (5 - 11 grades)	177 (28.5%)	
Years Teaching at This School	Less than 1 year	81 (13.1%)	616 (99.4%)
	2 - 5 years	181 (29.2%)	
	6 - 10 years	151 (24.4%)	
	11 - 25 years	148 (23.9%)	
	More than 25 years	55 (8.9%)	
Encountered the Topic of Dyscalculia Before	No	381 (61.5%)	619 (99.8%)
	Yes	238 (38.4%)	
	Pre-service TT program at Bachelor Degree	82 (13.2%)	
	TT program at Master's Degree	22 (3.5%)	
	TT program at Doctoral Degree	2 (0.3%)	
	In-service training course	87 (14%)	
	I found and studied materials myself	44 (7.1%)	
	I heard about it in some presentation	38 (6.1%)	
	I heard about it from my colleagues/friends	81 (13.1%)	
	Other	7 (1.1%)	

	Background variables	N	Total
Encountered the Topic of Dyslexia Before	No	318 (51.3%)	614 (99%)
	Yes	296 (47.7%)	
	Pre-service TT program at Bachelor Degree	90 (14.5%)	
	TT program at Master's Degree	31 (5%)	
	TT program at Doctoral Degree	5 (0.8%)	
	In-service training course	110 (17.7%)	
	I found and studied materials myself	69 (11.1%)	
	I heard about it in some presentation	52 (8.4%)	
	I heard about it from my colleagues/friends	92 (14.8%)	
	Other	14 (2.3%)	
Encountered Suspected Cases of Dyscalculia During Professional Career	Yes	201 (32.4%)	616 (99.4%)
	No	415 (66.9%)	
Whether teachers would like to participate in additional professional development courses on dyscalculia	Yes	406 (65.5%)	556 (89.7%)
	No	150 (24.2%)	
Additional comments	Courses are needed	11	
	"It would be nice to make special classes for such children".	2	
	"If there are such children, it may be more effective to teach them individually or in small groups"		
	"Very relevant for today"/"It is very important to solve this problem"	2	
	"This topic should be investigated more in depth"	1	
	"The topic is new, not quite familiar" "I would like to understand what Dyscalculia is?"	2	

Appendix F

Teachers' Knowledge of the "Definition and Nature of Dyscalculia"

No	Item			Primary	Secondary	Total		
1	All students with mathematics difficulties have dyscalculia.	Disagree	Count	94	40	134		
			Expected Count	96.1	37.9	134		
			% within Primary and Secondary	22%	23.7%	22.4%		
			DN	Count	167	69	236	
				Expected Count	169.2	66.8	236.0	
				% within Primary and Secondary	39.0%	40.8%	39.5%	
		Agree	Count	167	60	227		
			Expected Count	162.7	64.3	227.0		
			% within Primary and Secondary	39.0%	35.5%	38.0%		
			Total	Count	428	169	597	
			$X^2(2, N=597) = .65, p = .72, phi = .03$					
			2	Dyscalculia is a neurological disorder with a genetic origin.	Agree	Count	102	34
Expected Count	96.0	40.0				136.0		
% within Primary and Secondary	26.1%	20.9%				24.5%		
DN	Count	231				92	323	
	Expected Count	228.0				95.0	323.0	
	% within Primary and Secondary	59.1%				56.4%	58.3%	
Disagree	Count	58			37	95		
	Expected Count	67.0			28.0	95.0		
	% within Primary and Secondary	14.8%			22.7%	17.1%		
	Total	Count			391	163	554	
	$X^2(2, N=554) = 5.57, p = .06, phi = .10$							
	3	Inappropriate teaching methods may be the cause of dyscalculia.			Disagree	Count	81	44
Expected Count						87.7	37.3	125.0
% within Primary and Secondary						21.4%	27.3%	23.1%
DN					Count	170	65	235
					Expected Count	164.9	70.1	235.0

No	Item			Primary	Secondary	Total
			% within Primary and Secondary	44.9%	40.4%	43.5%
		Agree	Count	128	52	180
			Expected Count	126.3	53.7	180.0
			% within Primary and Secondary	33.8%	32.3%	33.3%
	Total		Count	379	161	540
	$X^2(2, N=540) = 2.33, p = .31, phi = .07$					
4	Dyscalculia significantly interferes with academic achievement or activities of daily living that require calculation ability.	Agree	Count	182	82	264
			Expected Count	184.6	79.4	264.0
			% within Primary and Secondary	48.7%	50.9%	49.3%
		DN	Count	159	62	221
			Expected Count	154.5	66.5	221.0
			% within Primary and Secondary	42.5%	38.5%	41.3%
		Disagree	Count	33	17	50
			Expected Count	35.0	15.0	50.0
			% within Primary and Secondary	8.8%	10.6%	9.3%
	Total		Count	374	161	535
	$X^2(2, N=535) = .92, p = .63, phi = .04$					
5	Students with dyscalculia usually have normal intellectual capabilities.	Agree	Count	158	64	222
			Expected Count	154.6	67.4	222.0
			% within Primary and Secondary	43.3%	40.3%	42.4%
		DN	Count	177	81	258
			Expected Count	179.7	78.3	258.0
			% within Primary and Secondary	48.5%	50.9%	49.2%
		Disagree	Count	30	14	44
			Expected Count	30.6	13.4	44.0
			% within Primary and Secondary	8.2%	8.8%	8.4%
	Total		Count	365	159	524
	$X^2(2, N=524) = .42, p = .81, phi = .03$					
6		Agree	Count	151	49	200

No	Item		Primary	Secondary	Total	
		Expected Count	138.5	61.5	200.0	
		% within	41.6%	30.4%	38.2%	
	Some developmental disorders, such as Attention Deficit Hyperactivity Disorder (ADHD), may co-occur with dyscalculia.	Primary and Secondary				
		Count	191	92	283	
		Expected Count	196.0	87.0	283.0	
		% within	52.6%	57.1%	54.0%	
		Primary and Secondary				
		Count	21	20	41	
		Expected Count	28.4	12.6	41.0	
		% within	5.8%	12.4%	7.8%	
		Primary and Secondary				
		Count	363	161	524	
		$X^2(2, N=524) = 10.34, p = .006, phi = .14$				
7	All students with dyscalculia have dyslexia.	Disagree	Count	74	33	107
			Expected Count	74.7	32.3	107.0
			% within	20.6%	21.2%	20.7%
			Primary and Secondary			
		DN	Count	210	94	304
			Expected Count	212.1	91.9	304.0
			% within	58.3%	60.3%	58.9%
			Primary and Secondary			
		Agree	Count	76	29	105
			Expected Count	73.3	31.7	105.0
			% within	21.1%	18.6%	20.3%
			Primary and Secondary			
		Total	Count	360	156	516
		$X^2(2, N=516) = .43, p = .81, phi = .03$				
8	If a student with dyscalculia is properly supported, symptoms can disappear.	Disagree	Count	16	9	25
			Expected Count	17.3	7.7	25.0
			% within	4.5%	5.7%	4.9%
			Primary and Secondary			
		DN	Count	204	90	294
			Expected Count	203.8	90.2	294.0
			% within	57.1%	57.0%	57.1%
			Primary and Secondary			
		Agree	Count	137	59	196
			Expected Count	135.9	60.1	196.0

No	Item		Primary	Secondary	Total	
		% within Primary and Secondary	38.4%	37.3%	38.1%	
	Total	Count	357	158	515	
	$\chi^2 (2, N=515) = .36, p = .83, \phi = .03$					
9	Unlike dyslexia, dyscalculia is a relatively rare disorder, affecting only 1% of students.	Disagree	Count	19	8	27
			Expected Count	18.8	8.2	27.0
			% within Primary and Secondary	5.3%	5.1%	5.2%
		DN	Count	223	119	342
			Expected Count	237.7	104.3	342.0
			% within Primary and Secondary	62.3%	75.8%	66.4%
		Agree	Count	116	30	146
			Expected Count	101.5	44.5	146.0
			% within Primary and Secondary	32.4%	19.1%	28.3%
		Total	Count	358	157	515
		$\chi^2 (2, N=515) = 9.8, p = .007, \phi = .14$				
No		Item		Primary	Secondary	Total
10	In your opinion, what is the cause of dyscalculia? (more than one alternative can be marked):	reduced intelligence	120	50	170 (27.4%)	
		lack of attention	194	76	270 (43.5%)	
		poor quality of education	87	52	139 (22.4%)	
		brain damage	110	53	163 (26.3%)	
		heredity	147	59	206 (33.2%)	
		emotional problems	88	44	132 (21.3%)	
		social problems	70	45	115 (18.5%)	
		other problems	85	25	110 (17.7%)	

Appendix G

Teachers' Knowledge of the "Symptoms"

No	Item			Primary	Secondary	Total		
1	Understanding and using mathematical symbols (+, -, x, :).	Agree	Count	210	71	281		
			Expected Count	201.7	79.3	281.0		
			% within Primary and Secondary	51.6%	44.4%	49.6%		
		DN	Count	133	50	183		
			Expected Count	131.4	51.6	183.0		
			% within Primary and Secondary	32.7%	31.3%	32.3%		
		Disagree	Count	64	39	103		
			Expected Count	73.9	29.1	103.0		
			% within Primary and Secondary	15.7%	24.4%	18.2%		
		Total			Count	407	160	567
		$X^2(2, N=567) = 6.01, p = .049, phi = .10$						
		2	Distinguishing pairs of numbers (e.g., 2 and 5, 3 and 8, 6 and 9, 17 and 71).	Agree	Count	173	59	232
Expected Count	163.5				68.5	232.0		
% within Primary and Secondary	46.1%				37.6%	43.6%		
DN	Count			137	64	201		
	Expected Count			141.7	59.3	201.0		
	% within Primary and Secondary			36.5%	40.8%	37.8%		
Disagree	Count			65	34	99		
	Expected Count			69.8	29.2	99.0		
	% within Primary and Secondary			17.3%	21.7%	18.6%		
Total				Count	375	157	532	
$X^2(2, N=532) = 3.5, p = .17, phi = .08$								
3	Reading numbers (e.g., "12" instead of "21").			Agree	Count	158	43	201
		Expected Count	140.9		60.1	201.0		
		% within Primary and Secondary	42.9%		27.4%	38.3%		
		DN	Count	125	55	180		
			Expected Count	126.2	53.8	180.0		
			% within Primary and Secondary	34.0%	35.0%	34.3%		
		Disagree	Count	85	59	144		
			Expected Count	100.9	43.1	144.0		
			% within Primary and Secondary	23.1%	37.6%	27.4%		

No	Item			Primary	Secondary	Total	
	Total		Count	368	157	525	
	$X^2(2, N=525) = 15.4, p < .001, phi = .17$						
4	Difficulties with solving word problems (e.g., selecting appropriate strategies/operations).	Agree	Count	237	103	340	
			Expected Count	238.5	101.5	340.0	
			% within Primary and Secondary	65.5%	66.9%	65.9%	
		DN	Count	113	42	155	
			Expected Count	108.7	46.3	155.0	
			% within Primary and Secondary	31.2%	27.3%	30.0%	
		Disagree	Count	12	9	21	
			Expected Count	14.7	6.3	21.0	
			% within Primary and Secondary	3.3%	5.8%	4.1%	
		Total		Count	362	154	516
		$X^2(2, N=516) = 2.3, p = .32, phi = .07$					
5		Difficulty in counting (repeating or omitting numbers).	Agree	Count	183	61	244
	Expected Count			170.4	73.6	244.0	
	% within Primary and Secondary			51.7%	39.9%	48.1%	
	DN		Count	108	54	162	
			Expected Count	113.1	48.9	162.0	
			% within Primary and Secondary	30.5%	35.3%	32.0%	
	Disagree		Count	63	38	101	
			Expected Count	70.5	30.5	101.0	
			% within Primary and Secondary	17.8%	24.8%	19.9%	
	Total			Count	354	153	507
	$X^2(2, N=507) = 6.5, p = .04, phi = .11$						
6	Understanding the concept of time (e.g., telling the time).		Agree	Count	197	62	259
		Expected Count		182.3	76.7	259.0	
		% within Primary and Secondary		55.6%	41.6%	51.5%	
		DN	Count	114	59	173	
			Expected Count	121.8	51.2	173.0	
			% within Primary and Secondary	32.2%	39.6%	34.4%	
		Disagree	Count	43	28	71	
			Expected Count	50.0	21.0	71.0	
			% within Primary and Secondary	12.1%	18.8%	14.1%	
		Total		Count	354	149	503
		$X^2(2, N=503) = 8.96, p = .01, phi = .13$					

No	Item			Primary	Secondary	Total		
7	Dealing with money (e.g., knowing the value of currencies, money exchanges).	Agree	Count	165	53	218		
			Expected Count	153.2	64.8	218.0		
			% within Primary and Secondary	46.5%	35.3%	43.2%		
		DN	Count	134	65	199		
			Expected Count	139.9	59.1	199.0		
			% within Primary and Secondary	37.7%	43.3%	39.4%		
		Disagree	Count	56	32	88		
			Expected Count	61.9	26.1	88.0		
			% within Primary and Secondary	15.8%	21.3%	17.4%		
		Total			Count	355	150	505
		$X^2(2, N=505) = 5.6, p=.06, phi = .11$						
		8	Performing activities that require sequencing elements (e.g., saying the correct sequence of the months of the year, days of the week and seasons).	Agree	Count	157	52	209
Expected Count	146.8				62.2	209.0		
% within Primary and Secondary	45.2%				35.4%	42.3%		
DN	Count			141	61	202		
	Expected Count			141.9	60.1	202.0		
	% within Primary and Secondary			40.6%	41.5%	40.9%		
Disagree	Count			49	34	83		
	Expected Count			58.3	24.7	83.0		
	% within Primary and Secondary			14.1%	23.1%	16.8%		
Total				Count	347	147	494	
$X^2(2, N=494) = 7.4, p=.03, phi = .12$								
9	Understanding abstract concepts for children with dyscalculia is more difficult than understanding concrete concepts			Agree	Count	187	78	265
		Expected Count	185.9		79.1	265.0		
		% within Primary and Secondary	53.4%		52.3%	53.1%		
		DN	Count	149	57	206		
			Expected Count	144.5	61.5	206.0		
			% within Primary and Secondary	42.6%	38.3%	41.3%		
		Disagree	Count	14	14	28		
			Expected Count	19.6	8.4	28.0		
			% within Primary and Secondary	4.0%	9.4%	5.6%		
		Total			Count	350	149	499
		$X^2(2, N=499) = 5.9, p=.052, phi = .11$						
		10	Students with dyscalculia have	Agree	Count	126	44	170
Expected Count	118.9				51.1	170.0		

No	Item			Primary	Secondary	Total
	difficulties in comparing quantities with terms like "more/less", and "bigger/smaller".	DN	% within Primary and Secondary	36.6%	29.7%	34.6%
			Count	127	60	187
			Expected Count	130.7	56.3	187.0
		Disagree	% within Primary and Secondary	36.9%	40.5%	38.0%
			Count	91	44	135
			Expected Count	94.4	40.6	135.0
		Total	% within Primary and Secondary	26.5%	29.7%	27.4%
			Count	344	148	492
	$\chi^2 (2, N=492) = 2.19, p=.34, phi = .07$					
11	Establishing one-to-one correspondence (e.g., between a number and a set of corresponding objects).	Agree	Count	163	65	228
			Expected Count	159.7	68.3	228.0
			% within Primary and Secondary	47.1%	43.9%	46.2%
		DN	Count	141	64	205
			Expected Count	143.6	61.4	205.0
			% within Primary and Secondary	40.8%	43.2%	41.5%
		Disagree	Count	42	19	61
			Expected Count	42.7	18.3	61.0
			% within Primary and Secondary	12.1%	12.8%	12.3%
	Total	Count	346	148	494	
	$\chi^2 (2, N=494) = .43, p=.81, phi = .03$					
12	Difficulties with writing numbers and symbols (e.g., inverted or rotated).	Agree	Count	167	54	221
			Expected Count	154.8	66.2	221.0
			% within Primary and Secondary	49.3%	37.2%	45.7%
		DN	Count	129	60	189
			Expected Count	132.4	56.6	189.0
			% within Primary and Secondary	38.1%	41.4%	39.0%
		Disagree	Count	43	31	74
			Expected Count	51.8	22.2	74.0
			% within Primary and Secondary	12.7%	21.4%	15.3%
	Total	Count	339	145	484	
	$\chi^2 (2, N=484) = 8.5, p=.01, phi = .13$					
13	Recognizing amounts without counting.	Agree	Count	161	69	230
			Expected Count	162.1	67.9	230.0
			% within Primary and Secondary	47.5%	48.6%	47.8%

No	Item			Primary	Secondary	Total	
		DN	Count	137	59	196	
			Expected Count	138.1	57.9	196.0	
			% within Primary and Secondary	40.4%	41.5%	40.7%	
		Disagree	Count	41	14	55	
			Expected Count	38.8	16.2	55.0	
			% within Primary and Secondary	12.1%	9.9%	11.4%	
	Total		Count	339	142	481	
	$X^2(2, N=481) = .49, p=.78, phi = .03$						
14	Understanding the concept of conservation (e.g., "6", "4+2" and "5+1" are equivalent to each other).	Agree	Count	154	48	202	
			Expected Count	142.7	59.3	202.0	
				% within Primary and Secondary	45.4%	34.0%	42.1%
			DN	Count	128	56	184
				Expected Count	130.0	54.1	184.0
				% within Primary and Secondary	37.8%	39.7%	38.3%
			Disagree	Count	57	37	94
				Expected Count	66.4	27.6	94.0
				% within Primary and Secondary	16.8%	26.2%	19.6%
		Total		Count	339	141	480
		$X^2(2, N=480) = 7.69, p=.02, phi = .13$					
15		Memorizing multiplication tables, formulas and rules.	Agree	Count	197	91	288
			Expected Count	202.2	85.8	288.0	
				% within Primary and Secondary	58.5%	63.6%	60.0%
			DN	Count	115	43	158
				Expected Count	110.9	47.1	158.0
				% within Primary and Secondary	34.1%	30.1%	32.9%
			Disagree	Count	25	9	34
				Expected Count	23.9	10.1	34.0
				% within Primary and Secondary	7.4%	6.3%	7.1%
	Total			Count	337	143	480
	$X^2(2, N=480) = 1.13, p=.57, phi = .05$						
16	Understanding multiplication tables, formulas and rules".		Agree	Count	197	90	287
			Expected Count	200.8	86.2	287.0	
				% within Primary and Secondary	59.5%	63.4%	60.7%
			DN	Count	106	37	143
				Expected Count	100.1	42.9	143.0

No	Item			Primary	Secondary	Total
			% within Primary and Secondary	32.0%	26.1%	30.2%
		Disagree	Count	28	15	43
			Expected Count	30.1	12.9	43.0
			% within Primary and Secondary	8.5%	10.6%	9.1%
	Total		Count	331	142	473
	$X^2(2, N=473) = 1.89, p=.39, phi = .06$					
17	Writing numbers in a slow, imperfect and illegible way.	Agree	Count	146	53	199
			Expected Count	140.3	58.7	199.0
			% within Primary and Secondary	44.0%	38.1%	42.3%
		DN	Count	137	64	201
			Expected Count	141.7	59.3	201.0
			% within Primary and Secondary	41.3%	46.0%	42.7%
		Disagree	Count	49	22	71
			Expected Count	50.0	21.0	71.0
			% within Primary and Secondary	14.8%	15.8%	15.1%
	Total		Count	332	139	471
	$X^2(2, N=471) = 1.39, p=.5, phi = .05$					
18	Understanding the concept of measure (e.g., weight, length, temperature, speed).	Agree	Count	193	74	267
			Expected Count	187.8	79.2	267.0
			% within Primary and Secondary	58.1%	52.9%	56.6%
		DN	Count	111	50	161
			Expected Count	113.2	47.8	161.0
			% within Primary and Secondary	33.4%	35.7%	34.1%
		Disagree	Count	28	16	44
			Expected Count	30.9	13.1	44.0
			% within Primary and Secondary	8.4%	11.4%	9.3%
	Total		Count	332	140	472
	$X^2(2, N=472) = 1.58, p=.45, phi = .06$					
19	Difficulty in spatial orientation (difficulties in the organization, writing and drawing difficulties, learning	Agree	Count	180	69	249
			Expected Count	175.4	73.6	249.0
			% within Primary and Secondary	54.7%	50.0%	53.3%
		DN	Count	120	51	171
			Expected Count	120.5	50.5	171.0
			% within Primary and Secondary	36.5%	37.0%	36.6%

No	Item			Primary	Secondary	Total	
	geometric elements) and lateralization (concept of leftness and rightness)	Disagree	Count	29	18	47	
Expected Count			33.1	13.9	47.0		
% within Primary and Secondary		8.8%	13.0%	10.1%			
Total		Count	329	138	467		
			$X^2(2, N=467) = 2.14, p=.34, phi = .07$				
20	Difficulty in interpreting and grasping information from maps, tables and graphs.	Agree	Count	179	70	249	
			Expected Count	174.5	74.5	249.0	
			% within Primary and Secondary	54.6%	50.0%	53.2%	
		DN	Count	121	59	180	
			Expected Count	126.2	53.8	180.0	
			% within Primary and Secondary	36.9%	42.1%	38.5%	
		Disagree	Count	28	11	39	
			Expected Count	27.3	11.7	39.0	
			% within Primary and Secondary	8.5%	7.9%	8.3%	
		Total	Count	328	140	468	
					$X^2(2, N=468) = 1.14, p=.56, phi = .05$		
		21	Children with dyscalculia may be anxious, nervous and may not concentrate well on learning mathematics.	Agree	Count	175	75
Expected Count	175.3				74.7	250.0	
% within Primary and Secondary	54.0%				54.3%	54.1%	
DN	Count			122	53	175	
	Expected Count			122.7	52.3	175.0	
	% within Primary and Secondary			37.7%	38.4%	37.9%	
Disagree	Count			27	10	37	
	Expected Count			25.9	11.1	37.0	
	% within Primary and Secondary			8.3%	7.2%	8.0%	
Total	Count			324	138	462	
					$X^2(2, N=462) = .16, p=.92, phi = .02$		

Appendix H

Teachers' Knowledge of the "Interventions"

No	Item			Primary	Secondary	Total
1	Individualized teaching that is adapted to a child's performance level is an effective strategy.	Agree	Count	257	103	360
			Expected Count	261.4	98.6	360.0
			% within Primary and Secondary	67.8%	72.0%	69.0%
		DN	Count	96	32	128
			Expected Count	92.9	35.1	128.0
			% within Primary and Secondary	25.3%	22.4%	24.5%
		Disagree	Count	26	8	34
			Expected Count	24.7	9.3	34.0
			% within Primary and Secondary	6.9%	5.6%	6.5%
		Total	Count	379	143	522
$X^2(2, N=522) = .89, p = .64, phi = .04$						
2	Stimulating memory helps to improve academic mathematics achievement among children with dyscalculia.	Agree	Count	233	103	336
			Expected Count	237.3	98.7	336.0
			% within Primary and Secondary	68.7%	73.0%	70.0%
		DN	Count	93	33	126
			Expected Count	89.0	37.0	126.0
			% within Primary and Secondary	27.4%	23.4%	26.3%
		Disagree	Count	13	5	18
			Expected Count	12.7	5.3	18.0
			% within Primary and Secondary	3.8%	3.5%	3.8%
		Total	Count	339	141	480
$X^2(2, N=480) = .90, p = .64, phi = .04$						
3	Providing physical and hands-on activities help children with dyscalculia to learn mathematics	Agree	Count	218	84	302
			Expected Count	212.2	89.8	302.0
			% within Primary and Secondary	65.5%	59.6%	63.7%
		DN	Count	105	50	155
			Expected Count	108.9	46.1	155.0
			% within Primary and Secondary	31.5%	35.5%	32.7%
		Disagree	Count	10	7	17
			Expected Count	11.9	5.1	17.0
			% within Primary and Secondary	3.0%	5.0%	3.6%

No	Item			Primary	Secondary	Total	
	Total		Count	333	141	474	
	$X^2(2, N=474) = 2.07, p = .36, phi = .07$						
4	Technology and computer-based interventions are effective in increasing students' math performance	Agree	Count	179	73	252	
			Expected Count	176.3	75.7	252.0	
			% within Primary and Secondary	54.9%	52.1%	54.1%	
		DN	Count	129	52	181	
			Expected Count	126.6	54.4	181.0	
			% within Primary and Secondary	39.6%	37.1%	38.8%	
		Disagree	Count	18	15	33	
			Expected Count	23.1	9.9	33.0	
			% within Primary and Secondary	5.5%	10.7%	7.1%	
		Total		Count	326	140	466
		$X^2(2, N=466) = 4.02, p = .13, phi = .09$					
		5	Motivating children by acknowledging and praising them helps students with dyscalculia in their learning.	Agree	Count	219	94
Expected Count	220.0				93.0	313.0	
% within Primary and Secondary	66.2%				67.1%	66.5%	
DN	Count			98	39	137	
	Expected Count			96.3	40.7	137.0	
	% within Primary and Secondary			29.6%	27.9%	29.1%	
Disagree	Count			14	7	21	
	Expected Count			14.8	6.2	21.0	
	% within Primary and Secondary			4.2%	5.0%	4.5%	
Total				Count	331	140	471
$X^2(2, N=471) = .25, p = .88, phi = .02$							
6	Improving reading and listening comprehension skills is effective in enhancing students' math learning (to understand word problems)			Agree	Count	218	86
		Expected Count	213.6		90.4	304.0	
		% within Primary and Secondary	65.9%		61.4%	64.5%	
		DN	Count	104	46	150	
			Expected Count	105.4	44.6	150.0	
			% within Primary and Secondary	31.4%	32.9%	31.8%	
		Disagree	Count	9	8	17	
			Expected Count	11.9	5.1	17.0	
			% within Primary and Secondary	2.7%	5.7%	3.6%	
		Total		Count	331	140	471

No	Item			Primary	Secondary	Total		
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$X^2(2, N=471) = 2.81, p = .25, \phi = .08$								
7	Consolidation exercises (lots of repetitions, rehearsals) are effective methods to support students with dyscalculia	Agree	Count	216	97	313		
			Expected Count	220.8	92.2	313.0		
			% within Primary and Secondary	65.9%	70.8%	67.3%		
		DN	Count	96	35	131		
			Expected Count	92.4	38.6	131.0		
			% within Primary and Secondary	29.3%	25.5%	28.2%		
		Disagree	Count	16	5	21		
			Expected Count	14.8	6.2	21.0		
			% within Primary and Secondary	4.9%	3.6%	4.5%		
		Total			Count	328	137	465
		<hr/>						
		$X^2(2, N=465) = 1.15, p = .56, \phi = .05$						
8	Using postcards is helpful in the memorization of facts	Agree	Count	215	86	301		
			Expected Count	210.4	90.6	301.0		
			% within Primary and Secondary	66.2%	61.4%	64.7%		
		DN	Count	100	48	148		
			Expected Count	103.4	44.6	148.0		
			% within Primary and Secondary	30.8%	34.3%	31.8%		
		Disagree	Count	10	6	16		
			Expected Count	11.2	4.8	16.0		
			% within Primary and Secondary	3.1%	4.3%	3.4%		
		Total			Count	325	140	465
		<hr/>						
		$X^2(2, N=465) = 1.13, p = .57, \phi = .05$						
9	Working in small groups has positive effects on students with dyscalculia	Agree	Count	212	97	309		
			Expected Count	216.2	92.8	309.0		
			% within Primary and Secondary	65.0%	69.3%	66.3%		
		DN	Count	101	38	139		
			Expected Count	97.2	41.8	139.0		
			% within Primary and Secondary	31.0%	27.1%	29.8%		
		Disagree	Count	13	5	18		
			Expected Count	12.6	5.4	18.0		
			% within Primary and Secondary	4.0%	3.6%	3.9%		
		Total			Count	326	140	466
		<hr/>						
		$X^2(2, N=466) = .79, p = .67, \phi = .04$						

No	Item			Primary	Secondary	Total		
10	Structured lessons beginning with more concrete and moving to abstract concepts is an effective educational method for students with dyscalculia	Agree	Count	187	77	264		
			Expected Count	184.4	79.6	264.0		
			% within Primary and Secondary	58.1%	55.4%	57.3%		
		DN	Count	123	54	177		
			Expected Count	123.6	53.4	177.0		
			% within Primary and Secondary	38.2%	38.8%	38.4%		
		Disagree	Count	12	8	20		
			Expected Count	14.0	6.0	20.0		
			% within Primary and Secondary	3.7%	5.8%	4.3%		
		Total		Count	322	139	461	
		$X^2(2, N=461) = 1.05, p = .59, phi = .05$						
		11	Training executive functions by teaching students to be organized (making plans, schedules) is an effective method to support students with dyscalculia	Agree	Count	182	75	257
Expected Count	179.5				77.5	257.0		
% within Primary and Secondary	56.5%				54.0%	55.7%		
DN	Count			121	54	175		
	Expected Count			122.2	52.8	175.0		
	% within Primary and Secondary			37.6%	38.8%	38.0%		
Disagree	Count			19	10	29		
	Expected Count			20.3	8.7	29.0		
	% within Primary and Secondary			5.9%	7.2%	6.3%		
Total				Count	322	139	461	
$X^2(2, N=461) = .41, p = .81, phi = .03$								
12	Providing extra time in carrying out activities, and allowing them to work at their own pace			Agree	Count	215	97	312
		Expected Count	218.7		93.3	312.0		
		% within Primary and Secondary	67.0%		70.8%	68.1%		
		DN	Count	95	39	134		
			Expected Count	93.9	40.1	134.0		
			% within Primary and Secondary	29.6%	28.5%	29.3%		
		Disagree	Count	11	1	12		
			Expected Count	8.4	3.6	12.0		
			% within Primary and Secondary	3.4%	0.7%	2.6%		
		Total		Count	321	137	458	
		$X^2(2, N=458) = 2.91, p = .23, phi = .08$						
		13		Agree	Count	214	95	309

No	Item		Primary	Secondary	Total
		Expected Count	215.6	93.4	309.0
	Stimulating attentional control by providing visual and auditory aids is an effective educational method for students with dyscalculia	% within Primary and Secondary	68.2%	69.9%	68.7%
		Count	89	40	129
		Expected Count	90.0	39.0	129.0
		% within Primary and Secondary	28.3%	29.4%	28.7%
		Count	11	1	12
		Expected Count	8.4	3.6	12.0
		% within Primary and Secondary	3.5%	0.7%	2.7%
	Total	Count	314	136	450
$\chi^2 (2, N=450) = 2.80, p = .25, \phi = .08$					