



AN OVERVIEW OF DYSLEXIA: SOME KEY ISSUES AND ITS EFFECTS ON LEARNING MATHEMATICS

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Received: July 13, 2022

Accepted: September 18, 2022

Published: December 31, 2022

Suggested Citation:

Kunwar, R., & Sapkota, H. P. (2022). An overview of dyslexia: Some key issues and its effects on learning mathematics. *Turkish International Journal of Special Education and Guidance & Counselling (TIJSEG)*, 11(2), 82-98.



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Abstract

Dyslexia is a specific learning disability caused by a neurological problem. It is a worldwide problem with a prevalence of 5–10% of the population. It is described mainly by difficulties in reading, spelling, accuracy, fluency, and decoding abilities. This article is chiefly concerned to provide an overview of dyslexia, some key issues based on identification, intervention, and support for dyslexic learners, and its effects on learning mathematics. The common characteristics of dyslexic learners vary from person to person. The context of the learner, availability of the resources, and teaching strategy also impact an individual to develop dyslexia. The dyslexic learner can be identified in various ways however the four levels of the sequential model are discussed to identify the dyslexic learner. Only two intervention methods as a response to intervention and the Orton-Gillingham method are discussed. Similarly, different ways of supporting dyslexic learners and the effects of dyslexia in learning mathematics are also discussed.

Keywords: Dyslexia, identification of dyslexic learner, intervention, mathematics.

INTRODUCTION

The term 'Dyslexia' is a kind of learning disorder that affects the learners' ability to read, write, spell, and speak. It is used in the field of education and medical sciences. It is a specific learning disability caused by neurobiological origin (D'Mello & Gabrieli, 2018). It is not caused by other external factors such as developmental hindrance, poverty, speech or hearing impairments, language, and other learning problems; however such factors may affect increasing reading disabilities (Snow, Burns, & Griffin, 1998). The children who have the problem of dyslexia are often elegant, energetic, and capable of hardworking, although they face trouble with accurate and fluent reading and spelling the words or letters. Thus, it is due to the deficit of the phonological component that is often unexpected concerning other cognitive abilities and the provision of effective classroom instruction. (Lyon, Shaywitz, & Shaywitz, 2003). It is widely known as a reading disability. Dyslexic children will repeatedly face mainly two types of difficulties related to reading text 'fluent word recognition and 'decoding difficulties'. They cannot read out or sound out correctly and fluently many of the new words in a text by single sight in comparison to the average readers. Similarly, they frequently make decoding difficulties or they feel trouble accurate sound out words and recognizing words out of context. These are the reading deficits related to the sound component of language that makes dyslexic learner trouble comprehending their reading texts. Thus, in general, dyslexia is considered to be a difficulty in accurate and fluent reading, spelling and decoding abilities.



In the beginning stage, the meaning of dyslexia was mainly limited to the reading and spelling out process or literacy. Originally it was called reading blindness. In the beginning stage, International Dyslexia Association (2002) defined dyslexia as expressive or receptive, oral, or written language difficulties. Gradually, the area of dyslexia has been broadening due to different research on dyslexic learners. Thus, some changes have been made in the definitions of dyslexia. Chinn & Ashcroft (2017) claimed that 60% of dyslexic people have suffered from some problems related to school mathematics. Only 11% of dyslexic people do well in mathematics. The overall prevalence of dyslexic people in the world is estimated at (5–10) % of the population (Al-Shidhani & Arora, 2012). According to Yeo (2008), (2-4) % of people may have severe dyslexia and may have people in a mild form. In this course, difficulties with mathematics in some fields most particularly in numeracy do recognize as a possible cause of dyslexia. Dyslexia is considered a global learning disorder. According to Rief & Stern (2010), the number of prevalence people in the United States with dyslexia is estimated from (5-17) % of the population. The global prevalence range of dyslexia is ranging from less than 5% to 20% of the population (Wagner, et al., 2020). Similarly, the estimates of the dyslexic school-age population in the world lie between (5-17)% and it is expected that 80% of all individuals diagnosed with some type of learning disability are likely to be dyslexic (D'Mello & Gabrieli, 2018). As stated by Rief & Stern (2010), the global prevalence ratio of boys was found to be higher than girls, approximately 3.4:1.

Traditionally, dyslexia has been used as a reading problem due to neurological causes. In the present situation, there are different models used to define dyslexia such as the Orthodox model, Devi's model, dual-route model, Socio-cultural model, motor dysfunction model, etc. The Orthodox Model emphasizes problems related to cerebral disease rather than brain injury. The Davis Model focuses on intermittent disorientation due to conflicting messages to the brain by the sensory organ such as the eyes telling the brain one thing and senses of balance and movement sign another makes confusing to execute the task. The dual-route model describes two distinct routes lexical and non-lexical. Lexical route denotes the use of regular words that are real words or phrases and are regularly used by people such as a table, milk, etc. The non-lexical route denotes the non-words or words used in speaking but pronounced by using grammar rules that generally create problems to respond correctly such as aaaah, um, etc. The socio-cultural model focuses on the mental illness of the learner due to the impact of race, ethnicity, gender, religious orientation, socioeconomic status, sexual orientation, etc. which can also contribute to dyslexia. The motor dysfunction model describes motor system dysfunction that causes dyslexia.

Meaning and Definition of Dyslexia

Etymologically, the word 'dyslexia' is considered to have formed from two Greek words: 'dys' and 'lexicaon'. Meaning of dys as insufficient or lack of and lexicon as verbal language or word. Thus, dyslexia is a language-based disorder having a poor language with phonological awareness, decoding words, and the inability to quick naming or recall items, such as colors, symbols, numbers, and other familiar objects (Rief, & Stern, 2010). It is an inborn disorder that causes trouble in using and processing speech and symbolic codes. Dyslexia was identified in 1881 by Oswald Berkhan (Jastak, 1934). The word dyslexia was coined by Rudolf Berlin, a German ophthalmologist, and professor at the University of Rostock's Faculty of Medicine, Stuttgart in 1887 in his monograph *Eine besondere Art der Wort-blindheit (Dyslexia)* as cited by Wagner (1973). He used the term dyslexia to describe the difficulty with words. The first description of dyslexia appeared in 1896 by Pringle Morgan W. in Sussex, England. A German professor of medicine, Adolph Kussmaul, first named the word dyslexia as word blindness in 1877 cited by Kuerten et al., 2020).

In the present situation, the meaning and definition of dyslexia are not limited to reading difficulty. It also comprises difficulty in literacy acquisition, cognitive processes, and discrepancies in educational outcomes (Al-Shidhani & Arora, 2012). Dyslexia is a lifelong condition and it affects people into old age. It is not a disease. The condition of dyslexic learners may differ from person to person. Some children may have problems related to speech and vocabulary, and others may have an inability in



decoding symbols and sounds. Similarly, some children may have an inability in number computation (Rief, & Stern, 2010). The problem regarding dyslexia occurs up to the age of 18 years (Al-Shidhani & Arora, 2012). The acquired dyslexia is always related to adults due to brain damage, while developmental dyslexia is only encountered in school-aged children (Jackson & Coltheart, 2001). According to Rief, & Stern (2010), dyslexia is a language-based learning disability in basic belonging to reading skills and spelling. The problems regarding dyslexia in children can be examined commonly while processing speech sounds within words and making the connection between sounds and written symbols such as letters and patterns of letter combinations. The International Dyslexia Association (2007) defines dyslexia as “a specific learning disability caused by neurobiological origin. It is a kind of inability with accurate and/or fluent word recognition due to poor spelling and decoding abilities. According to Catts & Kamhi (2005), dyslexia can be defined as a means of difficulty with words. Dyslexia comprises two key characteristics regarding specific learning disabilities. The first is the weakness in specific processes or weakness in phonological processing while using speech-based coding in oral or written language or cognitive functioning (Grigorenko et al., 2019) and the second is the reading problem (Fletcher et al., 2019).

Dyslexia and Mathematics

We often define dyslexia as trouble in reading or a reading disorder. It is primarily reading trouble, but it impacts other different subject areas of learning and expression. According to British Dyslexia Association (2009), the dyslexic learner feels difficulties in phonological awareness, verbal memory, and verbal processing speed. Dyslexic students should also face such problems while learning mathematics. They should often be able to understand mathematical facts and verbal memory to do higher-level mathematics quite well. Most dyslexic children have more difficulties in short-term memory than non-dyslexic children (Chin & Ashcroft, 2017). They further state that the dyslexic student takes about 50% more time to complete a set of questions related to arithmetic in comparison to other non-dyslexic peers. It indicates that dyslexic students are highly slow to perform their mathematics tasks and feel difficult to execute number and calculation-related tasks. On the other hand, in mathematics, student needs specific skills such as the ability to recognize numbers, symbols, mathematics rules, formulae, mathematical facts, and their relationship but it creates a challenge for dyslexic students. Such incompatibility can hinder significantly for the dyslexic learner to learn mathematics.

According to Rief & Stern (2010), dyslexic learners are very slow in learning the connection between sounds and letters, letter reversals (p/q) and inversions (u/n), poor in word sounding out, problems with recalling facts, problems in time concepts, symbols, and math facts, especially multiplication tables and understanding directions. Therefore, it is very difficult to get success in learning mathematics for dyslexic children. Dyslexic children can retain basic number facts, especially times table facts by rote learning (Chin & Ashcroft, 2017). This also signifies that remembering everything such as times table, division, patterns, rules, and connections processes in succession without any sense of logic seems probably difficult. The consequences of difficulties in accurate and/or fluent word recognition due to poor spelling and decoding abilities they cannot comprehend the instructions and verbal problems properly and also reduced reading habits that can hinder vocabulary and background knowledge (Lyon et al., 2003). Such problems may create difficulty to grasp the language of mathematics and the concepts connected with it (Almahrag, 2021). Thus, it makes it difficult to solve word problems for dyslexic students in comparison to other non-dyslexic students learning mathematics. Dyslexic children tend to write letters and numbers backward and have confusion over left/right differentiation and feel trouble writing in sequence (Hebert et al., 2018). Such difficulties obviously hinder learning mathematics for dyslexic children. They are always confusing when writing numbers in sequence such as writing 269 instead of 962 and also the language problem make them confusing, for example, the father's age is twice more than the present age of the son. In this situation, they try to escape from the problem, and due to not attempting the problem; they lose their different skills, facts, conceptual ability, and relations related to solving the arithmetic problem.



Dyslexic children tend to think initially with the help of images and pictures rather than through the internal monologue used by verbal thinkers (Yeo, 2008). They have poor intuitional thinking rather than observing patterns and sequence but the blended form of thinking is likely to be considered the most successful thinking style to success in learning mathematics (Almahrag, 2021). Mathematics is an alive subject that inquires about understanding the patterns within the world around us and the mind (Schoenfeld, 1992). He further states that the 'language of mathematics is based on rules that must be learned, it is important for motivation that students move beyond rules to be able to express things in the language of mathematics. Thus, dyslexic children should struggle to learn mathematics due to their slow processing of phonological information and cognitive ability (Hebert et al., 2018).

Most dyslexic children may have difficulty with certain operations of mathematics like integration, sequencing, or memorization of facts (Almahrag, 2021). According to Powell et al., (2011), fluency is an essential skill to enhance proficiency in literacy and it is the foundation for proficiency in math as well. Similarly, dyslexic children have difficulty in working memory which hinders them to perform various things while manipulating or analyzing the proper task immediately (Rief & Stern, 2010). Some dyslexic students' poor numeracy abilities do hinder by simple issues like difficulty in recalling oral math facts and multiplication tables (Almahrag, 2021). Therefore mathematics learning is considered to be difficult for dyslexic children due to their poor reading language, specific difficulty in processing numbers, sequential nature of mathematics, comprehending verbal problems consisting of decoding, vocabulary comprehension, patterns, and symbols, and comprehending the vocabulary used in mathematics.

Characteristics of dyslexia

Dyslexia is a kind of language-based learning disability that affects especially a person's ability to read and write. It usually causes trouble in spelling out the text, vocabulary development, and general learning. Dyslexia encompasses three fundamental components: troubles with reading words, spelling, and/or fluent reading (Roitsch & Watson, 2019). It can be observed as mild and severe depending upon the signs and symptoms or, containing one or more dyslexic components in the learner. However, it does not affect usually every aspect of the person's intelligence and other developmental growth. The characteristics of dyslexia may differ for different people depending on their ages (Lyon et al., 2003). The fundamental characteristics of dyslexic people that can be observed in different ages and stages are as follows.

- ✓ Poor decoding: It is a kind of difficult to read accurately or sound out the unknown word. Poor decoding is also a kind of word assembling problem based on their sounds. Actually, dyslexic children may have delayed speech development in comparison to other non-dyslexic children at the stage of development. This delay in speech development creates several speech-related problems for dyslexic children such as reduced memory and phonological awareness, jumbling up similar-sounding words, and speech deficiency.
- ✓ Poor fluency: It is the condition of a slow reading rate. The poor reading may cause by poor use of sight words that are immediately recognized by the reader but difficult to sound out. Fluency is the ability to read a word at an average conversational rate. Reading fluency comprises four key components: speed, accuracy, expression, and comprehension where each component is interrelated. The poor fluent readers always suffer in at least one of these components of reading and lack speed, accuracy, expression, or comprehension. Thus poor fluency finally affects the learner to development of comprehension.
- ✓ Poor spelling: It is a difficulty related to learning to spell out or with spelling words accurately. It is also a problem for dyslexic children. It is considered the effect of phonological processing and memory. The cause of poor spelling of dyslexic children can have trouble hearing the different small sound words in words phonemes and also difficult to break down the words into smaller parts to spell them. Poor spelling is considered widely a challenging difficulty for dyslexic children and adults because most dyslexic people can develop reading



skills well with the proper intervention and support but the difficulty in spelling appears to persist throughout life.

- ✓ Poor reading comprehension: It is the problem of poor understanding of what was immediately read. Particularly, moderate and severe stages of dyslexic children with poor decoding and inadequate fluency can hinder reading comprehension although comprehension of oral language skills is satisfactory. It is difficult to comprehend due to a lack of proper ability to decode easily or assemble the words based on their proper sounds. It is a poor phonological awareness or working memory, breaking into a small part, putting together, and manipulating the spoken syllables and sounds in words in order to use this information to read or spell.

These are the primary characteristics associated with dyslexic people. Different research indicates that dyslexic children often show these primary characteristics. Most dyslexic people feel difficulties in other areas as a byproduct of primary characteristics. Some of the learning difficulties in different areas are stated below.

- ✓ Follow multi-step instructions, sequence, rules, and procedures,
- ✓ Tell time, follow directions,
- ✓ Quick remember names, appropriate words, terms, formulas, and phrases,
- ✓ Understand mathematical word problems,
- ✓ Express ideas in an organized form at a moment,
- ✓ Complete the tasks at a given time frame or quickly,
- ✓ Differentiate similar letters and symbols both in reading and writing (like p and q),
- ✓ Do not like to read, write, and solve mathematics,
- ✓ The language of mathematics,
- ✓ Complex arithmetic calculation problems,
- ✓ The short-term and long-term memories required to remember arithmetic facts,
- ✓ Grasping mathematical concepts that are presented only in two-dimensional form,
- ✓ Trouble in integration and organization of varied concepts and skills such as visual and motor skill integration,
- ✓ Memorization of multiplication tables and number skills,
- ✓ Motor skills and coordination.

Key Issues Regarding Dyslexia

The key issues related to dyslexia for secondary school students depend on different aspects such as the context and priority within the field. The issue helps to create a forum for discussion, sheds light on a different perspective, and ensures minimizing the problem at hand. There are several issues related to dyslexia however in this section, the issues related to identification, intervention, and support to the dyslexic learner are discussed focusing on specific difficulties related to learning mathematics.

Context of Mathematics Learner and Teaching

Context is an atmosphere or phenomenon where the learning and learner are bounded. The learning context may be considered a bounded container or atmosphere within which the learning takes place (Richard & Kate, 2007). It shapes the learning environment either favorable or unfavorable. It has greater effects on how we conceptualize the matter or things in the learning process associated with the pedagogic practices. Therefore, it is a specific situation where the organism engages, conceives, and receives the certain outcomes of the activities. The learning context can be observed in two ways in terms of the availability of facilities as an appropriate learning context and a manageable learning context. The proper learning atmosphere, as well as the appropriate context of the learner, can assist to learn effectively by means of conceptually, methodologically, and pedagogically however, there are different perspectives of learning mathematics (Panthi & Belbase, 2017). In the same way, factors such as teacher variables, existing curricula, diverse social and cultural context, and lack of useful

resources for classroom practice can also hinder especially for mathematically weak students (Belbase, 2016). Students construct their mathematical concepts of what they learn through active cognitive and adaptive processes (von Glasersfeld, 1995). This perspective also suggests that different teaching aids, tools, and materials are needed to make them engage in learning, sharing ideas, and participating actively in knowledge construction (von Glasersfeld, 2001). It also suggests the proper learnable classroom environment so that it could be easy to tackle the different issues such as gender, language, social justice, equity and access, use of technology and affordance, pedagogical choice, and achievement-related issues (Panthi & Belbase, 2017).

However, the present context is different; several school-level mathematics learners are beyond access to such a well-equipped classroom learning environment, especially in developing and underdeveloped countries. Thus, in this situation, most institutions from the developing country are trying to manage the convenient learning context for learning mathematics. It is the obligatory condition for creating such classroom conditions due to the poor management aspects and unavailability of different resources. In such a context, the issue related to learning mathematics for dyslexic children is more challenging.

Identification of Dyslexic Learner

Identification of the dyslexic learner is a challenging issue in the manageable classroom context through analyzing their learning attributes. It can be diagnosed clinically by a clinician or doctor by using brain imaging techniques like MRI and MEF (Rice & Gilson, 2022). The school-based identification of dyslexia as a specific learning disability is generally used to diagnose by the trained school teacher/educationist. A clinical diagnosis of dyslexia is not necessarily required for a school student to address the problem regarding dyslexic learners (Snowling, 2013). However, it is necessary to screen the students having at-risk and no-risk groups for the need for attention and provide proper intervention from the beginning stage (Coskun & Mitrani, 2020). It is the foremost step while designing the instructional program. The need assessment of the learner or the gap between the student's actual status and the desired status would be the first step to be analyzed before planning an instructional program. Thus, the overall learner's perspective such as prior knowledge, skills, attitude, motivation level, preferences in learning, level of education, etc. should be considered before identifying dyslexic learners (Rice & Gilson, 2022). Similarly, the context where the learner or the target population takes place should also be analyzed (Dick et al., 2005) before planning and implementing an effective instructional design. In this concern, we can follow the four levels of the sequential model to identify the dyslexic learner.

Identification of Dyslexic Learner

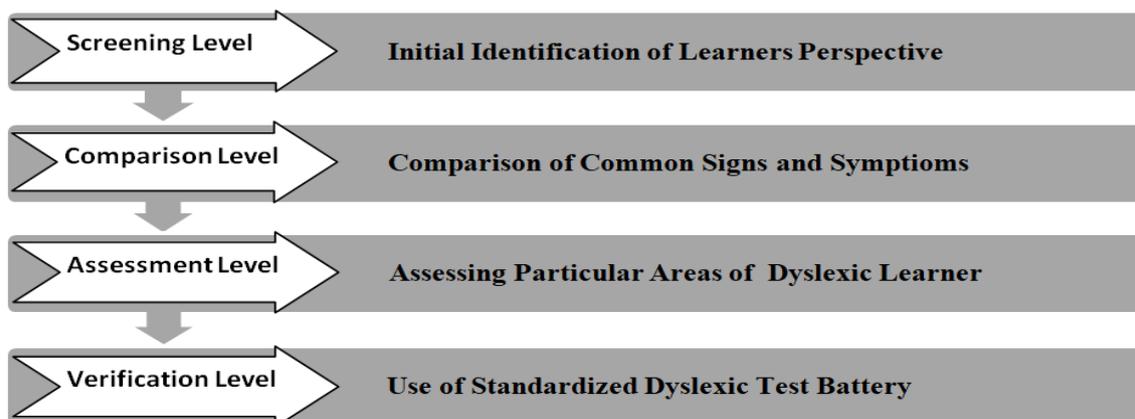


Figure 1. Identification of dyslexic learners.



Initial Identification of Learners' Perspective

It is the observation or screening level of the learner. At this level, it is necessary to go beyond the context of the learner. The main purpose of this level is to make the group of students according to their inherited personal characteristics and the learning context. Such different perspectives of the learner such as prior knowledge, skills and attitude about the topic, motivation level for instruction, general learning preferences, ability and level of education, range of achievement, etc. should be observed and screened comprehensively by collecting the information through interviews, observations, and testing. The prior or prerequisite knowledge, skill, or ability that possesses in the learner helps them to learn any subject matter or task. Such abilities of the learner enhance their motivational state, goal determination, and readiness for performing any task. As a result, the learners' prior knowledge impacts the whole teaching-learning process.

The prior knowledge of the topic area includes especially the cognitive domain of Bloom's taxonomy (Bloom, 1956). This includes different skills, information, and abilities in the related context and subject matter so that they can take advantage while recognizing, using, and defining specific facts to grasp knowledge, skills, and new information. In the same way, attitudes refer to an overall evaluation of a stimulus object or evaluation of people, places, and object in the social world and also impact both the way we perceive the world and how we behave. The learners' positive attitudes toward learning new content or skill enhance and also ensure more faster and effective learning and vice-versa (Lindstrom, 2019).

Motivation level for instruction is the major part of learning because only motivated students can focus on developing and mastering the skills. They can pay more attention, be active, enthusiastic, and optimistic about their better academic achievements. The motivated students always engage actively and exert intense effort in the learning process and thus develop knowledge, skills, and understanding at a faster rate (Lindstrom, 2019). This also helps to make effective classroom delivery or content delivery to the learner. The use of a proper amount of time and effective teaching materials can foster the motivation level and thus enhance meaningful learning.

Learning preference refers to the choices of the learner to take part in learning more comfortably and effectively. People can learn differently depending on their personal preferences such as visual, auditory, reading, or kinesthetic. When the learners get their preferred learning style or learning preferences then the level of retention and understanding may increase. The specific learning preference of the learner directs the teacher to adapt the preferable teaching styles for their students. Similarly, different skills and the ability of the learner also depend on their level of education. However, dyslexic students can exhibit low self-esteem, frustration, low motivation to take part in learning, attention difficulties in the classroom, etc. (Lindstrom, 2019). The achievement level or the range of achievement of the learner is the aggregate result of the learner's ability, skills, and attitude towards the subject, learning activity, or participation in learning which also shows some possibility of dyslexia (Falzon, 2020). Thus, can be observed comprehensively the initial characteristics of the learner concerning dyslexic children.

The main reason to screen the learner at the initial phase is to identify the problematic learner and their specific area of difficulty. Then we observe the learner and classify on basis of specific learning difficulties concerning difficulties with reading, spelling, and math. It is very difficult to identify dyslexic learners just by observing some common signs and symptoms, their ability, and performance fluctuation because such signs, symptoms, and behaviors may have appeared due to other causes. Many non-dyslexic children may have the same sign and symptoms as dyslexic children in the early stages of learning especially in reading such children can be diagnosed through a multi-level diagnosing approach. Sometimes dyslexic students can be diagnosed by investigating the family history that either any one member of their family have dyslexic or not because dyslexia also depends on a hereditary condition.



Comparison of Common Signs and Symptoms

It is the comparison level of different common signs and symptoms of dyslexic learners. At this level, different characteristics of the learner such as prior knowledge, skills, and attitude, motivation level, classroom activity (oral language skills, word recognition, decoding), performance related to oral reading fluency, reading comprehension, spelling, math fluency, math calculation skills, mathematical problem-solving skills, processing speed, general information, ability to recall, learning preferences, achievement level, vocabulary level, self-esteem, etc. obtain by the students from the group of the dyslexic learner is compared with the other non-dyslexic group of students. While comparing such activities and characteristics of the learner, their errors, inconsistency mistakes, difficulty with spelling, and troublesome condition of writing letters and spelling the words are noted down. The phonological awareness, reading, writing, and spelling discomfort, and frequent errors are also compared to the non-dyslexic learner. In this way, the overall common signs and symptoms are compared to the activities, performance, and characteristics of the dyslexic learner.

Assessing the Particular Areas of Dyslexic Learner

The third level of identifying dyslexic learners is to assess the common signs and symptoms of dyslexic learners. In this level, particular areas of the suspected learner such as letter sound and word decoding (identifying individual letters and producing sounds of the single letters); reading fluency (read silently the sentences and reading a passage quickly); spelling/encoding (writing single letters and spell words that are dictated); reading comprehension (read a passage silently and answering the questions) are assessed and make sure that the group of students is dyslexic or not. Similarly, naming common objects, symbols, letters, colors, and/or digits fluently, ability to recall sounds, words, symbols, and formulas; understanding the letter, and symbols about their specific sounds and their relationship to speech sounds; ability to encode words accurately; fluent recall of factual information related to a different subject, accuracy, and automaticity in basic computational processes, ability to recall quickly the basic mathematical facts and ability to mathematics reasoning and solving word problems are also assessed to confirm the learner either dyslexic or not. Most learners with dyslexia struggle to recall different language-based information such as multiplication tables and mathematical language that hamper solving math word problems.

This level is generally the last stage of identification of dyslexic learners based on their learning attributes in school-level education to provide support and intervention. The process of collecting the information regarding dyslexia can be done by any trained teacher or other trained personnel in the related field however the identification process is very difficult due to the common characteristics of dyslexic and non-dyslexic learners. Therefore, the teacher or the professional involved in gathering the information and assessing the particular areas of the dyslexic learner should be well familiar with dyslexia, the development of literacy skills, and their impact on other areas of learning (Snowling, 2013). Several screening tools have been developed to identify the problem related to early language, literacy, and communication skills concerning dyslexia and also are the potential to identify the learner who is at risk zone however, no such screening tools are perfect (Snowling, 2013).

On the other hand, such screening tools measure the human attributes and behaviors objectively in a predefined frame that cannot incorporate all the developmental characteristics of the learner. Therefore, it is better to use the response to intervention (RTI) approach for screening dyslexic learners to maintain the subjectivity of the context and the attributes of the learner while identifying their learning difficulties (Gresham, 2002).

Use of Standardized Dyslexia Test Battery

The last level of diagnosing dyslexic students is the use of diagnostic tests battery or standardized dyslexic test battery that is specially designed to test the ability to manipulate sounds, decoding and processing skills, and productive ability of the learner. So, to verify or to confirm the learner is either dyslexic or not the standardized dyslexic test battery is used at the final stage however a single assessment sometimes may not be appropriate to provide a holistic assessment to identify dyslexic

learners. It is the most comprehensive diagnostic evaluation process. Basically, it is not necessary to use the diagnostic test battery for school-based identification of dyslexia because the main reason for the identification of the dyslexic learner is to provide the proper intervention and support in time. The standardized dyslexic test battery is used for more severe cases or referral cases when the document is needed to be eligible for admission or join in specially designed instruction. This level of diagnosis is generally administered by a special team of professionals or a dyslexia specialist, psychologist, neuropsychologist or educational psychologist, or education teacher for assessment.

Intervention and Support for Dyslexic Learners

The reading deficit not only impacts language learning but also hinders learning the subjects like mathematics and science. The problems related to the dyslexic learner at the beginning stage can consider simple problems but when it takes a time span it becomes more problematic to catch up on the problems. The lack and gaps of the learner to learn correctly the basic knowledge, skills, and information that serve as background knowledge for learning new knowledge that also creates more difficulties in their further learning. As a result, gradually, frustration, a sense of negativity, and the sense of poor self-esteem and self-concept can be developed in the learner (Rice & Gilson, 2022). Therefore it is essential to identify or screen the dyslexic learners who are at the primary stage to develop a tentative road map for intervention. The timely diagnosis of the dyslexic learner can help to design and implement specialized instruction focusing on the learners' needs. It helps the students to address to meet their specific skills, and gaps and identified specific weaknesses. The specialized instruction can prevent some problems related to reading and helps to reduce the impact of more serious reading difficulties (Mather & Wendling, 2012). There are different approaches for the effective intervention of the dyslexic learner however two most effective methods of effective intervention have been discussed below.

Response to Intervention (RTI) Method

The RTI method can be used for both interventions and support the dyslexic learner (Fletcher et al., 2007). It is also used to provide proper intervention that consists of a continuous monitoring system to the learners' activities and progress that help to improve their learners' difficulties (Snowling, 2013; Fuchs et al., 2008). This approach is not only useful to identify the dyslexic learner but also helps teachers and schools better target, and support both students and their skill deficits (Gresham, 2002). It is a well-integrated approach for instruction and intervention for the learner that provides intervention at increasing levels of intensity to accelerate their rate of learning (Kovaleski et al., 2013). RTI is a multi-level model that consists of 'primary intervention' referring to special inclusive classroom instruction; 'secondary intervention' that involves more intensive intervention in a small group; and 'tertiary intervention' that denotes more intensive care for special education (Singh & Anshu, 2013; Elliott & Grigorenko, 2014; Fletcher & Vaughn, 2009). The three-tier/step model describes a variety of programs and provides different services for students with their learning difficulties. The brief process of the three-tiered model is discussed.

Stage 1: High-level Classroom Instruction, Screening, Group Interventions, and Support. All the students receive high-quality instruction and behavioral support. The screening process runs continuously within a certain period and measures the literacy skills, intellectual ability, and behavior of the learner to identify the struggling learners or learners at risk who need additional support (Fletcher et al., 2007). Thus identified learner receives added instruction regularly for about two months. During this time, the teacher uses a variety of appropriate teaching strategies and approaches on the basis of their performance and monitors the students' progress continuously (Christo et al., 2014). At last, the students who achieve significant progress are returned to the regular class, and who do not attain adequate progress are shifted to Stage 2.

Stage 2: Targeted Interventions. The students not attaining adequate progress in Stage 1 and shifted in Stage 2 are the targeted learner and treated in Stage 2 providing intensive instruction according to their capability, needs, and levels of performance. The intensive intervention is provided to these



targeted learners in a small group up to the level of intensity besides the instruction of the general curriculum (Fletcher et al., 2007). Generally, interventions are typically based on the areas of reading and mathematics. The time for intervention and support to the targeted learner depends on the case however it should not exceed normally a whole year. The students whose progress lag behind the expected level or attain very poor are then shifted for more individualized intensive interventions to Stage 3 (Christo et al., 2014).

Stage 3: Individualized Interventions and Comprehensive Evaluation. In this stage, the individualized, intensive interventions are provided and referred for a comprehensive evaluation of the student's skill and ability deficits to the targeted learner who does not attain the preferred level of improvement in Stage 2. In this stage, a comprehensive evaluation process is carried out by a multidisciplinary team to find out the eligibility for special education and other related services. Similarly, parents are informed about the comprehensive evaluation and its due process to determine whether the student is eligible for special education and related services or not (Fletcher et al., 2007). Thus, in this stage, the individualized intensive intervention is implemented, and also held a comprehensive evaluation of the learner (Christo et al., 2014). This approach always seeks to support academic success by utilizing universal screening, early intervention, frequent mentoring, and implementing individualized intensive interventions for the learner who is at risk of underperforming and continually facing difficulty (Fletcher & Vaughn, 2009).

Orton-Gillingham Method

The Orton-Gillingham method was developed by the American physician Samuel Orton and his associate, psychologist, Anna Gillingham from the meantime of 1930s to 1940s. It is a highly structured, systematic, sequential, and multisensory method to teach individuals suffering from dyslexia. In this method, explicit instruction regarding phonology and phonological awareness, correspondence of sound-symbol, syllables, semantics, morphology, and syntax is provided (Rief & Stern, 2010). It is a diagnostic method specially designed to teach reading, spelling, and writing to struggling students (Laney, 2011). The main feature of this method is multisensory, visual, auditory, kinesthetic, and tactile learning. It is based on individualized instruction and is provided incrementally and cumulatively to get the mastery level.

A brief of the key components that exist in the Orton-Gillingham method based on reading programs is stated below.

Multisensory Learning. The learning is designed so as to learn through multisensory input and activities for each individual so that they can learn best by using multiple sense organs. A multisensory learning method involves the mood of visual, auditory, kinesthetic, and tactile learning. The use of a multisensory mood of learning at a time helps the learner to grasp the knowledge and skills in a variety of ways. It is more interactive and also helps to make the learner more active by involving in reading, listening, touching, viewing, sometimes moving around the space and gesturing, etc.

Individualized Instruction. The intervention is completely personalized or individualized to get the needs of the learner and to move forward. The process of intervention began from the existing level of the learner and gradually moves forward as the learner improves their weakness and the teacher monitors each activity of the learner regularly. Each learning program is designed so as to fulfill the individual needs of the learner.

Sequential, Systematic, and Structured. The learning frame is so designed that the instruction starts from a simple concept and gradually moves toward more complex. Similarly, the learner moves from simple known to unknown or more complex. Systematic teaching denotes the skills and concepts that are taught in a planned, logically progressive sequence. The information which the teacher presents in a systematic, as well as an ordered way, signifies the relationship between the content taught and previous material. The contents of the curriculum are so structured linguistically as well as logically that facilitate student learning and progress.

Incremental, and Cumulative. The instruction and learning always start from one step to the next after mastering each level of language skills. The students are introduced in a certain order of words or letters based on logical steps that build on one another. While teaching the lesson, the linkage of each lesson is carefully linked with the previous. The learning of each component is so designed that the previously taught skills and material consistently helped to the mastery of the next component.

Flexible Implementation. The instruction of the teacher depends on the need and background of the students. In this method, when the teacher gets training about the teaching strategy for dyslexic learners they can implement their knowledge and skills in various ways in different groups depending upon the need of the student. Thus, it is flexible to implement the teacher's skills and approaches into any curriculum or classroom with students of all ages. It can be adapted over time to endorse continuous learning and problem-solving in each classroom.

Language-Based. It is completely language-based instruction and teaches the fundamental language structure that begins with sound/symbol relationships and moves ahead to more complex concepts such as higher-level spelling rules and other Greek and Latin Bases. It is also related to sound and symbols.

Support for Dyslexic Learners

As already discussed, dyslexia affects the memory and processing speed of the child which impacts working memory, literacy development, mathematics, sequencing, and organization of skills to varying degrees. It also affects the skills related to accurate and fluent reading and spelling. It can occur at any level of intellectual development however it mainly affects up to the age of adolescence. A large number of students are still suffering from problems related to dyslexia and its byproduct effect. Hence, it is necessary to provide support to them from the primary stage to assist with their language learning difficulties and cognitive weakness that can affect learning mathematics. According to Chin & Ashcroft (2017), most dyslexic children have short-term memory difficulties than non-dyslexia learners' impact arithmetical problems such as number sequence, reverse number, remembering basic number facts, formula, and times table facts. So, to minimize the challenges of dyslexic learners, it is necessary to support them in their teaching and learning by creating a proper learning environment, creating a sense of belongingness, encouragement, motivation, and self-esteem (Miller & Katz 2002). The ways of providing support for dyslexic learners are discussed briefly.

Developing an Inclusive and Supportive Learning Environment

An inclusive classroom refers to a learning environment where all students feel supported, feeling respected, feel a level of supportive energy and also feel a sense of belonging in the classroom regardless of any biasness (Ellery, 2020). In such a learning environment the teacher and student work together with support, coordination, respect, and mutual understanding for the success of the entire learner. As stated by Kaplan and Miller (2007), most students can be more likely to do well academically in the collaborative modes of learning that allow students' personal experiences. The development of such an inclusive and supportive learning environment can enhance the learner equally in each classroom setting and also create a culture of helping hands. It can also develop a collaborative culture that focuses on the establishment of sharing ideas, and supportive relationships and makes it easier and more confident for the struggling learners in the classroom. Such a learning environment can benefit all learners.

Creating Proper Learning Condition by the Use of Support Tools and Resources

Teaching and learning can be made effective by utilizing various tools and the necessary resources according to the age, interest, level of class, and size of the students. The student learning condition can be made through the students' active participation, proper classroom arrangement, praising the students positively, use of technology, and the use of different supportive tools. Similarly, the use of accessible resources in teaching such as interactive whiteboards, smart boards, computers, different software, etc. also can make teaching-learning more interesting.



Use of Multisensory Teaching-Learning Approaches

Multi-sensory teaching-learning approaches refer to the process used in teaching and learning that can be used to deliver education effectively in various ways. The main purpose of using the multisensory approach is to provide information or input the knowledge and activities to the learner in more than one way to make connections and learn the concepts. In this approach, learners can use more than one sense organ at the same time and their brain is stimulated in multiple ways so that the learning could be more effective. While using a multisensory approach, the dyslexic learner can also grasp information, activities, or skills through different forms such as listening, viewing, moving physically around the space, touching an object, or using gestures. Thus, instead of only listening, the learners can make images of the events through visual and auditory which makes learning easier, more effective, and long-lasting, and also increases the routes of memory and strengthens the information (Kormos, 2017).

Establishing Strong Relationships among Students, Teachers, and Parents

A good relationship between the student, teacher, and parent encourages the students to continue their learning effectively. The strong relationship among them also helps them to communicate with each other so that up-to-date information regarding the student's interests, work, and study habits can be obtained regularly (Allen et al., 2021). Such a relationship also helps to encourage the learner in their learning and also helps to make them aware of the social, emotional, and behavioral difficulties of the children for timely support. Therefore, the strong relationship of the student, teacher, and parent not only helps to support their needs but also makes it easier for earlier intervention that also assists the teacher and parent to pay sincere attention and play a supporting role in the children (Allen et al., 2021).

Developing Pupil's Confidence, Motivation, and Self-esteem

Student self-confidence is a sense of belief about any qualities, judgment, and abilities. It is the base for motivation and success in further education and also the enhancement of self-esteem. Motivation encourages the person for the best performance. A positive motivation always enables the learner to engage in their action and increases their performance and vice-versa (Hanich & Laurie, 2011). Thus, self-esteem is the product of the overall factors of an individual or sense of well-being and value of a person. The dyslexic learner mostly has full of fear and anxiety about their weakness. So, primarily, it is necessary to bust them positively and increase self-confidence, motivation, and self-esteem towards their learning before supporting them or solving their difficulty regarding dyslexia.

Providing Continuous Support, Encouragement, and Feedback

The dyslexic learners have poor or difficulty in reading, spelling, comprehension, confusion in a sequence of letters and symbols, and problems in the arithmetical calculation. Due to these weaknesses, they also have some sort of frustration and retention problems so they need continuous support in their respective areas. Similarly, they need encouragement and feedback to make them engage in the task. In some difficult areas regarding language learning, they need repetition and drill. Thus, a dyslexic learner needs a series of support that can only address their learning problem. Dyslexic learner requires a supportive and collaborative classroom so that they can get the chance of encouraging each other individually and also feel comfortable. The praise for every good activity and encouragement help them to empower and overcome their learning difficulty as well as emotional suffering.

Provide Sufficient Time for Revision and Overlearning

As mentioned earlier, dyslexic learners have language processing difficulties, poor reading comprehension, developmental delay, poor fluency, difficulty in remembering and recalling, etc. So, it is essential to provide sufficient time to encourage and facilitate the dyslexic learner. On the other hand, revision and overlearning or practicing recently acquired skills beyond the point of initial mastery are also essential. Revision and overlearning or repeated practice help to further strengthen the memory and the performance of the learner. The repeated practices enhance the function of short-term



memory and help to overcome remembering and recalling difficulties. It is conventional learning frequently boring rote learning however it is an essential and effective method to conquer the difficulty of the dyslexic learner.

The Effects of Dyslexia in Learning Mathematics

Dyslexia is mainly concerned with the ability to read, spell and comprehend the written language or problem however it also affects the child's mathematics learning abilities. It is a specific learning difficulty having a neurobiological origin. It is related to the difficulty to read, master, or acquisition of different skills and acquire mathematical abilities. As stated by Chin and Ashcroft (2017), 60% of dyslexic people have some problems with mathematics 11% of dyslexic people can do mathematics well and the rest of the dyslexic people have no learning difficulties. The survey report shows that (2-4) % of people may have severe dyslexia (Yeo, 2008). Dyslexia is a specific learning difficulty concerning the acquisition of basic skills related to reading, spelling, and/or writing or in a broad sense literacy (Roitsch & Watson, 2019). Thus, the dyslexic learner struggles to learn basic math vocabulary, symbols, memorizing multiplication tables and telling time, and other common problems related to specific vocabulary and arithmetic calculation (Snowling, 2019). It is claimed that 60 percent of dyslexic learners could have difficulties in learning mathematics due to cognitive difficulties in phonological deficit, memory, and processing speed (Joffe, 1980). Dyslexic children face difficulties in some areas of mathematics such as language, short-term memory, visual, processing speed of work, sequencing, conceptual ability, anxiety, thinking style, understanding of place value, and notation (Almahrag, 2021). The major areas of difficulty to learn mathematics for dyslexic learners or the effect of dyslexia in learning mathematics are discussed below.

Reading and Comprehension

The consequences of the difficulty in reading and comprehending language for the dyslexic learner affect the language of mathematics too (Almahrag, 2021). In mathematics, there is a large number of new vocabularies associated with the different mathematical concepts. Each such word is interconnected and is used interchangeably so that it can create confusion in each mathematical operation as well as mathematical word problem (Almahrag, 2021). The student cannot confine the actual solution of the problem when they do not know what is asked to do or do not comprehend the meaning of the mathematical term used. Therefore, it is essential to be proficient in the language of maths for learners with dyslexia. The maths language problems create confusion while solving maths, feel difficulty with word problems, and also makes trouble reading information from tables, figures, and graphs (Snowling, 2019).

Working Memory and Processing

The dyslexic learners have working memory deficits. Working memory refers to the ability of the brain to hold and manipulate different information over short periods of time. It has a vital role in mathematical fluency. Dyslexic learners have poor working memory (Roitsch & Watson, 2019). Similarly, the processing speed denotes the measure of time required to respond to and/or process the information in a specific situation. A dyslexic learner takes 50 % more time to complete a task than a non-dyslexic learner (Chinn & Ashcroft, 2017). They feel difficulty in learning and recalling number facts, new vocabulary, and formulae and suffer from rote memorization. Similarly, the dyslexic learner feels trouble remembering the multiple steps with processes. They feel difficult while solving word problems which require multiple steps such as reading the information, understanding the problem, retrieving the necessary math facts, and performing calculations to get the answer. Multiple steps are also necessary for substitution large numbers with borrowing, division, sequencing, etc. Dyslexic people usually are slower in maths, with many factors such as slow recall of basic facts, processes, and calculations due to poor short-term and working memory (Almahrag, 2021). Thus, the dyslexic learner is always focused on providing conceptual understanding rather than a procedure to support them. Similarly, enough time is given to dyslexic learners to learn, work and solve the problem.

Maths Anxiety and Self-esteem

The dyslexic student having weak in certain areas of mathematics also makes them anxious about mathematics. It is a negative emotional reaction toward learning mathematics and that also hampers the learner with the manipulation of numbers and the solving the mathematical problems (Chinn, 2008). Poor performance in mathematics leads to increase mathematics anxiety and vice versa (Ma, 1999; Ashcraft & Moore, 2009). Mathematics anxiety can have a significant impact on learners who are facing difficulties to learn. A large number of students can have anxiety with mathematics (Henderson, 2013) which hinder the learner to tackle efficiently the mathematical problems (Kunwar, 2020). Self-esteem is the overall state of satisfaction and comfort of a person. It consists of several factors such as self-confidence, security, self-respect, competence feeling and a sense of belonging. So, self-esteem is the overall well-being of the learner and impacts the learners' motivation, positivity, and level of inspiration to learn mathematics and also increases the level of confidence and encourages the learner to enhance the performance.

Cognitive Competency

A large number of dyslexic learners have difficulty learning mathematics (Miles & Miles, 2004). Mathematics learning also involves many cognitive processes and competencies. In some dyslexic learners, the abilities regarding cognitive competency do hinder recalling oral math facts, and specific words, and delay in developing essential counting, symbols, and multiplication tables (Almahrag, 2021). Similarly, they face problems in counting number sequences than other non-dyslexic learners (Chin & Ashcroft, 2017). They have also difficulty understanding the concept of time, sequence, and order. Dyslexic learner have often the problem of confusing math symbols and reverse numbers that look similar which lead to errors while performing the simple arithmetic calculation. Cognitive competency or having a quick sense of how these concepts, facts, and relations work and helps the learner to establish and solve the problem is the major part of learning mathematics. Thus, more repetition and practice are employed for the dyslexic learner to develop cognitive competence.

Conclusion

The problem of dyslexia in school education, especially in teaching and learning language and mathematics, is a crucial condition. Most developed countries have already developed the mechanisms for special teacher training, classroom management, and the utilization of various effective technologies in teaching. However, the scenario of an underdeveloped country is different. The term "dyslexia" is still a new term, and no teachers have been given special training about how to teach dyslexic children, nor do the teachers have enough knowledge about it. In this regard, this article provides a short overview of dyslexia, general characteristics of dyslexic children, dyslexia and mathematics, ways of intervention for dyslexic learners, and provides necessary support to the learner. It also makes the teacher as well as parents aware of why their children do not concentrate or give priority to learning math and why they are becoming poor in mathematics. This also elucidates the reasons for anxiety and frustration in mathematics and helps to identify the dyslexic person's means of intervention and support to overcome.

Ethics and Conflict of Interest

I declare and confirm that we have acted in accordance with ethical rules throughout the entire research and that there is no conflict of interest between authors.

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